Bridging Knowledge and Technology Gaps in Camel Production

Edited by
Seyoum Bediye
Sisay Tilahun
Getachew Animut
Mehadi Egie
Tezera Getahun

EIAR
SoRPARI

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Proceedings of
International Conference on Camel Research and Development
Held in Jigjiga, Ethiopia
October 27-29, 2011

Copy editing and design
Abebe Kirub

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Preface

Among animal species reared in the pastoral setting of Ethiopia, camel deserves special attention because of its peculiarities. Despite various challenges, camel is the preferred livestock species in the dry lands and it continues as a major means of livelihood. In view of this fact, any research and development initiatives directed towards improving the production and productivity of camels is believed to improve the livelihoods of pastoral communities. Thus an international conference on camel research and development: Enhancing livelihood of Ethiopian pastoralists was organized to share the available technology and knowledge on camel research and development.

The purpose of this publication is to bring together global, regional, and national experiences in camel research and development to draw lessons and best practices for pastoral production system. This proceeding contains a total four papers of global nature, 7 papers representing various regions and countries, i.e., Ethiopia, India, Israel, Kenya, Sudan, Oman, Saudi Arabia, and 15 national papers presented by Ethiopian scientists to cover wide array of experiences in camel research and development.

This publication is an outcome of substantial contribution of multiple institutions engaged in camel research and development. We appreciate the full support and guidance of conference organizing institutions, i.e, SoRPARI, EIAR, HU, PFE, and Camel Forum Ethiopia. We would like to express our heartfelt thanks to SoRPARI, EIAR, HU, PFE, and OXFAM UK who financially supported the conference. We appreciate the Somali Regional State and SoRPARI for hosting the conference. The financial support of FAO sub-regional office in Ethiopia for preparation and printing of this publication highly acknowledged. We are very much grateful to all international and national scientists who responded promptly and positively to our invitation and for their significant contribution in this publication.The technical support of the conference organizing committee and the editorial team is also very much appreciated.

Sultan Welle, PhD
Director General, SoRPARI

Solomon Asefa, PhD
Director General, EIAR

Welcoming Speech

Mohammed Sharif Ali
Director General
Somali Region Pastoral and Agro-pastoral Research Institute

It is my great pleasure, and on behalf of Somali Region Pastoral and Agro-pastoral Research Institute (SoRPARI), to welcome youall, from abroad and within Ethiopia to participate in this International Conference on Camel Research and Development: Enhancing Sustainable Livelihoods of Ethiopian Pastoralists.

In pastoral production systems, livestock is a key asset for poor people, fulfilling multiple economic, social and risk management functions. However, the food security and livelihood situation of pastoralpeople is highly threatened because of degradations in biological and physical resources caused by various man-made problems and recurrent droughts.To alleviate these challenges of food security and biophysical degradation, a paradigm shift in livestock holding has revealed in favor of camel in many of the pastoral areas as a coping strategy.

Camel uses water and feed resources very sensibly under very harsh and hostile environmental conditions. Moreover, camel is very effective biological creature, needs very scarce inputs and produce efficiently more than other livestock on per unit feed/water consumption.It is needless to say that camel is everything for our community and camel is our mark of recognition as we have in our region's flag and logo of Ethiopian Somali Democratic Party.

Despite all these facts and the scanty research information available at hand; it remains a gloomy fact that camel is one of the neglected domestic animals by research and development endeavors of the country.

Thus in order to fill the gap, the scientific community plays an essential role and therefore, at this crucial point, SoRPARI as a national center of excellence in camel research organized this international conference in collaboration with Ethiopian Institute of Agricultural Research, Institute of Pastoral and Agro-pastoral Studies of Haramaya University, Pastoral Forum of Ethiopia, and Camel Forum Ethiopia.

The objective of this conference is to acquire a global experience and knowledge that will contribute to the improvement of camel research and development in the country and enhance sustainable livelihoods of Ethiopian pastoralists.

I am very much glad that there will be opportunities for us in this conference and after it to learn much from each other and tackle the challenges on the way. I am very much confident that this conference moment will foster future collaborations.

Finally, I, on behalf of SoRPARI and organizing committee, want to say welcome and thank you all sincerely.

Opening Address

His Excellency Mr. Ahmed-Dek Mohammed
Vice-President of Somali Regional State

It is a great honor and a privilege for me to extend my sincere and heartfelt welcome to you all to this international Conference on ***"Camel Research and Development in Enhancing Sustainable Livelihood of Ethiopian Pastoralists,"*** and this is no empty ritual phrase, but one filled with a deep sense of solidarity.

Your presence in this conference is an evidence of your concern, dedication, and devotion to promote and uphold such collaborative learning and global partnership that will lay a foundation for solid, viable, and sustained livelihoods of pastoralists from sub-Saharan Africa, Ethiopian pastoralists and other pastoralists in the World.

The Somali Regional State is greatly honored to have you all here, in Jijiga, to contribute to the future research and development action plan of camel for the best possible use of pastoralists' in the country.

Your decision to come to this conference, from which we expect to gain much towards enriching the countries camel research and development directions, which are the basis for the future impact oriented research and development activities, is highly appreciated. I believe this gathering will give each one of us an opportunity to realize how much camel is important to pastoralists in Ethiopia. Once again,I hope this gathering will shape strategies and directions for best utilization of this precious creature "Camel".

The Somali Regional State is the second largest of the nine regional states of the Federal Democratic Republic of Ethiopia. The Region is endowed with plenty of natural resources that include livestock, minerals, precious trees, gum and incense, and rangelands. The rangelands are suitable for the pastoral production system that is estimated to be greater than million hectares. The majority of the region's people are 80% pastoralists and theyare largely dependent on livestock production as well as crop farming. In the past few decades, the agricultural production of the Region has been declining steadily, partly because of adverse effect of climatic change, such as droughts, long dry seasons, and floods that the region has been experiencing. These constraints limited the effective utilization and exploitation of the Region's natural resources, including livestock.

Somali Region has put all its effortsto ensure good governance, democracy and economic development as a pre-requisite towards improvinglivelihoods of its pastoral and agro-pastoral community. However, we still feel that these developmental efforts made so far are not adequate. We still need to address more developmental issues with regard to exploiting the potential of our natural resources in order to attain satisfactory and sustainable economic growth in the country and the region in particular. In view of

this fact, it is worth mentioning that through such scientific conference whereby camel scientists from the globe, development actors, policy makers, NGOs and Pastoral communities share their experiences and knowledge, things can be changed from words to action.

This conference is meant to pave the way for joint efforts to beat the triple dragons, draught, famine, and grinding poverty in the region and in the nation. The strategic advices and recommendations on camel research and development that is to be delivered at the end of this conference have crucial roles in enabling Somali Region make the best use of its potential unexploited huge camel resources. The plans and programs of this conference and the issues to be addressed and discussed have lifted our expectations high to the sky. The people and the government of the Somali Regional State expect genuine, scientific and practical recommendations to promote camel production and productivity for pastoralists' best use. It is our sincere hope that concrete, practical and sustainable ideas and suggestions will emerge from your discussion and deliberations.

Once again, on behalf of the people of the Somali Regional State, I would like to heartily thank you for all your presence here today and welcome you all to this Great Region. Jijiga is your city and Somali Region is your home. We will make sure everyone of you enjoyshis/her short stay in the Somali Region. Meanwhile, we expect from you to make sure that it is not your last time to be with us rather everlasting.

Thank you all for honoring Somali region and for your willingness to share your expertise and experience with us. Moreover, I would like particularly to thank the organizers of this conference for being at forefront in the fight against food insecurity and poverty in the region and the country as well.

May Allah give us the unity and the strengths to pull our people out of the poverty and lead them towards the path of development and prosperity? Finally, I am honored to declare that the conference is officially open.

Keynote Address

Belay Kassa
President, Haramaya University

I would like to extend my sincere thanks to the organizing committee for inviting me to give aspeech at the international conference focusing on **'Camel Research and Development: *Enhancing Sustainable Livelihood of Ethiopian Pastoralists'***.Iwant to begin by indicating how strongly the title of this conference speaks to me.

My speech begins by taking you back to historical issues highlighting a series of development interventions that took place in pastoral areas of Ethiopia. I believe such events could enable us to draw lessons so that to be able to adjust our future policies and strategies in promoting sustainable development of pastoral societies.Since the late 1950s, there were three important externally funded development interventions in pastoral development. The first one was implemented between 1958 and 1963, narrowly focusing on dairy development. The second one existed from 1973 until 1981, was initiated by the then Ethiopian Livestock and Meat Boardand placed emphasis on the expansion of marketing facilities and other infrastructure with the purpose of facilitating livestock sales and processing. The third intervention took place between1975 and 1992 across three target areas (northeast, east, south and southeast) inhabited by pastoralists. The overall aim of the three interventions was to modernize the pastoral sector. In particular, the third one was widely implemented and aimed at increasing production efficiency with special focus on natural resource management. The strategies employed were improving services, establishment of feedlots, providing training and introducing modern range management that was based on the western tradition of ranching without understanding the pastoral production ecology and objectives in mixing livestock species to avert risk in disequilibrium environment. Even though, the presence of donors support encouraged such anintervention, there was no significant attention given at the national level towards policies supporting pastoral development. As a result, many intervening agencies, including governmental or non-governmental organizations, did not have clear guidelines to be able to make decisions about where to start to improve the livestock sub-sector and pastoral livelihoods.This was believed to be the consequence of poor input by research in informing policies and providing adequate guidelines for action.

Pastoralists as constrained by a number of in camel production. One is encroachment by sedentary cultivators, creation of national parks and conservation areas and establishment of state sponsored farms eliminating dry-seasongrazing reserves, which affected the production and development activities by restraining accessto better grazing resources for camel. Land tenure policies favoring sedentary life have continuously marginalized the traditional production system, which has resulted in the uncontrolled collapse of common property grazing lands. For instance, the introduction of group ranches during the socialist regime in Ethiopia in parallel with collective farming in thehighl ands has excluded outsiders who previously had access to pasture. In many circumstances, by associating irrationality with traditional herd

management practices, irrelevant and misguided policy interventions that aimed at controlling herd mobility and manipulation of livestock number have further compounded the problem. As a result, the system that maintained livestock environment balance through efficient use of rangeland resource has been breaking down with weakening of traditions, degradation of natural resources and growing vulnerability to ecological and economic stress.

Second, rangeland degradation and feed shortage have been the main threats to the pastoral areas. There is growing evidence showing that feed unavailability is becoming a critical constraint to livestock production mainly due to the expansion in cultivation, destruction of range trees for charcoal making, bush encroachment by invading plants, conflict, and drought. For instance, a recent estimate shows that pastoral communities have lost about 2.6 million hectares of their prime grazing territories to the emerging different land uses. The change in land use from rangeland to other forms of agriculture without due consideration to the benefits of the local pastoralists is considered a threat to the pastoral production system. Although the emerging agricultural activities in the area may contribute to the national economy, I believe that greater attention must also be given to improving the welfare of the pastoralists and the ecology of therangelands for camel production.

Rangeland degradation due to rapid population growth, poor management system, deforestationfor construction, firewood, and demand for charcoal, and over exploitation of vegetation fordomestic use is also seen as an underlying challenge, especially in areas, which are close to bigbusiness centers, refuge settlement camps, and towns. As successive years of rainfall deficit occur, the fodder availability does not commensurate with the camel population. This results in overstocking, thus bringing about overgrazing. Besides, the practice by different households inmoving their livestock from different areas to where better pasture and water is available can cause overgrazing of the latter. This calls for concerted efforts in research undertakings todevelop an effective grazing policy to reduce such threats.

The third common challenge to the pastoral livestock production is the pervasive nature of interand intra-clan conflicts over the rangeland resources, mainly for grazing land and water points especially during the dry season, which have contributed to the decline of the resources. Conflict over resource is becoming a common feature of the pastoralists in many parts of the world and several clans and ethnic groups in pastoral areas of Ethiopia. Such conflicts result in human and livestock losses that in turn cause the shrinkage of the overall size of the traditional pastoral territory available for grazing. Although camel is a browsing animal and mobility is instrumental to have better access to browsing resources, conflicts undermine such an opportunity. The fact that pastoralists practice the compensation of victims in conflict resolution using camel and camel equivalent of other livestock shows how important camel is in their cultural and economic settings.

To respond to these and other challenges, the Ethiopian government has taken an initiative toestablish a number of regional research institutes. These include Somali

Region Pastoral andAgro-pastoral Research Institute (SoRPARI), Afar Pastoral and Agro-pastoral Research Institute (APARI), and Yabello Pastoral Research Center, all being located in three dominant pastoral areas of Ethiopia. Such amomentum has taken shape in terms of generating new and relevant knowledge to support the development of technologies for improving camel husbandry.

I would also like to take this opportunity to inform you that my University (Haramaya) (HU) has established the Institute of Pastoral and Agro-pastoral Studies (IPAS) with the intention of filling the gap left by other institutes mandated to work in pastoral areas. The Institute has carried out research on pastoral systems such as management of water points, resource-based conflicts, rangeland management, the role of livestock in foodsecurity, land use, and sustainable land management and conservations of livestock feed. I am confident that this network can serve as aforum of exchange of new ideas and information crucial to the development of the pastoralcommunities, which will promote a better understanding of pastoralism among policy-makers, researchers and other stakeholders. All these initiatives are pivotal in joining hands and actcollectively to examine emerging challenges to pastoral development in the country and beyond.

In the prevailing government policies, pastoral and agro-pastoral communities in Ethiopia are being given higher priority than ever before. There are important indicators for this. First, the Federal Government has established a Pastoral Affairs Standing Committee in the Parliament, and the Pastoralist Area Development Department (PADD) under the Ministry of Federal Affairs. In addition, the Pastoral and Agro-pastoral-dominated Regional States have incorporated pastoralism into many of their institutions. Second, the sustainable development and poverty reduction strategy of the government recognizes that pastoralists have a high economic contribution to make to the national economy since pastoralism is accepted as a viable way oflife and through formulating appropriate pastoral development policies and strategies. Following a series of consultation workshops, the national poverty reduction strategy has taken account ofthe interest and issues relevant to pastoralists, including land use policy that is in harmony with traditional land use systems, disaster management, micro-finance services, and promoting livestock markets. It is also gratifying to note that pastoral development has been given the attention it merits in the GTP.

Among the most important activities that are planned to be implemented in the pastoral areasduring the GTP period are improving livestock marketing; improving the provision of mobile veterinary services; increasing the number of professionals and strengthening their capacity; water development; improvement of pastoral land irrigation development; infrastructure development; and identifying, selection and dissemination of improved livestock breeds.

Such national commitments and concerns can only be translated into long-term development inpastoral areas through undertaking well-coordinated, integrated, and holistic research that generates relevant knowledge, which could be a base for

(re)designing or amending national policies to make them pertinent to the pastoral production systems.

One approach to tackle poverty and improving pastoral livelihoods is to develop the livestock assets of pastoralists, as these remain their basic assets as can be witnessed by themselves. Nevertheless, livestock improvement strategy is dependent on improving the vast rangelands, utilization, and conservation of genetic resources, enhancing infrastructure, and control of diseases that either limit the movement of livestock or their products, or constrain the potential buyers investing in them due to their poor quality with respect to food safety. In addition to improving livestock-based livelihood, developing the pastoral area has an added advantage from the point of view ofnational economy. The vast rangeland with its quality livestock resource in the pastoral and agro-pastoral production system is a potential that could provide great opportunities for livestock andlivestock product related investments. Therefore, to develop this potential, livestock-centered, integrated, and coordinated market-oriented research and development strategies are highly needed.

As the objectives of this conference cover development of knowledge and technology to supportcamel production, creating linkage between research and development actors is crucial. Ofcourse, one of the linkage mechanisms could be the network I was mentioning a while ago. Thus, it is time to move away from the tradition that forced researchers, development practitioners, and policy-makers to act in isolation that had resulted in functional differentiation and poor integration of the knowledge and information systems. It is my sincere belief that this conference will have an immense contribution towards refining and improving the research and development plan to increase camel productivity in the future. We will have sufficient time to deliberate on anumber of themes including reviewing of achievements and contemporary challenges in camel production, health and marketing. This would lay a basis for improving the benefits from camel production in the pastoral system.

I believe that the outcome of this three days' gathering will enable us to define camel research priorities and identify future directions of research and development in terms of short, medium- and long-term. Such a process will help us effectively respond to the underlying challenges I havetried to outline earlier. Once again, I want to express my confidence that this conference, by consolidating efforts that have been exerted over several years on camel research, will assist young researchers to move to the frontier and be ready to fill existing research and development gaps to enhance pastoral livelihoods.

Keynote Address

Seyoum Bediye
Advisor to the Director General of Ethipian Institute of Agricultural Research

Pastoral production system is an essential component of Ethiopian agriculture accounting for the vast majority of livestock population and land holding. In the pastoral production system, camel is the basis of livelihood of pastoralists and agro-pastoralists. With climate change and dynamics in vegetation composition of the range resources, structural change in herd dynamics is in favor of camel and expectedly its role in food security increases. With respect to national growth and transformation plan, and millennium development goals (GTP and MDG) pastoral production system is a strategic site seeking intervention.

From the perspectives of poverty reduction,high value agriculture is more appealing to contribute to the growth.High value commodities require more labor and generate more returns compared to low value agriculture.The small holders have sufficient labor of their own and high value agriculture offers opportunity to use family labor more effectively. Livestock production and its commodities belong to high value agriculture with significant contribution to growth and transformation. Potential sources of growth in livestock sector are technology and knowledge demanding sustainable delivery of alternative technology/knowledge, which fits to the demands of market-led economy.

The pastoral production system is one of the areas deserving attention in terms of attaining the set targets because of the vast majority of the poor wealth category dominating in this environment and the dominance of the livestock production system in the environment under discussion. About 72% of the pastoral population falls in the poor wealth category calling for substantial effort for the years to come.

Camel has significant socio-economic role in the pastoral and agro-pastoral production system of Ethiopia. It is a source of the highly valued milk supply and beyond nutritional value; it has remarkable medicinal values for diseases related to auto immune system. Camel has also considerable contribution as source of meat supply for human population in arid and semiarid environments. It has also remarkable contribution as means of transport. From socio-economic perspectives, camel serves as an indicator of wealth and high social status particularly in pastoral and agro-pastoral society. Camel is considered as champion of domestic herbivores in arid and semiarid agro-ecologies by its capacity to convert vegetation in such environments in to valuable products and byproducts for human consumption.

Despite the above-mentioned contributions and potentials, camel research and development in Ethiopia has formally started very recently indicating a significant lag\ behind other species. However, there are recent trends suggesting that more can be

done in the area of camel research and development. The recent trends of organizing research institutions and centers catering for pastoral and agro-pastoral environments in Somali, Afar and Oromiya Regional States of Ethiopia is a major step forward in camel research and development.

Camel production is recently expanding to mid altitude and adjacent areas to pastoral production system mainly because pastoralists provided the farmers with the opportunity to observe near by the specific advantages of camels; the salt trade route has persuaded farmers to employ camels as pack animals; and the use of camels in transporting trading goods from and to Djibouti. Moreover, there are observations that camel production is extended to Borana area in the Oromiya Regional State and there is a growing interest in the SNNP as well.

The driving forces are also identified as follows:

- Drought:The recurrence of drought and its immediate impact in terms of shift in the preference of camels to cattle, donkeys and mules has led to the increasing use of camels;
- Shrinkage of grazing areas:Populationpressure has resulted in the shrinkage and, in some cases, the total disappearance of communal pastureland in some mid-altitude areas, making it difficult for farmers to sustain grazing animals; and
- Euphorbia: A major push factor for increasing preference of camels over grazing animals seems to be the availability of Euphorbia species.The most common Euphorbia type that is found nearly everywhere in the mid-altitude range is *Euphorbia tirucalli* (locally known as kinchib).

The value of camel transactions in Ethiopia is estimated at 60 million USD indicating substantial contribution of camel. Trends in meat production in ECA are also in favor of camel.

The pastoral production system has a lot of technical constraints and specifically camel production and productivity is heavily affected by the following major constraints:

- **Camel breed:** Indigenous and has not undergone any genetic improvement apart from natural selection and empirical indigenous practices. Lowland livestock breeds are poorly identified and documented. Most groups have been exposed to genetic adulteration due to mobility;
- **Livestock feed and water:**The weakening of the traditional authorities in managing natural resources using rotational grazing patterns reduced the rangeland and the conventions of valley bottoms; previously used as dry season grazing areas converted into opportunistic crop farm plots.This has led to grazing pressure and induced improper range management and the occurrence of cyclic drought every 2-3 years is driving force;
- **Camel health:** The major disease of attention include: respiratory disease complex, sudden death, trypanosomiasis, Camel pox, and internal and external parasites;

- **Production system:** Poor knowledge about pastoral production system, depletion of the resource basis (bush encroachment, climate change), natural fodder output of rangelands has decreased at a mean annual rate of 0.5%. In the absence of technology-led range conservation practices, the best grass fields of the lowlands would face exhaustion in the next 50 years; and
- **Lack of Market information and accurate camel population data:** There was no regular and systematic collection of market information to determine the economic significance of transactions and the impacts on livelihoods for appropriate planning of interventions. Camels have been marginalized as a species due to factors that include the underestimation of the population size and the under-rating of their economic significance. These perceptions have to change for valid reasons. The change in perception could be started by re-assessing the true camel population in the country—through a reliable census—and by conducting an evaluation of the existing and potential economic contribution such as milk, meat, hides, and transport of the species at the household and the national level.

Accounting for 15% of the national milk production target and fulfilling several purposes, camel is a key commodity, which deserves research and development attention. Camel showed a dramatic increase since 2005/6 suggesting structural change in herd composition and its role in food security in pastoral production systems. Camel production can be modernized by linking to export channels and the level of productivity can be intensified through various interventions, which can reduce or remove the above constraints. Transforming pastoral production system requires multiple stakeholder involvement, commitment, and institutional innovations. Technology generation and transfer through networking and institutional innovation would help as major strategic direction in this regard. The following are the major areas of engagement encompassing short term, medium and long-term activities to advance camel research under Ethiopian perspective.

- Organize National/Regional center of excellence for camel research;
- Launch research and technology transfer through networking: collaborating centers and institutions including Werer, , Yabello, Semera, Haramaya University, Jigjiga University, Mekele University and Other institutions;
- Review and prepare synthesis of past achievements and global experiences;
- Develop strategic document; and
- Undertake on-farm promotion and scaling up of proven technologies

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The International Society of Camelid Research and Development: A Challenge for the Camel Scientist Community

Bernard Faye[1], Alhadrami G[2], Khallafala A[3], Bornstein S[4], Touhami K[5], Al-Jassim R.[6]
1. CIRAD-ES, Montpellier, France, 2 College of Food and Agriculture, Al-Ain, UAE University, UAE
3 ACSAD, Damas, Syria, 4 SVA, Uppsala, Sweden, 5 IRA, Médenine, Tunisia, 6 Queensland University, Australia

Introduction

At the international level, the economical importance of camelids could be considered as low compared to other ruminants. With an official population of 25 millions of camels and 8 millions of domestic small camelids, the world population is far away from the number of cattle, sheep, and goats. However, the camelids are quite linked to some ecosystems: desert and semi-desert areas in old world and high mountains in new world.

Camelids play important role (i) they are an essential element of the margin ecosystems in arid lands for large camelids and mountainous regions for small camelids; (ii) they allow to maintain a rural economical activities in those areas where the agriculture is impossible or very problematic; (iii) they are an important element in human population from those areas for poverty alleviation and food security; and (iv) they can play a role in the market oriented system by their production.

Camelids could be adapted also to intensive farming system and express their productive potential, for both meat and milk and fibres. Therefore, the camelid are engaging in the modern productive revolution. They can enter in the modernity, to be adapted to intensification process and answer to the international animal products market. However, the training institutions and research institutes have to deepen their knowledge for a better insertion of camel farming in this dynamic and support camel producers in these main changes.

Yet, since a recent time, the scientific community interested by camelids was not structured. The foundation of the International Society of Camelid Research and Development is an important step for increasing the quality of research activities on camelid.

The Camelid Sciences Community

The organization of the camelid scientists into an international association is recent contrary to other species as *International Goat Association.* In the world of camelid research, a first dichotomy between camel specialists and small camelid scientists was observed with very few interactions. A second dichotomy could be observed between the camel scientists from Arabic countries and other camel scientists' community from China, Central Asia or even Sub-Sahara countries. This last dichotomy could be linked to three aspects:

- Most of the publications in Central Asia and in China, at least up to a recent time, were in local languages (Russian, Chinese) and consequently poorly available to the international community;
- The means of research in many African countries for working on camel were low, especially in countries where the camel pastoralists were in conflict with the central government (Mali, Niger); and
- The camel research implemented in rich Arabic countries (Emirates, Saudi Arabia, Oman) were mainly focused on high tech activities (embryo transfer, genotyping, biotechnology) which were totally non accessible for developing countries.

Regarding international conferences, we assist to an increasing of camel conferences since Khartoum in 1989. But most of these conferences were focused on one topic (camel reproduction at Paris-1991, camel milk at Nouakchott-1994 and Niamey-2003, young camel at Ouarzazate- 1999), or gathered a limited number of participants (Eilat in 1996, Bikaner in 1998 and 2005, Al-Ain in 1998 and 2002, Sadri in 2003, Ashkhabad in 2004, London in 2011) or had mainly a national impact (Almaty in 2000 and 2006, Garissa in 2010). Except at Dubai in 1992 which was organized with the strong support of the Emirates government, and at Qassim in 2006, supported by Saudi University, it is difficult to gather the majority of the camel scientists of the world, mainly because numerous camelid scientists are coming from developing countries having difficulties to participate at those meetings. Elsewhere, a high variability in the research quality or in the interest for camel development is observed, underlining the necessity to support a useful research both for the knowledge of camelid biology and for the improvement of camelid farming and production.

A few international projects on camelids are supported. FAO has participated to several projects on camel milk and is presently involved in the camel project in Saudi Arabia, but in most of the cases, camel researches are achieved through small-scale projects at national or local level. The scientific production in camelid is slightly increasing (Fig. 1 involving large camelids only) with an average of 250 registered publications per year. However, the scientific papers on camelid are published in a high variability of journals at national or international level but only one international journal was specific to camel research (Journal of Camel Practice and research managed by Dr Gahlot in India).

Figure 1. Changes in number of scientific publications on camel since 1999

Regarding the publications on large camelids, 3 remarks could be done:

- The publications are mainly originating from "Camel countries" (Figure 2), but there is no correlation between economical importance of camel and number of publications. The number of publications is rather linked to the importance of the national research facilities. Thus, India, Egypt, KSA, Iran, and Emirates are the main contributing countries. Except for Sudan, African countries where camel is economically very important are poorly represented in international camel sciences community. An important increase is observed in Ethiopia and Kenya. Emerging interest for camel sciences are observed also in China and Kazakhstan;
- A growing interest of western researchers for the camel as a "Biological model" is observed—camel immunology, camel milk composition, and genetic. That explains the number of publications from USA, France, Germany, UK, Spain and others which are not "camel countries." ; and
- Many publications included authors from different countries showing an important international cooperation, especially in the frame of PhD program.

All these reasons have pushed some camel scientists to found an international association for stimulating and promoting the camelid sciences and supporting camelid research for development.

The idea to structure the camelid scientific community and to create an international organization of camelid scientists was proposed for the first time at Ouarzatate workshop (Morocco) on the young camel by Dr Bengoumi and Dr Faye. It was proposed again in 2004 at the Ashkhabad camel workshop by the same scientists. Finally, the first general assembly of the **International Society on Camelid research Development** (ISOCARD) was hold at the conference organized at Al-Ain (United Arab Emirates) in 2006, considering this conference as the first ISOCARD conference. The founders of ISOCARD are Dr M. Bengoumi (Morocco), Pr G. Alhadrami (UAE), Dr A. Tibary (USA) and Dr B. Faye (France). DR Faye was named chairman of ISOCARD for the year 2006-2009.

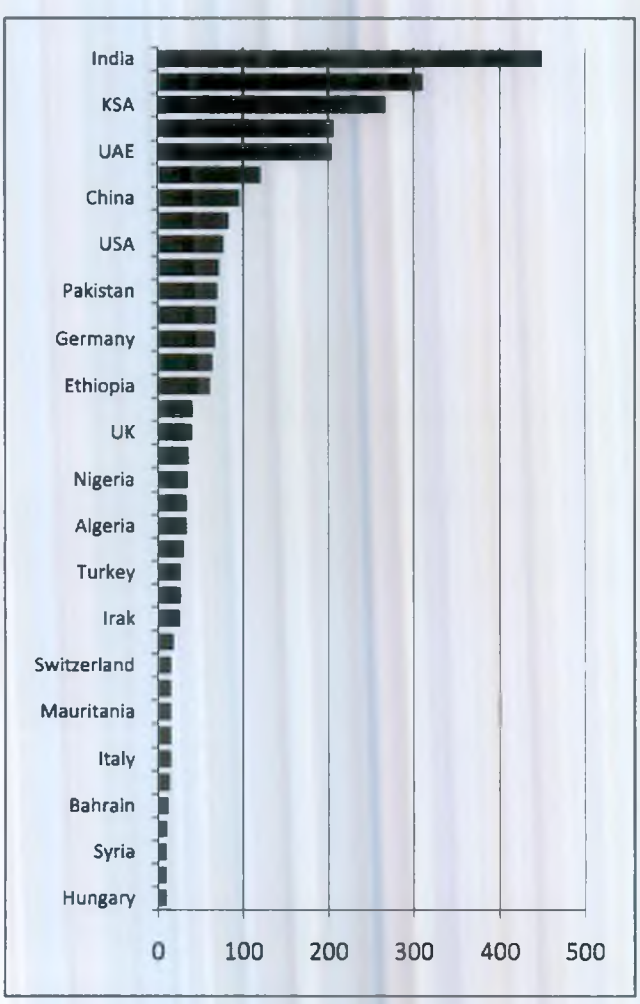

Figure 2. Number of scientific publications on camel by country 1999-2010

What is ISOCARD?

According to its status approved by the general assembly, ISOCARD is a non-political, non-religious, and non-profit federation of camelid scientist or similar scientific and professional associations. The objectives of this association are:

- To give international scientific status for camelid sciences;
- To promote the camelid science and practice;
- To promote the contributions of camelid scientists to the development of camelid farming ;
- To promote scientific publications in camelid fields;
- To set high standards in camelid education and training;
- To promote standards of health and welfare in camelids;

- To organise International camelid Conference every 3 years;
- To encourage the exchange of information on camelid interest between the members and different networks and involved organisations; and
- To establish and maintain relations with other organisations whose interests are related to the objectives of the society

The first constitutive general assembly was hold at Al-Ain (UAE) on 15th April 2006. The permanent secretariat office is based in Emirates at UAE University. A first Executive committee (the "government" of ISOCARD) was elected. It comprised 6 members (Chairman, Vice-chairman, Secretary, Treasurer, Scientific Affairs and Public Relations). Four of these members are renewed every three years.

For the moment ISOCARD has organized two international conferences, the first one being the constitutive conference at Al-Ain in 2006, and the second was hold at Djerba (Tunisia) on March 2009. The third one will be hold at Muscat (Oman) on January 2012, the ISOCARD conferences being organized every 3 years. The choice of the places of conference is based on competition, each applicant having to submit a proposal to the Executive Committee.

A correspondent from different countries is named at national level through the local camel association; for example, the Camel Research, and Development Association in Morocco, the Pakistan Camel Association, the Sudan Camel Association or the Kenya Camel Association).

Main Activities of ISOCARD

After the establishment of an official logo, a website was created **www.isocard.** At the moment, 421 camelid scientists are official members of ISOCARD (registered in ISOCARD website) among them seven are from Ethiopia. For some of the memberships, a CV is available on line in the "who's who in camelid sciences". ISOCARD has participated to the chapter "Camel" in Wikipedia, the on-line encyclopaedia, but has created also a specific camel encyclopaedia on line named CAMELPEDIA available on the website **camelid.wikia.com**. In order to increase the international visibility of camelid sciences, ISOCARD has created also a specific journal with international Editorial board entitled **"Journal of Camelid Sciences (JCS)".** A second issue was recently published. It is the official journal of ISOCARD and it is CAB registered. It is free on-line journal, but printed copied are available for purchase. It includes original papers but also the proceedings from ISOCARD conferences.

ISOCARD has also co-organized a satellite workshop with FAO at Djerba on the transboundary camel diseases with participants from Maghreb and Central Asia. ISOCARD is participating as network of camel scientists to the international camel gene project managed by the University of Bienne in Austria.

The challenges of Camelid Sciences Today

Researches on camel deal with to 3 main challenges:

- The camel as a biological model;
- The camel as a producing animal in arid conditions including health constraints; and
- The camel as an element of desert ecosystems faces to global change (Faye, 2005). Camelid research has known important progress for the last decades and is regarding different fields. However, some challenges have to be taken up:

    - Camel genetics is better known (breed characterization, genomic) but the performances' control is still poorly developed in order to set up an efficient selection plan (Mahrous et al., 2011);
    - Biotechnology of reproduction (AI, ET, hybridization) is now controlled in some places but few studies on risk factors of infertility are achieved and the low reproductive performances is still a constraint for the improvement of the numerical productivity (Skidmore, 2005);
    - Camel milk technology and fine composition of the camel milk is better known but few data on camel milk economy are available and there is a lack of innovative research on camel milk processing (Al-Haj and Al-Kanhal, 2010);
    - Camel milk and health effect are often studied but more effort are needed to have proper protocol to prove the true health effect and avoid believes and legends (as for example aphrodisiac effect of camel milk or benefit for cancer control) (Konuspayeva and Faye, 2011);
    - The knowledge on camel meat composition and quality is now in progress, but there is still a lack of reliable data on regional meat market and development of camel meat processing (Kadim et al., 2008);
    - New elements on camel nutrition are available both for general or specific nutrients but still researches are needed on the requirements according to the different status of the animals and overall according to the change in camel farming system characterized by the intensification of production (Faye et al., 2002);
    - Better techniques for diseases control are at disposition but the kits for diagnosis are rarely adapted to the camelid species which have a special immunological system, and the studies by ecopathological approaches or on epidemiology of emerging diseases (like PPR) have to be encouraged (Khalafalla et al., 2010);
    - Camel farming system face to climatic changes are beginning to be studied but more efforts have to be done to consider camel as element of desert ecosystem and to understand the possible changes in the farming systems through the world (Benard et al., 2008); and
    - The adaptation of camel to intensive system is better known but the impact on productivity and on environment is not yet sufficiently documented (Bekele et al., 2002).

Conclusion

The camelid sciences are going on, but the international scientific community has to conjugate more efficiently its potentiality for convenient studies and to promote the excellence of the camelid research.

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Curing Diseases Associated with Immune Disorders

Levy, A, van Creveld, C. ** and Yagil, R***
**HemdatHadaromScience College, Netivot, Israel*
*** Ben-Gurion University of the Negev, Beersheva, Israel*

Introduction

A pertinent point when considering the camel immune system is that the Homeland Security of the USA makes use of camelid blood for the "special qualities of the camel immune system" as biosensors for determining the substance that will be used in a biological warfare attack (Choi, 2006). The special immunoglobulins in camel milk are very small, nano-sized, and very active, in contrast to those of humans, which cannot penetrate thick tissues (Hamers et al, 1993).

Another important point when discussing the medicinal effects of camel milk is the historicaluse of camel milk. When the Prophet Mohamed sent hungry and ill persons to his camel herder to drink their milk (and urine), they became well (Khan, 1974). In addition in a book comparing the Koran and Talmud, in the chapter on "Camels", Dr. Weill states that G-D gave the she-camel to the world to "cure all diseases and poverty" (Weill,1863).

It is also important to remember that camels are NOT ruminants but tylopodes, accounting for the great differences in milk composition with its medicinal properties (Yagil, 2000).This article focuses on the milk of the one-humped (*Camelus dromedarius*).

Camel Milk and Medicinal Values

Fat

Dromedary milk is low fat (2%) which is mainly polyunsaturated fatty acids (PUFAs), known as Omegas. The fat is completely homogenized in small globules. Therefore, the milk is pure white and the fat exerts no stress on the liver.

Lactose

Lactose (4.8%) is similar to that in mothers' milk so is readily digested by those suffering from lactose intolerance.

Proteins

Proteins (3.5%): There are no allergens as in ruminant milk. There is insulin which is not destroyed in the stomach, directly passing into the intestines and into the blood where it reduces blood sugar (Zagorski et al, 1998).

There are a number of "Protective Proteins" (Kappler, 1998) mainly of bacterial origin, making pasteurization problematical. The protective proteins govern the immune system and have powerful antibacterial, antiviral, and antifungal properties. There are also antitumor and tissue repair properties (Kiselev et al, 1998).

Vitamins

Vitamin C is in high concentrations and plays an important role in tissue repair and absorption of calcium.

Electrolytes

Calcium and iron are of especial importance because of bone structure and anemia.

Examples of camel milk for treating immune problems are:

Allergies

Children suffering from severe food allergies, either 10-14 years old, or very young who are hospitalized because they cannot absorb any food except their mother's milk, have been cured by drinking camel milk. Cows' milk contains the allergens which do not exist in camel milk. Therefore, there are no allergic reactions to drinking camel milk. In addition the immune system is rehabilitated.

Autism Syndrome

Autism is assumed to be a brain affliction. However in fact the autism complex is an autoimmune disease affecting the intestines. There is no consensus as to how the autoimmune disease occurs. The probable causes could be genetic or associated with the childhood inoculations. It could be that genetics is the basic cause but the practice of injecting a "cocktail" of antigens into a developing immune system could lead to the attack on intestines. In the last year many millions of dollars have been awarded to families who have won court cases by confirming the relationship of child-hood inoculations and autism.

Yes! The primary attack is on the intestines and NOT on the brain. In the intestines there is a malfunction in the breakdown of two caseins (the allergens) in forming amino acids. What is formed is a powerful opioid, casomorphin. It is the casomorphin that induces the behavioral and cognitive symptoms in autistic-syndrome children.

Sun & Cade (1999) confirmed this theory by injecting urine with casomorphin to laboratory rats, who then showed autistic manifestations. Because the symptoms are caused by drinking cow milk it is enough to remove all cow milk and products from the diet. However, the actual disease is not cured and symptoms recur if cow milk or products are consumed.

As camel milk does not contain the allergens and rehabilitates the immune system, autism is cured. It must be noted that there is an age dependency: after the age of about 15 brain damages can persist even though the autism is cured. In no way is it suggested

that children should not get their childhood inoculations. Instead, it is proposed that instead of the "cocktail" of antigens the injections should be given one at a time. It may be logistically complicated but could reduce the epidemiological outbreak of autism in young children.

Crohn's Disease Syndrome

It is assumed that Crohn Disease is an autoimmune disease and the treatment is given for this, steroids. In fact it is primarily a bacterial infestation. The symptoms vary from mild, diarrhea to severe diarrhea, with loss of blood and painful cramps. Often even if the person sits outside the toilet he/she cannot get in before the diarrhea bursts out. This means that person cannot leave the house. Often surgical removal of part of the intestines is carried out.

In cattle there is a debilitating disease called Johne's disease. The cattle have severe diarrhea with powerful intestinal cramps, a loss of weight and eventually death. The cows at all stages of the disease secretea bacteria, Mycobacterimavium paratuberculosis (MAP) into their milk.

It is noteworthy that the symptoms of Crohn's Disease are similar to those of Johne's disease. This is probably due to the fact that MAPfrom cows' milk is not destroyed by pasteurization. In an article in the Dutch Veterinary Journal in August, 2011 it is estimated that up to 50% of the Dutch milk is infected by MAP (Santema, 2011). In Canada there is a movement to clean cow milk from MAP (Diane, 2011).

The MAP enters the intestinal wall and exists there as a saprophyte. When a severe emotional stress occurs the MAP becomes active, leading to the symptoms. The body sends out its antibodies to control the problem but they cannot enter the relatively thick intestinal wall so it becomes an autoimmune attack on the intestines. Therefore Crohn's Disease is primarily a bacterial infection and only then becomes a secondary autoimmune disease. Steroids are actually contraindicated.

Camel milk, with its powerful antibacterial properties and immune rehabilitating properties account for its healing affect. It is interesting that although it is now extensively known about the MAP in store milk there has not been any move to raise the temperature and/or time of pasteurization.

Hepatitis

Another disease associated with the immune system is hepatitis. This world-wide affliction is caused by allergic or immune response to an antigen, both which are controlled by camel milk.

Hepatitis B

Camel milk regulates the expression of Th1/Th2-type cytokines, and corrects the imbalance of Th1/Th2 cytokine network, which strengthen the cellular immune

response, inhibit the replication of virus DNA, and promote the recovery of the chronic hepatitis B patients (Xi Bao, 2009).

Hepatitis C

A camel domain antibody fraction is a potent and selective inhibitor of hepatitis C enzyme system (Martin et al, 1997).

Conclusion

The components in camel milk have been scientifically documented and explain how camel milk can cure various diseases associated with a malfunction of the immune system.

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Achievements and strategy of Camel Research and Development in India

N.V.Patil and Rajan Gupta
National Research Centre on Camel
Jorbeer, Bikaner, Rajasthan, India, 334 001
ICAR HQ, New Delhi, India, 110011

General Backgound

Uses of Camel in Indian conditions

In India, the camel is an important component of fragile desert ecosystem. The proverbial *Ship of Desert* earned its epithet on account of its indispensability as a mode of transportation and draughtability in desert. However, its utilities are subject to continuous social and economic changes. The camel has also played significant role in civil law and order, defence and battles from the ancient times till date. Camels formed an important component of Mauryan Army (C.322-232 BC) and continued through Mughal period (1200-1700 AD) to the present times. The world famous Ganga-Risala of erstwhile Bikaner state was accepted as Imperial Service Troup and participated in World War I and II. Presently, the camel corps constituted an important wing of Border Security Force of Indian Para-Military Service.

Despite mechanical transport taken over some of their function, it still contributes considerably to energy needs of the area inhabited by them. It is used for transport of crop residues, cash crops, and similar entities from villages to adjoining towns and cities for sale. Camels in carts also transport urban goods more economically than motorized vehicles particularly where small quantities are delivered to individual service points with relatively long halts. Camel also easily accomplishes household needs, such as transport of water and other similar needs of normal houses. Camels are used widely as plough animals and seem to be equally as efficient in producing draught as most other species. The camel milk is used in the camel rearing people as a source of nutrition and health and its use is very much comparable to other conventional milk.

Camel population scenario

World Camel population is estimated to be around 25.89 m spread across 47 countries. About 85% of the camel population inhabits mainly eastern and northern Africa and rest in Indian subcontinent and Middle East counties. The majority of world's camel population is of dromedary type except small population of Bactrian camels in central Asia. Per Governemnt of India Census, the country rank 7th in the world for camel population and in Indian camel population is mainly confined to the northwestern part of the country. Accordingly, the states of Rajasthan (0.498 million), Haryana (0.128 million), Punjab (0.043 million) and Gujarat (0.058 million) inhabitate, hence, almost 93.12% of Indian camel population do reside in these states. The other states where camel occurs in the substantial numbers are Uttar Pradesh (0.036 million) and Madhya Pradesh (0.015 million). Looking at the geographical distribution of camels, availability of very good camel genetic resource, excellent scientific infrastructure and human resources, India has unequivocal opportunities to take leadership in camel research, development, and training all over the world.

Shift in Camel Population

As per 18th livestock Census 2007 overall camel population in India showed a decline of 18.2% from 2003 population figures; whereas in Rajasthan state, the decline during the period was by 13.6%. In the last one decade camel population in the arid zone shows decreasing trend of about 25 percent which is matter of great concern and it can be mainly attributed to continued shrinkage in grazing resources and increase in command area both under canal and tube well irrigation and fast urbanization pressure.

In India out of approximately 3.29 million km^2 total land area almost 0.32 million km^2 is arid and almost 30% of cultivable land is owned by small and marginal farmers, who maintain 80% of domestic livestock. In this back drop draught animal power is main energy source for agricultural operations and transport. In recent years due to changing social and economical scenario where pastoralists are becoming sedentary, motorized mechanization in these areas is gaining popularity. In the periurban and nearby urban rural areas, animal traction is often perceived as old-fashioned, backward, and out-modeled technology. However, considering the economical viability, acceptability, and wide use of animal traction and camels, particularly in the dry land it is presumed that camels will continue to be utilized extensively and economically in distant future as source for energy and food where they are managed on locally available renewable resources.

Genetic Resources

Dromedary

Based on utility two main classes of Indian camels are distinguished - draught camel and riding camel. There are eight distinct camel breeds/strains besides several other strains developed and named after local breeding tracts. These strains are syntheses of mostly one or more of the 4 main camel breeds, viz. Bikaneri, Jaisalmeri, Kachchhi and Sindhi. Comparatively small-sized hill camels available in Mewar belt are called Mewari camels. This is popular camel breed used for draught purposes in this area.

Bactrian—Double-humped camel

Based on Livestock Census (2007) the population of Bactrian- Double-humped camel (*Camelus bactrianus*) in India is 563 camels which are available in the Leh and Nubra Valley of Ladakh (J & K). Mostly they are wild. Detail survey and data were collected on different aspects of (hair production & quality, reproduction, nutrition, disease etc.) double humped camel. These should be further researched for future utility and conservation of this species. Immediate efforts are needed to create utility of these camels in the area and to multiply these animals for their conservation. Bactrian camels are suitable for cold desert and can prove to be very useful economically viable domestic animal in this zone through agricultural and short distance transport.

Except Rajasthan and Gujarat states where there is one camel breeding farm in each state, there are no organized breeding farms to provide genetically improved animals. In Bikaner centre mainly three breeds Bikaneri and Jaisalmeri and Kachchhi are maintained. The other important camel breeds/strains are being propagated only through private breeders in progressively less and less numbers. Therefore, it is likely that unless timely action is taken, the country might lose this very important genetic resource.

The Northwestern region is rich with varied indigenous camel resource. They have genetic potential for further improvement for specialized purposes, viz. draught, milk, hair, and race animal and for specific eco-systems (hot and cold deserts). The camel has many unique qualities to survive under harsh climate and utilize low-quality feed resources, which other species cannot consume. Dromedaries represent integral facet of the Indian arid and semi arid rural scene. In fact, camels are lifeline for about 30% percent of rural population of this region comprising of small and marginal farmers.

Race camels

he camels are becoming very popular as game animals, particularly in the Gulf countries where very remunerative prices are paid for good racing animals. The race animals have very good remunerative price and export potential. Studies so far conducted at NRCC, Bikaner have revealed that with proper research input, Indian Jaisalmeri camels partially young age group (3-4 yrs) female are superior in race as comparison to males and other breed and can be developed to compete with race camels presently used in several Gulf countries.

Camel Production and Management Scenario

Camels are generally considered environment friendly and are not associated with environmental degradation. No negative environmental impact is expected from increased use of camel. The following systems of management exist in India.

Systems of Management

The camel has been domesticated more recently than other animals. The most probable period of domestication of camel is prior to 1800 B.C. The methods of camel keeping are now changing worldwide because the grazing land is decreasing continuously as more land is brought under cultivation reducing the total area of free grazing land. Camels, which are largely maintained under extensive system earlier, are now facing problem and their management needs a better alternate system, which is socially acceptable and economically viable.

Community System

Indian camel owners can be categorised as camel users and camel breeders. Camel user are the farmers who utilizes camel mainly for carting and agriculture purpose in cities as well as in villages areas and earning money is a means of livelihood in their day to day life. They generally do not breed camels, whereas camel breeders mainly breed the camels and produce offspring and rear for few years and then sell out in livestock fairs. Camel users come from a wide variety of social background, viz: Saansi, Meghwal, Meena, Bheel, and Kalbelia who aspire to camel ownership. For these groups camels are valuable income-producing assets. These users are dependent on camel breeders for the supply of camels. Breeders own larger numbers of female camels which are kept mainly for the purpose of reproduction.

Extensive Management System

This practice is very common among camel breeders who rear small, medium to large camel herds. Under this system camels are sent for grazing and are reared on the available rangeland. Everyday camels cover a distance of around 15 to 20 km along the activity of browsing and grazing. The camels in herd are collected in the spring season for hair shearing, treatment against mange, branding etc. The animals are released for free grazing again after above operations. It is usual practice to collect camel herds during the 3 months of the rainy season (July to September) to prevent any type of damage in *Kharif* crops. Most, but not all herders also like to supervise their camels during the breeding season which traditionally falls between the two important festivals of Diwali (around November) and Holi (around March) in order to prevent fights between competing males.

Semi-extensive Management System

This system is practiced around town and villages in the marginal area. Camels are partly offered with traditional local fodders like *Moth Chara* (*Phaseolus aconitifolius*), *Guar phalgathi* (*Cyamopsis tetragonoloba*), as per the availability and prevailing market rates and are partly allowed for grazing and browsing in nearby common grazing land. The recent camel management by *Raikas* is extremely diverse; varying from free ranging for most of the year at one extreme to continuous closely supervised herding at the other. The ecological setting and the degree of competition from other land use strategies determine which particular herding system is adhered to it. Many of the migratory camel herds return at regular intervals to the villages for water, but they can also range several hundred kiolmeters from their owner's home. The Raikas are able to keep track of their movements as they can identify the foot prints of each of their camels in the herd.

Intensive Management System

This system is mainly followed in cities/big towns where camels are used as a source of livelihood by transporting various materials viz: food grains, gas cylinders, building materials, fodder etc. Under this system camels are stall fed exclusively on purchased feed form market. The average daily income in such system is around Rs.500-600 in cities and Rs. 250-300/- in small towns. Some of these camel owners also are engaged in agriculture farming during rainy season (July to October months).

Marketing and Utility Scenario

Domestic aspects

Marketing of camels is an important trade sale/ purchase in arid lands. Many livestock fairs are being held in Rajasthan and Gujarat. The price sale/purchase trend is fluctuating depending on fodder availability and drought conditions. Marketing is linked not only with camel-breeding communities but middleman also.

Economic analysis of bullock and camel power use on farms revealed that maintenance cost of a pair of bullocks on cultivated farm was higher than the cost of a camel. This study also indicated that bullocks and camels both were under-utilized. The average working days/year is less than 163.33 days. Therefore efforts should be made to utilize remaining draught power either in custom hiring service or transport or as animal bio-energy for power generation. Alternatively, this power may be diversified for other non-conventional uses such as grinding and chaffing. The average cost of adult healthy camel now ranges from Rs. 10,000 to Rs. 35,000 depending upon age, sex, and health. Milk, an important camel product can have substantial utility in some of hilly belts and can be source of income in addition to other products like hair, bones, dung and hide in village cottage industry.

Some of families of camel rearing communities keep the lactating animals to provide milk for house-hold needs. It is usual practice that the camel breeding families prefer to sell cow and buffalo milk and use camel milk for them. Camel milk is also gaining some commercial status in Gujarat and parts of Rajasthan where it is sold at the competitive price. Camels could be exploited for augmenting the country's milk production capacity, since milk production potential of camels in India have remained untapped and considering its therapeutic utility. Camel milk is marketed presently by few families but not in any organized system, and it is also utilized by some camel keeper societies for their household consumption. A rough estimate of milk production potential at the rate of about 1,000 liters/year/adult female comes to about 150 million liters/year from the estimated 0.15 million adult female camels in lactation. This milk production can be increased significantly to a higher level through better management, nutrition, and genetic improvement. Camel milk can be an important supplementary milk resource in India for the benefit of increasing human population.

Camel slaughter is banned in India therefore its use as meat animal do not find place in camel development policy.

Long bones of camel are in demand as economic replacement of ivory and many small bone items/ toys are being prepared in village cottage industry. The hair is being utilized for making carpets, daries, bags, blankets, wall hanging etc., by the farmers and also the small-scale industries. Nicely finished camel hair products are quite popular with tourists. Blends of camel hair with silk waste, polyester waste and wool have been experimentally used for making fabrics in collaboration of with the Central Sheep and Wool Research Institute, Avikanagar. The results are very promising and can be additional source of income of camel keepers.

A survey on the use of camel draught power as source of livelihood and their contribution to augment income of family conducted by NRCC, Bikaner revealed that average net income to the camel cart owners ranged from Rs. 6,000 to Rs. 8,000/month/cart and the maintenance cost was estimated to range from Rs. 80 to Rs. 85/day depending upon fodder availability and its rates.

Export Potential

There is also good export potential for race and milk camels. The Jaisalmeri breed has genetic potential to be developed as racing camel thoroughbred strain. The Kachchhi has very good milch potential and Bikaneri breed is one of the finest draught breeds of the world. The items made out of camel hide and bone are very popular with the tourists. Thus, improved camel development programmes are likely to open high export potential for the Indian camel breeders.

A national policy in this respect can prove to be very beneficial for the country considering the multiple utility of camel and its products. India can become one of the major camel and camel by-products exporters and can contribute for future development of this species. The major benefits of a successful programme to improve camel production systems in the country would be of technical as well as socio-economic nature.

Camel Milk products

Functional Food Concept and other Camel Products

Camel milk is also gaining some commercial status in Gujarat and parts of Rajasthan where it is sold at the competitive price. Camels could be exploited for augmenting the country's milk production capacity as a supplementary milk resource in India for the benefit of increasing human population. Since milk production potential of camels in India have remained untapped and considering its therapeutic utility it can fetch good price. Milk can have substantial utility in some of hilly belts and can be source of income. In addition other products like hair, bones, dung, and hide in village cottage industry can be source of supplementary income.

In its nutritive value it may differ in some of the constituents and shelf life but it is rich in vitamin C, some of the micro minerals (copper, zinc and iron), whey proteins and free form of calcium. These properties make camel milk an important health promoter, an animal product having neutraceutical values and it is expected that value added milk products can be formulated in future. Commercial dairies have also been set up at few places. It is now felt that camel milk used for the human consumption will serve as a life support system for the peoples of drought prone arid areas. As a milk animal camel is advantageous because it can produce milk for a longer period, especially it provides milk during dry season.

Camel milk is unique in terms of having low fat (1.5-3%), low protein (2.5%) have longer shelf life, higher ratio of b-casein to k-casein, absence of Lysozyme C and b-lactoglobulin and presence of Whey Acidic Protein and Peptidoglycan Recognition Protein. There are reports on its antibacterial and other therapeutic properties but milestones in this regard are yet to be achieved and research efforts are needed to study the neutraceutical and adjuvant role of camel milk in view of the nutrient compositional uniqueness.

Fresh and fermented camel milk is an important nutritional and functional source has been reported to provide particular health benefits to the consumer depending on the bioactive substances in milk. More extensive research is needed in laboratory animals to confirm these proposed health benefits including its role as a antimicrobial agent or as a protein source for children allergic to bovine milk. Primary structures of peptides formed from camel lactoferrin need be studied and activity of such peptides on inhibition of bacterial growth be tested to get better understanding of the action of lactoferrin in camel milk.

Research in Camel

The National Research Centre on Camel(NRCC) is the premier research centre on camel not only in India, but has also gained prominence as one of the prominent research organisation in the world dedicated to the cause of camel and camel keepers. The contribution of the Centre in conducting, collating and coordinating research on camel has received national and international recognition and it is mandated to fulfil the following research and development needs.

Mandate

- To undertake basic and applied research for improvement of camel;
- To provide leadership and co- ordinate camel research and training nationally and act as a National repository of information; and
- To collaborate with national and international agencies for camel research and development

The National Research Centre on Camel (NRCC), Bikaner was established on 5th July1984 as a Project Directorate. Government of Rajasthan transferred the physical

- Databases on growth, annual hair production, daily milk production, reproduction and mortality (disease wise) have been prepared and updated;
- Characterisation of Bikaneri, Jaisalmeri, Kachchhi, and Mewari breeds using 25 polymorphic microsatellite markers has been completed. Existence of population structure in all four Indian breeds was observed. The Consensus trees have been constructed;
- Breed descriptors of Bikaneri, Jaisalmeri, Kachchhi, and Mewari developed; and
- The Mewari breed has been introduced at the Centre to cater the requirements of the camel owners of the breeding tract and to provide superior studs in future for the genetic improvement in the field.

Camel Nutrition

Achievements

- Nutritional Analysis of locally available camel feeds and fodders done;
- Nutrient requirements for various physiological functions were worked out;
- Camel calves fed on complete feed blocks attained maturity at 3 years of age;
- Breeding male camels during rut period provided complete feed blocks showed higher feed and nutrient intake resulting in less body weight loss;
- Supplementation of urea molasses mineral blocks enhanced growth (269 g/d) of camel calves of 2.5 years of age and it replaced 30% of concentrate mixture;
- Complete ration formulations developed using local feeds;
- Cu and Zn have been found deficient in blood samples of camel in arid zones of Rajasthan;
- Soil has low levels of nitrogen, phosphorus, copper and zinc in all the zones of arid Rajasthan; and
- Cu and Zn were deficient in all the fodder samples analyzed in the arid zone, whereas, Fe was in ample quantity. Ca, P, Mg, Co and Mn levels were in sufficient amount.

Camel health

Achievements

- Field survey conducted for knowing parasitological infestations;
- *Hyalomma dromedary* and *H. anatolicum* were the common tick infestations;
- Broad spectrum anthelmintic evaluated for effectiveness to reduce egg count and better haemato-biochemical parameters;
- Comparative studies on parasitological examination, mouse inoculation test, antibody ELISA and polymerase chain reaction (PCR) for diagnosis of surra infection in camel revealed Polymerase chain reaction (PCR) to be gold standard in detection of cameline surra;
- Anti camel hyperimmune sera have been developed and IgG fraction has been purified through protein –A column. The purified fraction was coupled with peroxidase and FITC for production of conjugates to be used in sero diagnosis and other related purposes;
- Cultural examination and somatic cell count revealed infection of udder with *Staphylococcus, Streptococcus, Corynebacterium* and *Bacillus*.Characterization revealed 10 species of staphylococci viz. *Staph aureus, Staph hyicus, Staph intermedius, Staph haemolyticus, Staph auricularis, Staph sciuri, Staph hominis, Staph epidermidis, Staph capitis, Staph warneri* associated with camel mastitis and

combination of amoxicillin and cloxacillin along with vitamin–E and selenium proved better treatment;

- Nine medicinal herbs revealed broad spectrum antibacterial activity with crude and methanol extract of anar (*Punica granatum*) and pardesi kiker (*Prosopis juliflora*) leaves. Datura, (*Datura metel*) leaves, ashawagandha (*Withania somnifera*) leaves, and garlic (*Allium sativum*) bulb were also found to possess good antibacterial activity, whereas crude juice of peepal exhibited 100 % activity against *E.coli* isolates tested. These plants may be of some value for the treatment of certain infectious diseases, after evaluation of cytotoxicity, storage Stability and excretion of the compounds after degradation or as such from the body;
- Biotyping, ribotyping, resisto typing and pathogenesis study of Salmonella, *E. coli* and *Staphylococcus* have been conducted;
- Epidemiolgical study of sarcoptic mange in camel was conducted and Indigenous herbal preparations comprising of extract of garlic, onion and lemon in combination of camphor and linseed oil in different proportion and combinations were tried against sarcoptic mange. Some of the formulations were found encouraging in terms of both clinico-parasitological recovery and economics of the particular formulation as compared to conventional allopathic preparations;
- The repeated trials on role of raw camel milk as nutritional adjuvant in human tuberculosis and management of type-1 diabetes were undertaken. The positive role of raw camel milk was observed against these diseases;
- Partial sequencing of the haemagglutinin gene of camel pox virus done and submitted.
- Schlafen-like protein gene of camel poxvirus has been cloned, sequenced and the nucleotide sequences submitted;
- The causative agent of contagious ecthyma in Indian camels has been identified is Pseudocowpoxvirus(PCPV);
- First time the complete nucleotide sequence of the envelope gene and topoisomerase gene of PCPV from Indian dromedaries has been done at global level and submitted in the NCBI database (GQ390365, HQ844268);
- First time, the IL-2, IL-4,IL-6,IFN-Gamma and TNF-Alpha genes of dromedarian camels were sequenced at global level and their corresponding accession numbers in the NCBI database are HM051105, HM051106, HM051107, HM051108 and HM051109, respectively;
- Partial sequencing of the cytochrome oxidase gene of *Hyalomma dromedarii* from Indian dromedaries has been done and submitted to the NCBI database (GQ483461); and
- Partial sequencing of the salivary gland protein P-18 gene of *Hyalomma dromedarii* from Indian dromedary has been done and submitted to the NCBI database (HM051110).

Camel Management

Achievements

- In changing agro-ecological condition, the appropriate system of camel management (stall feeding plus 6 to 7 hours of grazing supplement) found beneficial;
- The ethological aspect of 1st order of camel grazing / browsing behavioral preference has been established among trees, bushes and grasses in rangeland area;

- The farming use of camel system is profitable and beneficial over the bullock system for farmers in hot arid region; amd
- Camel carting has been found to be cheapest means for short distance (30-40 km/day) transport.

Future thrust areas of Camel Research through Harnessing Science advancements

In order to reestablish the place of Camels in the arid and semiarid zone of the country NRCC would make efforts for the benefit of farming system prevalent in the region and also improve its utility to human and animals for supporting the health and production aspects. The efforts done would consist of undertaking basic and applied researches on following aspects.

Conservation of camel genetic resources

The different camel genetic resources available in the country will be preserved by maintaining representative stocks *in vitro* and *in vivo*. To establish elite herds of different camel breeds in their respective home tracts so that improved purebred sires can be distributed for local camel breed improvement programme and also purebreds of respective breeds are to be conserved. Immediate attention for Conservation of double-humped (Bactrian) camel is needed as only few hundred animals are available in the country. Different agencies like State Animal Husbadary Departments, SAUs, NGOs, or Breed associations will be contacted for elite gemplasm preservation programme. Similarly for taking advantage of unique characteristics of camel, the work on Evaluation of breed/strains, Molecular genetic studies like marker assisted selection and gene stacking, identification and cloning of gene segments for disease resistance, higher milk production using micro satellite techniques, creation and updating of various data bases and RFLP genes for economic importance in camel will be taken up.

Camel Biotechnology

The proposed work includes Characterization of Toll-like receptors of the dromedary camels with reference to disease resistance and development of new generation vaccine for camel and other livestock, Validation of recombinant cytokines and chemokines, Validation of Heat shock proteins of camel, Exploitation of Single Domain Antibodies from camels to develop diagnostics and therapeutics for human and animals, Functional genomics and proteomics of cells involved in the immune system of camel, Development of diagnostics and new generation vaccine against infectious diseases of camels, Development of vaccines against the vectors infesting the camel, Generation of cell lines of camel origin, Stem cell research, Transgenesis with reference to production of nutraceuticals and pharmaceuticals of human and animal importance, Recombinant milk proteins in camel milk, Animal cloning of camel, Functional pathways involved in the metabolism of macromolecules in camel, Functional genomics and proteomics of secretions and excretions of camel with reference to

mucosal immunity. Research work would be initiated for faster growth, embryo transfer technology, and development of preventive vaccines and immuno-diagnostics against common camel diseases.

Camel Production and Management

Research to develop package of innovations to introduce ideal management practices, for working and breeding camels appropriate to eco-systems and traditions applicable to region for economic and healthy upkeep of camels will be initiated. Study of traditional camel management system and its shifting towards intensive and semi-intensive in light of changing cropping pattern and shrinkage of grazing resource, change in irrigation patterns and its impact on social and economic status of camel-rearing societies will be studied.

Although the camels are adapted to various kind of environmental stress situations like, high temperature and solar radiation and camel makes every attempt to maintain a constant condition of entire body at the cost of the energy available, but it remains a limiting factor for optimum growth performance. The efforts will be made to ascertain adaptability of camels to a modified comfortable but practicable type of micro climate/ shelter and know its effect on production functions as well as on the adaptive physiological functions and also on biological and behavioral responses. The studies on ethological aspects of camel are necessary because camel have to adapt changed effect of climate to maintain better health status. The feeding behavior, neonatal, parturition and rutting behavior would be required to study to formulate scientific package of practice.

Marketing of camels is an important trade sale/ purchase in arid lands and a new avenue for income source. Some camel rearing communities keep lactating animals to meet milk needs for house-hold. It is usual practice that the camel breeding families prefer to sell cow and buffalo milk and use camel milk for them. Camel milk is also gaining some commercial status in Gujarat and parts of Rajasthan where it is sold at the competitive price. Similarly besides traditional products made out of camel hair like carpets, durries, bags, blankets, wall hanging etc., the efforts will be made to have blends of camel hair with silk waste, polyester waste and wool in collaboration with other ICAR institutes to add to income of farmers rearing camels. The emphasis would be on developing perspective and strategic camel improvement policy and to develop some programs related to camel produce and linking its importance through various institutions of the region for future sustenance of camel.

The wide reaching, participatory information and communication technology would be evolved by optimizing print and electronic delivery system and by showcasing the research products in the Museum for effectively linking research accomplishments with camel rearing community.

The major benefits of a successful programme to improve camel production systems in the country would be of technical as well as socio-economic nature.

Camel Nutrition

Camel nutrition remain an important area of attention as the rearing system is changing with loss of grazing grounds and too much restrictions on the movement of grazing animals. Research on capability of camel to survive under stress on coarse fodder under drought and scarcity conditions will be focused. The studies on development of improved nutrition management practices for high yielding dairy camels, Optimization of protein and energy utilization from different feed resources for improving productive and reproductive performance will be initiated. There is need to continue Studies on nutrient requirements for different physiological stages like growth, pregnancy and milk production and to work out feeding standards for camels by utilizing local feed resources for optimum and economical production.

The unique ability of camels to utilize feeds of poor quality need be studied by knowing the rumen kinetics, fermentation pattern with special reference to methane mitigation and isolation of rumen microbes of importance and study their morphological, biochemical, molecular characterization and enzyme profile. By the metagenomic approach the functional metabolism of the nutrients in camel rumen and GI tract in general need proper research attention. In order to develop low cost feed there is need of identification; evaluation and utilization of feed and fodder resources available locally. Detailed studies will be conducted on nutritive values of shrubs, grasses and trees available in the range-land. And with loss of grazing and browsing feeds there is need to identify newer feed resources and integrate these in the complete feeds as TMR or feed blocks or as complete feed pellets so that the feeding of camels become economical and balanced. Research is required to be done to evolve Suitable technologies for improving the utilization of conventional and non-conventional feeds and fodders, Evaluation of toxic/anti-nutritional factors in camel feeds and fodders especially tannins, their metabolism and amelioration with respect to camel feeding and address the problem of Poor growth rate, late maturity and Poor draughtability of camels by Strategic feeding of deficient nutrient supplements, develop appropriate area specific mineral mixture and evaluate under farm and field conditions, use of Probiotics/ prebiotics for enhancing nutrient utilization, Processing poor quality animal feeds from crop residues and waste from food-processing industries.

Camel Physiology and Biochemistry

Camel is known for its established draft in difficult areas of semi arid and arid areas of Rajasthan and its surrounding states since long but its utility as milch animal is being promoted with beneficial features tagged to its milk. Thus camel can be used as a dual purpose animal. The draft power of camel can be harnessed for agricultural operations in small holdings and in those sowed fields where agricultural tools operated by tractors cannot be used. The efforts will be made to exploit animal draft and study work physiology, draught capacity, work-rest cycle and to associate work standards with physical, physiological and biochemical parameters. Suitable selection criteria will be developed for the improvement of work capacity of camels.

The ever growing prices of fuel is also compelling farmer to opt for animal draft power particularly camel who has high endurance power to high temperature (in reference to

changing environment to a warmer side) and scarcity of feed and fodder .The efforts will be made to assess draught ability of camel, energy budgeting and utilization in different spheres of transportation, farm operations and power generation and also to know Physiological and performance adaptability of camel under hot arid environment. Research on suitable, modified camel-drawn implements viz. plough, see-sawing needs to be conducted. This will be very useful to sustain the camel utility for the agriculture workers and to utilize camel energy at its optimum for agricultural operations and short distance transport and camel bioenergy for small scale power generation.

To know the practical ability of camel for various purposes like working efficiency, milk production capacity, performance in terms of physiological and productive functions like growth, reproduction etc based on its body condition, the efforts will be made to derive the body condition scores for Camels and relate it to various functions.

Camel Reproduction

Camel reproduction has inherent peculiarities which in some way are also responsible for the decreased or reverse population growth. These are: Seasonal breeder (traditionally bred in winter- December to March only); Long gestation period (almost 13 months); induced ovulation in females and gelatinous semen (mainly responsible for not yet standardized artificial insemination in this species). These factors are jointly responsible for longer inter-calving period.

The Centre strive to blend ARTs. behavior science and biochemistry to find effective solutions to the above mentioned problems in order to improve reproductive efficiency in camel at farm as well as field level. The ARTs like use of ultrasonography will be used to facilitate unorthodox breeding and artificial insemination. The efforts will be made to find out the relation between reproductive behavior and various physiological events of male and female camel. The modern analytical techniques like GC-MS, SDS-PAGE etc. will be used for identification of phero-communicators in camel reproduction and improvement in AI.

Camel health

Health management of camel need a special attention in the light of calf mortality in young camel calves in the age group of below 1 year due to common but curable diseases which is one of the reasons for reduced camel population. Camel health programme will include epidemiological studies on camel diseases, their diagnosis, prevention, and treatment. Research on development of vaccines against trypanosomiasis, camel-pox, and enterotoxaemia using latest biotechnology techniques will be priority areas. Attempts would be made to develop immuno-diagnostic kits for some important camel diseases. Research investigations on control of skin diseases, abortions and mastitis are some other health problems, which need immediate attention and surveys in the areas will be conducted to know the prevalence and traditional practices followed by the farmers and based on the information available the scientific validation will be undertaken for ethno veterinary products and practices in general and as per need the treatment and diagnosis support services will be offered.

Biological Data Collection

As the scientific database for camel is scanty but information would be unique, it is required to have data generated on hormonal profile during different periods for improving reproductive efficiency, A.I., performance of camel drawn agricultural implements, selection for draught ability and race, evaluation of feeds & fodder and feed requirement and supplementary feed practices in different agro-climatic zones, Biological and physiological adaptation, immunology, economic and effective measures of prophylaxis and treatment including traditional methods.

Animal management data

In the management of the data specifically the information on management of new born calves, care during advance pregnancy and of lactating females, level of supplement and economic feeding during scarcity and droughts and also for improvement in milk production would be of practical significance. Inventory of management practices such as of pasture; length of grazing periods; watering regimes; seasonality of breeding; selection and culling practices for breeding stock; type, amount and timing of take off of products; and traditional application of preventive and curative medicine will be collected and will be made available to farmers through extension services offered by centre may be by local visits, display, demonstrations or by print and electronic media.

Socio-cultural data

There is need to know the Social, cultural and ritual acceptability of camel milk and other products for consumption and/or other uses for societies, groups or individuals within societies. The studies will identify the Social structures conducive to or limiting extension work and dissemination of information. The major over-riding of research would be the identification of socio-economic constraints to resource-poor camel production systems, collection and analysis of socio-economic information dealing with trends in domestic market demands for camel products, prospects for export, producer prices, income analysis within the pastoral sub-sector (including that of other livestock species) and outside the pastoral sector (wage labour or self employment etc.) need significant attention. Also, herd fragmentation, implications of infrastructural advances (roads, vehicles etc.), economics of supplemental feeding in relation to traditional consumption behavior, migration of traditional herders, hired under absentee-ownership regimes are important research topics which require ample attention. Further, the gender implications in camel-oriented production systems need investigation and correlation with other socio-economic variables.

Rangeland management

Being one of the important factors for reduction in Camel population the Surveys will be conducted of traditional land-use patterns as seasonal migration, establishment of reserve grazing areas, harvesting and storage of feeds, and distribution and use of watering points. Studies on carrying capacity of range-land and mineral status of soil and fodders in different zones and forage development programme of traditional bushes where normally camels browse will be conducted. Information would also be obtained on the use of rangeland improvement techniques like burning, deferred

grazing, rotational /sequential grazing of different livestock species, control of stocking density and grazing pressure, and oversowing or re-seeding. Factors conducive to or limiting improvements in range management, i.e. land tenure, grazing rights, water rights and actual population densities, are essential by active involvement of state forest department will also be studied.

Research on Camel milk, value added milk products and other products

Various value added camel milk products have been developed and evaluated. Keeping the nutritive value of camel milk, the work on Characterization of bioactive compounds from camel milk will be initiated to amplify and clone the milk protein genes of the Dromedary camel, to develop the recombinant camel milk proteins through the expression of the milk protein gene(s) in a suitable system and evaluate the biological activities of the recombinant camel milk proteins in a laboratory animal model to provide a potential treatment for a series of diseases such as dropsy, jaundice, tuberculosis, asthma, and leishmaniasis or kala-azar and also for the metabolic diseases like hypertension, diabetes and Coronary Heart disease (CHD).

There is need to initiate marketing of these products and specialized items for developing sustainable market, packaging of camel milk and its products. Efforts will be made to coordinate the marketing activity with local and state government agencies including state cooperatives to undertake marketing of the camel milk products at local and regional level to generate consumer base. Research should be undertaken for improvement and marketing of various products, milk, skin cream, hair, manure, bone and hide products. There is immediate need to explore and promote sale of value added camel milk products, milk, hair, and hair blend items. Areas and agencies are to be identified. Present trends in domestic market and demands are to be surveyed. The involvement of family members in village cottage industry will be studied. Research efforts may be initiated on meat and its quality especially in view of illegal slaughter of camels and to detect camel meat at different sale points either alone or mixed with meat from other animals.

Human Resource development, extension, and training

At present there are no courses or specialized training programmes available at the agricultural universities where degree/diploma is awarded in camel management and health. The NRCC is conducting a short course of only 1 to 2 week duration and some specialized training programme, and providing research facilities to PG and Ph.D. students. However, taking into account future needs of human resource development it is essential to formulate future programmes like training and extension programme so that competence of local staff is generated in a manner that at least "3-tier system" of researchers are available in each discipline for camel research, development and training of field veterinarians on camel production and management .There is a need to initiate post-graduate diploma courses in camel diagnostics, camel health and camel biotechnology.

Conclusion

India holds a sizeable camel population however in the last decade there has been drastic reduction in the numbers for the reasons well known. In order to regain the status of camel production system for the people of arid and semiarid areas as a source of economic sustenance, the efforts have been made to put the camels for alternate uses like milk production, energy generation and develop it as a species to contribute to human health. The programmes envisioned in the future aims for basic and applied studies in all aspects of Camel production system which needs coordinated efforts from various agencies involved in Camel research and development. The activities proposed for the next plan period 2012-17 encompasses all the aspects of research and development involving all the kinds of collaborative and network programmes.

The Situation of Camel Population in the Kingdom of Saudi Arabia

Mahmoud Abdel Aziz
King Faisal University, Saudi Arabia

Background

Camels hold an important position in the Kingdom of Saudi Arabia. They supply meat, milk, fiber and energy to many people living in the Kingdom. However, the potential of camel is generally underestimated, due to its nature as a nomadic animal living most of the time roaming in remote areas such as deserts. Therefore, its accessibility is difficult. At the present time, there are no up to date and accurate descriptive statistics of the real number and the productive status of the entire population of camels in KSA. If we really want to exploit the potentiality of this victim species, research plans must be designed under the framework of three main aspects underlying the importance of this animal, as a biological model, as a productive animal supplying food to many people and as an element of the arid ecosystem, contributing to desertification combat and food security. There should be a high interest in the camel for the promotion of desert productivity and preservation, and this step must be taken seriously.

Camel Production System

Nomadism is an ancient and relatively static subsistence strategy in Saudi Arabia, (Cole, 1975). However, seasonal and tribal movement patterns of traditional nomadism and transhumance have been changed. In recent years, significant changes in the mode of livestock production in KSA have taken place, including increased availability and utilization of crop residues, supplementary animal feeds, mechanized pastoralism, and introduction of modern production units (Bourn, 2003). With the transportation of animal feed supplies and water tank trailers, pastoral livestock production is no longer dependent on rainfall and range conditions as it used to be. Traditional seasonal patterns of movement to and from specific areas are no longer followed and have been replaced by more erratic and opportunistic movements to areas with seasonal crop residues and natural pasture, and where water and supplementary feed can be supplied. The country has made vehicles available at subsidized rates to pastoralists to assist with animal transport, and it seems likely this pattern will be more and more frequent; especially as the problem of controlling animals in increasingly densely settled environments may get worse. Attempts to settle the pastoralists in the country go back to 1910, when King Abdul Aziz moved Bedouin into what is called Hijra schemes. These centers grew until 1929, when a revolt destroyed them and they have completely reverted to herding settlements by the 1950s, (Chatty, 1990).

The major farming system in Saudi Arabia is the sparse, arid system, characterized by very arid rangelands where livestock are kept by nomadic pastoralists on annual

Abbas, et al., (2000) gave a crude mortality rate of 17% in Saudi camels. The highest mortality rate was observed in the 0-1 year-old camels, mainly as a result of camel calf diarrhea, pox, ecthyma and starvation due to orphanage or dam rejection. Another peak of mortality rate of 9% was noticed in the 2-3 year-old females, particularly in the larger herds. Mortality causes included pox outbreaks, trypanosomosis, pneumonia and gastroenteritis. They observed that the main causes of death in older camels were pneumonia, trypanosomosis, snakebites, traffic accidents, pox, fractures, dystocia and poisoning due to accidental pesticide exposure. Al-Mutairi (1999) recorded lower mortality rate of 13.7% among Saudi camel calves between birth and three years of age. Agab (2002) gave a crude mortality rate of 7.4%. The most common causes of mortality recorded in his study were "Heyam" syndrome (53.3%), Diazinon toxicity (15%), snake bites (10%), calf diarrhea (8.9%), undiagnosed cases (5%), bone fractures (3.3%), urea intoxication (2.8%), uterine prolapse (1.1%) and dystochias (0.6%).

Issues of Production Systems

Majority of camel herders inherit this profession from their ancestors of subsistence economy. Though they are well versed with camel raising yet their indigenous camel production systems need up-gradation based on modern animal husbandry practices, keeping in view a shift from subsistence level to commercial camel production. The production systems of these households can vary at least in the following important ways: herd composition, herd size, degree of nomad involvement in agriculture, household size, and degree of entry into the national wage-labor economy. As a result, it must be emphasized that the overriding characteristic of households exploiting range resources in the Arabian Peninsula is organizational flexibility. Little is known about the specifics of Saudi Arabia's Bedouin households. For example, little is known about the impact of market oriented herding on the size of and labor requirements within the household. It is known that camels are sometimes sold in urban markets. In addition, it appears likely that most Arabian sheep herders are market oriented, but what influence this has on family structure is unclear. Nevertheless, the meager sources suggest that in both the small stock and camel situation, herds are owned and are the responsibility of individual households even though small groups of households may coordinate their grazing schedules.

Breeding and Selection

The small number of stud breeders makes the implementation of an effective national breeding policy virtually impossible. Another major threat is the uncontrolled mating of disseminated stock, if any. Even, the disseminating stock is not genetically proved. A characterization and performance evaluation of the population is still missing or incomplete. In addition, there are other points such as: lack of national breeding policies, insufficient in-situ conservation plan for genetic resources, lack of well-defined breeding strategies, lack of continuity of breeding programs, insufficient support of relevant research and training activities, insufficient number of qualified animal breeders available, non-existent of livestock improvement programs, lack of performance recording schemes, non-existent of organization of animal breeders,

unavailability of communication, transport and computation facilities, ineffective sire exchange and artificial insemination programs, small herd sizes and unreliable animal identification, genotype environment interactions often neglected, long generation intervals through extended and late maturing animals, no performance testing, low accuracy of the estimated genetic parameters due to small active breeding population.

Management

No definite policies can be inferred for managing the different herds or managing camel genetic resources all over the country. This, in turn, has great impact on the production system as a whole. As an example, reproduction problems can be solved simply by practicing a proper management regime. Calving interval of she-camel is unnecessarily long and this can be improved by competent management through heat control combined with early pregnancy testing. Specifically, the primitive approach of camel management in all three production systems (i.e. nomadic, sedentary and transhumant) manifested in the general poor feeding of animals, hence slow growth rate, delayed maturity, long calving interval, low calving rates and high disease incidence are common constraints on camel productivity.

- **Feed Resources:** Feedstuffs are always in short supply, especially during summer season. Two problems are associated, seasonal variation and low quality of feeds in the existing systems;
- **Financial Resources:** Projects developed to improve camel production fall short of funds;
- **Socio-Economic Implications:** The majority of camel herders are illiterate. Pastoralism is an ancient form of animal production often complemented with other activities such as crop production or practiced alone without any supportive activity, (Allen, 1965). The remoteness of the areas occupied by pastoralists as well as their continuous mobility has endowed pastoralists with a high degree of self-reliance and conservatism (Cloudsley-Thompson, 1977; Gauthier-Pilters and Dagg, 1981). These factors must be borne in mind when designing or implementing research and development activities targeted towards pastoralists. Many development ventures have failed because the concerned or target population was not specially addressed and its actual needs as well as technological potentials were not tapped (McCorkle, 1986; Hogg, 1990);
- **Marketing Concerns:** There are many problems associated with marketing of camel milk and meat. In addition, market prices for the animal products are low and no government control on market operations;
- **Disease Problem:** High incidence of parasitic as well as infectious diseases in camel herds are a serious concern;
- **Veterinary Extension:** The majority of camel herders are using traditional medicine for sick animals. Abbas, et al. (2002) reported that traditional healers have extensive knowledge on camel husbandry and physiology and camel diseases. They further stated that ethno-veterinary medicine still played an important role by providing a viable service to a large base of clients. It is thus envisaged that ethno-veterinarians should be the focus for developments targeting animal breeders in rural areas. This should enhance the principle of techno-blending, a factor necessary for sustainable development;

- **Policy Implications:** The livestock sub-sector has traditionally been given low priority within the agriculture sector. And under the livestock sub-sector, the camel had been a victim of neglect by both research and development functionaries;
- **Technological Deficiency:** There is severe deficiency of camel specific and appropriate technological packages for camel herders to construct a track for camel development;
- **Gender Issues:** Women are rarely involved in marketing of camels and their products and are mostly not consulted for decision making. Majority of women are unaware of the concept of development and an increase in number of animals is development for them;
- **Machinery Threats:** Camel has lost its traditional draft value mainly against machinery and tractors. Under this scenario, the traditional camel production systems may not sustain too long; and
- **Drifting of Production Systems:** The three traditional classes of pastoralists (i.e. nomad, sedentary and transhumant) have been subject to transformation in one or other way. Nomads are found highly vulnerable to external forces.

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Camel Research and Development in the Sultante of Oman

Osman Mahgoub and Isam T. Kadim
Animal and Veterinary Sciences, College of Agricultural and Marine Sciences
Sultan Qaboos University, Sultanate of Oman

Introduction

In many parts of the world, the camel has helped many human societies for sustainance and survival over centuries. However, the camel is currently facing a diallemma as it is loosing its signficance as a sign of prestige and as a draft, transport, and producing animal. It has been replaced by motorized vehicles in many countries. Camel products of milk and meat are not as widely used as it used to be even in traditional camel rearing countries due to a marked change in culture and eating habits of many societies. Being capable of producing high value food under harsh environment and from meager resources, the camel is capable of significantly contributing to the wellbeing of its owners and the national economy in many countries especially under the current conditions of global climate changes and economic uncertainties.

The camel has also been accused of causing signficant damage to the environment. In several countires the camel has been singled out as a major cause of overgrazing resulting in desertification.These attitudes are widely spread around the globe which make it difficult to defend the camel espeically with its production contributions and potential being ambiguous and with lack of influencial supporting groups.

A major issue that affects camel is that it is widley regarded as the "Nomad's animal" and consequeqently, it is anticipated to be reared by a primitive, low income sector of the society. This resulted in the camel being relatively insignificant and less defendable due to lack of lobbying groups in many countries. This affected decisions and policies meant for devleopment and management of the camel sector. It is important that issues pertaining to camel development should always be addressed within the socio-cultural and economic aspect of society setup.

Research at various levels would help to suport the camel cause for survival and appreciation. The camel is mostly important in countires characteized by underdevelopment and low income. Consequently, research *per se*, and that on camels in particular, is not well established due to lack of well-trained scientists and ample funding. The bulk of resarch on the species is made up of early studies on the anantomy and physiolgy of the animal. It was concentrating on certain aspects of the uniqueness physiological abilities of withstanding harsh environmental conditions such

as high termparatures and water scarcity. Very limited research had been carried out on improving the camel's abilities to produce high quality products that would compete with other products in the well-organized, higly-competitive interernational markets.

This paper discusses the current global situation of the camel with speical reference to Oman and outlines opportunites and strategies to improve its utilization for the welfare of the country at large and camel owners in particular.

Global Economic Status of Camel

To be able to appreciate the camel status in Oman, it is important to understand the global issues of importance to the camel. These include camel populatoin and camel production and products. This will be discussed in comparison with that of other livestock.

Camel population

They are not many trustworthy recent statistics for the camel in the world except those provided by the FAO (FAOSTAT, 2011) which are mainly estimations. However, some conlcusions will be drawn from these statistics to throw light on the camel status in Oman in relation to the world. The camel population in the world is very low compared to other farm animals. In 2009, there were 25,385,468 camels in the world compared to 1,382,241,378 cattle, 1,071,274,348 sheep, 867,968,573 goats, and 941,212,507 pigs (FAOSTAT, 2011). The majority of the camels in the world are one-humped Arabian or dromedary camels with about 84% of them in Africa and the rest in Asia with minimal camel population in other continents. The overwhemling majority of camel population (Table 1) is found in countries with common characteristic economic features as rated by the Food and Agriculture Organization of the United Nations (FAO) recently. These features are:

- Net food improting developing countries;
- Low income food deficit countries; and
- Least developing countires.

The majortiy of camels in the world are found in arid and semi-arid regions, which are continously subjected to harsh environmental conditions including frequent draughts and desrtsification. Several countries in these regions also suffer from political unrest as well as being influenced by the current economic crisis. Another important factor that affects the camel survial and exploitation is that its centuries-old production systems are now regarded as primitive and conflicting with development plans such as large-scale farming. The camel sector also suffers from rivalary between the camel-keeping societies and other communities with conflict inerests such as sedentary farmers as well as competition with fellow tradtional communities which keeps other livestock types specifically cattle. All these factors influence attitudes towards the

species and policies on the camel. Development and research plans should consider these factors.

Interestingly, the vast majority of camels in the world are found in "net importing countries with food defict". This implies that the camel is not fully exploited in these countries to bridge this food deficit. Devleopment and research should aim at exploiting camels more towards satisfying local markets as apparently there are plenty opportunities. More work is needed for promoting the camel as an animal with great potential for producing high quality safe products, which may replace expensive imported foodstuffs.

Plenty of work is needed in extension within camel raising communities and the society to change the negative picture of the camel and its products. Governmetnal bodies as well as non-governmental bodies should be involved. Specialists of concern including animal scientists, veterinarians, socio-economists, and politicians should be involved. The aim of camel development should not be only increasing camel numbers, but balancing offtake with increasing numbers so as not to put pressure on natural resources, providing regular supply of camels for local and export markets and providing jobs for all segments of the community.

Table 1: Camel numbers in the world (FAOSTAT, 2011)

Region/country	Camel numbers
World	25,893,855
Net Food Importing Developing Countries	23,198,782
Low Income Food Deficit Countries	24,077,008
Least Developed Countries	20,614,457
Africa	21,853,999
Eastern Africa	10,755,784
Middle Africa	1,391,050
Northern Africa	5,368,000
Southern Africa	75
Western Africa	4,339,090
Asia	4,032,834
Central Asia	287788
Eastern Asia	517050
Southern Asia	1,931,000
Western Asia	1,296,996
Europe	7,022

Table 2 shows the major countries with camel population in the world. More than half of the world dromedary population is shared between Somalia, Sudan, and Ethiopia. These countries carry the previoiusly mentioned economic characteristics of low development and food deficit. However, these countries have a favourable strategic geographical position as they are within a close range of the Arabian Gulf states especially Saudi Arabia, which are signficant, markets for live camels especially during Hajj times. It should be taken into consideration that these markets are now applying stringent regulations on animal health and disease control as well as expectations of a high quality product. For instance, outbreaks of epedimics in Africa such as the Rift Valey Fever led to a halt in live animal exports to these countries in the past few years. Camel research and development plans in East African countries should aim for improving camel health and body conditions especially prior to export. Improvement and diversification of camel products especially meat should be of a high priority.

Tabel 2: Countries with highest camel population in the world (FAOSTAT, 2011)

Country	Camel numbers
Somalia	7,000,000
Sudan	4,521,000
Ethiopia	2,400,000
Niger	1,654,380
Mauritania	1,495,000
Chad	1,391,050
Mali	1,150,000
Pakistan	957,000
Kenya	947,200
India	632,000
Yemen	383,533
United Arab Emirates	380,000
Eritrea	338,584
Algeria	295,000
Saudi Arabia	260,000
China	240,000
Tunisia	235,000
Iran (Islamic Republic of)	152,000
Kazakhstan	148,300
Oman	127,000

Importance of camels in Oman

Oman camel population was estimated at 127,000 heads in 2009 (FAOSTAT, 2011), most of which is found in the southrern region (Dhofar). Other significant numbers are found in the eastern region (Sharqiyah), Batina and Dhahira. The major activity for camel herders in the latter regions is racing camels. They keep small herds of well-

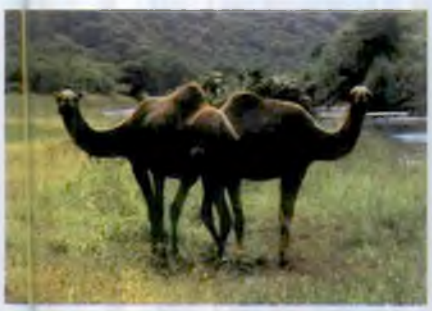
known pedigree racing camels. Owners know camel breeds very well and travel for long distances to serve female camels with renowned sires. The Royal Camels Corps of Royal Diwan Court offer free breeding services to camel herders. However, some of them travel to neighbouring countries such as UAE for breeding their camels.

Racing camel owners has deviced a certain protocol for managing their camels, which they believe, is effective in winning races. They feed their camels on alfalfa, barley grain, dates and supply it with special diet items including honey, ghee, and milk. They use supplementary mineral and vitamin mixtures. Owners are very meticulous with parasitic infestation control especially ticks. They are particularly aware of dangers of trypanosomiasis where they use trypanocidal drugs for prophylaxis.

Racing camel industry is booming with the major market being neighbouring UAE. Camel racing fans from UAE regularly visit Oman looking for excellent racing camels and they pay a premium for such animals. Parallal industries of the racing camel such as animal feed and health care products have flourished.

Dhofar region is characterized by monsoon showers, which extend over the period between June and September and produce lush grazing pastures, which could support camels plus other livestock espeically cattle and goats during this period and few weeks thereafter. However, after the rainy season, livestock in this region are subjected to undernutrition and camel owners become under a lot of economic pressures with the majority of them being illiterate and not finantially capable. Consequently, camel owners expect signficant support from the government in the form of subsidies and purchase of stock. Camels are mainly owned by the Jablai tribes but camel herding frequently extends to the mountains in the desert to the north. Camels in this region are used mainly for milk production and some are slaughered on irregular basis for meat. Some young camels are exported to UAE for slaughtering.

The camel sector in Oman in general and the southern part in particular suffers from underdevelopment and lack of appreciation. Additionally there is a very negative attitude towards the camel. This resulted in serious govenmental policies that aimed at reducing camel numbers. However, there is now some encouragement for local camel keepers in the form of annual competition for she-camels with high milk produciton organized by the Diwan Royal Court in the desert areas north of Salalah. This led to improvement of camel breeds for milk production. Some camels are reported to produce more than 30 liters a day, which indicates a good potential for milk production in Dhofari camels.



a) During monsoon season cmaels graze lush green grasses (photo: Family Bookshop, Oman)

b) Same area during the dry season (practically nothing to graze)

Figure 1. Omani camels grazing natural rangeland during the mosoon and the dry season in Dhofar

Camel products

The major products of the camel are meat and milk as the role of the camel as working animal has declined. Meat surpasses milk in importance, as almost all camels can produce meat including those that serve a full-time career in work or racing. In 2009, about 32,000 camel heads were slaughtered in the world, yieleding 360,623 tons of meat (FAOSTAT, 2011). The camel contributions are neglibile to the global meat market compared to other animal species (Table 3). The total camel meat production amounts to 0.13% of total global meat production (283,887,210 tonnes). This is extremely low comapred to swine, poultry, cattle, sheep and goats, respectivley (FAOSTAT, 2011). Another factor that affects the camel's contributions to the world meat market is that its products are by far less developed and diversified in quality comapred to those from othec livestock.

Table 3: Global meat and milk production (tons) of farm animal species in 2009 (source: FAOSTAT, 2011)

Item	Tones	% of total
Meat:		
Total meat	283,887,210	
Camel meat	360,623	0.13
Cattle meat	62,836,983	22.13
Sheep meat	8,240,030	2.90
Goat meat	4,996,242	1.76
Poultry meat	91,982,140	32.40
Pig meat	106,326,306	37.45
Milk:		
Total milk	702137429	
Cow milk, whole, fresh	583,401,740	83.09
Camel milk, whole, fresh	1,840,203	0.26
Sheep milk, whole, fresh	9,246,922	1.32
Goat milk, whole, fresh	15,510,416	2.21

and paseurization of small quantities of milk would be a good solution for camel milk marketing. A good example of this sort of excerise is practised in the camel-rearing areas of Kenya (Garissa region) with local camel milk market has been organized. This could be in the form of farmer's cooperatives that may be developed with assistance of an organization such as Camel Herders Society. Such a cooperative would be able to device a system of milk collection from various parts of the mountains and delivery to a medium-size dairy processing plant. For instance, there are some dairies in the Gulf Region such as in Dubai and Al-Ain in UAE where are plants to process milk produced from hundreds of camels. Marketing may be enhanced by producing various camel milk products such as laban, youghort, and flavoured milk.

Some camel meat is sold as grilled or roasted to tourists. The locals also prepare a local food from camel meat cooked in camel fat known as "Maajeen". It is well liked by the Dhofari community. A commercial processing of such a type of food as well as dried camel meat may be explored.

Figure 1: Omani camels in Dhofar used for milk production

Research on Camel in Oman

Traditionally, camels are raised in most of the camel-raising countries on the scarcest resources. This might be the reason that their true performance and potential for production has not been exploited. Improving the environment, health, management and nutrition of the camel under intensive or semi-intensive systems would be expected to result in a marked improvement in its performance. Very little research had been carried out to evaluate the performance of camels under traditional extensive as well as intensive systems. The major factors that govern camel production are age and availability of feed required to satisfy camel needs for maintenance and production. Camel meat has been discriminated against as it usually comes from old animals. Work at Sultan Qaboos University (Kadim et al., 2006) indicated that 1-2 years is the optimum age for slaughtering camels to produce high quality carcasses with very tender meat. However, slaughtering animals at this age would result in light carcasses, which may reduce revenue. Therefore, markets should be well studied and camel production should be directed towards these markets. For instance, Gulf market require

small tender camel carcass whereas camel meat processing would require large amounts of meat that may be of older camels with higher dressing.

Generally there are some are research lagging behind in the camel. For instance, research on the nutritional aspects of the camel is needed to cover areas of nutritional requirements of the camel under extensive and intensive management. Until now, nutritional aspects of camels are mostly postulated from cattle for requirements and rumen digestion. Research on camel nutrition should also cover the area of identifying non-conventional feeds to reduce pressure on the environment and support camel feedlot systems. Camels had been branded as a major cause of overgrazing leading to desertification in many parts of the world. Finding other feed options would help in reducing such misconcepts. There was an attempt in Oman to produce a "Camel Complete Diet" from various feed ingredients to feed to camels during the dry season in Dhofar.

Few studies were carried out on camels under traditional systems in Oman. These include a study on Omani camel calves in a traditional management system (Musa et al., 2004). A survey on local camel traditional management systems had been carried out (Amal Al-Kharousi, personal communication). This would help studying the social and economic aspects of camel production in the sultanate. A survey on meat acceptance and preference including camel meat had been carried out (Kadim et al., 2004). This survey is important for studying attitudes of consumers towards camel meat, which would help in improving marketing of camel meat in the local market.

Basic research on the camel anatomy and physiology had been carried out in Oman. An example is the study of the anatomy and histology of the reproductive tract of the female Arabian camel (Srikumar et al., 2003). Such studies are important, as one of the important issues in camel production is its low reproductive efficiency compared to other livestock. Other studies were carried out for determination of normal values of hematology and serum mineral contents of the Omani racing Arabian camels (Elthahir 2010). These studies are important in setting normal values for Omani animals as it had been recommended that various laboratories should define normal values for local animals for use of clinicians and scientists. A study on camel esonophils had been carried out on Omani camels (Johnson et al., 1999) and yielded interesting findings on the unique aspects of the species. A paper on camelidae genetic resources had been presented in an international meeting (Kadim et al., 2004). Currently, there are preparations to launch a project by the Royal Diwan Court to study the genetic aspects of Omani camels using molecular markers as well as defining phenotypic characteristics of Omani camels.

Some studies have been carried out in Oman to evaluate the meat production capabilities of the camel under intensive systems. A research program has been carried out at Sultan Qaboos University studying camel performance under controlled environment or intensive management (Mahgoub et al., 2010, 2011). The aim was to improve camel performance and carcass quality to produce meat of high quality suitable for the supermarket industry. An experiment was carried out to study the effect

of level of nutrition on camel performance and carcass characteristics. Omani male camels were fed a concentrate and Rhodesgrass hay diet. The concentrate was provided by Oman Livestock Development Company. It was meant to provide "complete" diet for camel sustainance during the long dry season in Dhofar (Table 4). Camels were randomly allocated into three groups and received a feed intake equivalent to 1.5, 2.0 and 2.5% of body weight, respectively with 60:40 concentrate:hay ratio for 5 month. Camels were slaughtered and data on carcass and non-carcass components were collected and pooled. The study findings indicated that camels may be raised under feedlot systems and produce excellent carcasses with high meat quality as good as beef. Camel meat also contained less fat which makes it a good choice of health conscience customers.

Table 4. Composition of the concentrate feed as given by producing company (National Livestock Development Company; Sultanate of Oman)

Specification	Level	Unit
Moisture (maximum)	12.5	%
Crude Protein (minimum)	14	%
Crude Fat (minimum)	2	%
Crude Fiber (minimum)	12	%
Acid Insoluble Ash (maximum)	8	%
Calcium (minimum)	0.7	%
Phosphorus (minimum)	0.5	%
Vitamin A	5000	IU
Vitamin D3	500	IU
Vitamin E	20	Mg
Metabolizable Energy (Minimum)	10	MJ/kg

The performance of Omani camels fed the "Complete Diet" is given in Table 5. This clealry showed that improvement of camel management would result in improved performance.

Experimenal animals did not show ill health signs under intensive management. Housing was designed as a simple enclosure built from cheap material. Feed and water troughs were provided. A scale is important to monitor growth of the camels throughout the growth period. Such feedlot experimental work may be adopted on commercial levels for finishing range fed Omani camel calves for niche markets in the gulf countries and local markets where tender camel meat is a delicacy.

Evaluatoin of camel meat composition was carried out by determining the proximate, amino acid, fatty acid, and mineral composition of fresh and cooked camel meat (Kadim et al., 2011). Effects of age on fatty acid composition of the hump and abdominal depot fats of the camel were studied (Kadim et al., 2002). Quality characteristics and nutritive value of camel meat including tenderness, color, cooking loss, water holding capacity, sarcomere length etc. were evaluated by Kadim et al., 2006,2009a,b,c, 2008a). Effect of age and storage on meat quality was studied (Kadim et

al., 2006, 2007). Effect of Electrical Stimulation and age on muscle structure and meat quality of camel as well as comparatieve studies with beef had been carried out (Kadim et al., 2009a,c). Effect of low voltage electrical stimulation and splitting carcass on histochemical and meat quality characteristics of the camel muscle was also investigated (Kadime et al., 2009b).

Table 5. Body weight growth parameters, feed intake and feed conversion in Omani camels maintained on three levels of feed intake

Parameter	Experimental Group						Treatment effect
	Low		Medium		High		
	Mean	SE	Mean	SE	Mean	SE	
Average daily concentrate intake (kg)	1.451	0.228	2.520	0.198	3.487	0.198	***
Average daily hay intake (kg)	1.071	0.077	1.712	0.066	1.670	0.066	***
Average daily total intake (kg)	2.522	0.263	4.232	0.227	5.157	0.227	***
Total feed Intake (kg)	408.5	42.53	685.6	36.83	835.46	36.83	**
Intake/BW (%)	1.20	0.004	1.84	0.003	2.19	0.003	***
Initial BW (kg)	204.0	17.021	202.8	14.74	203.75	14.74	NS
Final BW (kg)	228.0	22.600	259.0	15.98	268.50	15.98	NS
Total BW gain (kg)	11.50	6.000	56.25	4.243	64.50	4.243	**
Average daily gain (g/d)	71	37.0	347	26.2	400.0	26.2	**
Feed conversion ratio	35.48	0.590	12.21	0.590	12.96	0.590	*

Many publications had been produced from Sultan Qaboos University camel meat group. These were published in major journals such as Meat Science, Animal Feed Science and Technology and Jorunal of Food Science. An extensive review of the growth and carcass and meat quality characteristics of the one-humped camel had been compliled and published in the Meat Science journal (Kadim et al., 2008b).

Future aspects of research on camel were planned. Effect of ageing on camel meat quality parameters using proteomics is ongoing peoject with an investigation of using camel meat as a medicine by dicover specific chemicals.

There is an ongoing project to study milk quality and milk products from Omani camel with United Arab Emirates University. This entails studying the characteristics of camel milk as well as using it for producing dairy products (Dr Ahmed Al-Alawi, personal communication)

The racing camel industry in Oman, in particular, and the Gulf in general relies on what is perceived as the best protocol for management and nutrition of the camel. That entails a rigorous program of feeding and exercise. The racing camel is fed the most unorthodox feed for a ruminant or pseudo ruminant animal. These feeds contain a limited amount of barley, honey, ghee, milk and other performance boosting substances. Feeding the camel on such items should disturb the functions of its rumen. A very strong reserch progam had been carried out in the Diwan Royal Court and Royal Court Affairs on camel reproduction. The objectives include camel semen collection and preservation, artificial insemination of camels and embryo sexing.

There is some research activity on camel health in the Ministry of Agriculture and Fisheries mainly involving surveillance of important diseases and parasites. This includes goiter (M.H. Tageldin, personal communication), brucellosis (El Taher, 2011; Al-Ismaily, 1988), and rabies. Surveys of parasites including internal (theirleriasis, trypanosomiasis and hydatids) and external parasites had been carried out (Idris et al., 1999). The MAF laboratory in Salalah is doing work with internal and external parasites. A survey on tick distribution in Oman was carried out (Dr Akin Bobade, personal communication). That included surveying of camel ticks in the Dhofar regions, the major region of camel breeding in Oman.

Development of the Camel Sector

This applies to Oman as well as other camel countries around the world. Development of the camel sector should entail two aspects, the traditional sector of camel production and the improved systems. It should also consider improvement and marketing of camel products to enable the camel to compete with other meat-producing animals. The traditional sector needs significant improvement and development of infrastructure, animal health, and marketing of live camels.

Nutritional limitations remain the major constraint of camel production. Camels are still raised under extensive systems based on range grazing. The quality and quantity of range is progressively deteriorating. Therefore, camel management systems should take into consideration supplementary feeding. Although this would increase, the cost but it will improve the quality of camel products. Use of agricultural by-products may help to reduce cost. One approach is to raise camels under traditional systems till weaning. Subsequently camels would be transferred to areas with more feeds availability to finish them on higher levels of nutrition before slaughtering or exporting. This may be applied in countries like Ethiopia, Somalia, and Sudan, which are within a close proximity of important markets. The Omani market could benefit from such an approach. Camels may be raised till weaning in Dhofar then brought to the Batina region which has considerable forage cultivation to be finished and marketed in the close-by UAE or Saudi markets. However, a lot of work is needed to be carried out on marketing of camel products.

Figure 3: Omani camels under intensive management. This will improve performance and quality of product. Note the improved simple housing.

Figure 4: Excellent carcasses of Omani camels raised under improved management

Parallel facilities for transporting, unloading, slaughtering, and processing of camel carcass are needed. Therefore, modern camel slaughterhouses are needed with special design and facilities (Figure 4). This should be taken into consideration when exporting camel meat products are needed.

Important findings from SQU research work

Optimal age of came at slaughter

The optimum age of camel at slaughter is a very important issue. Usually camels are slaughtered at old age after they finish their productive life. This led to an impression that camel meat is tough and less acceptable than other red meats. Studies at Sultan

Qaboos Unveristy indicated that the optimum age for slaughter camels is below 3 years. At this age, camel meat quality is comparable to that of beef.

Meat pH

This was determined over the ageing period as well as an ultimate pH. It is an important aspect for meat quality determination as it affects meat color, tenderness, as well as cooking loss. Young animals will produce tender meat but their meat will have high pH due to the low glycogen in the muscles. Consequently, meat may be less attractive due to dark color.

Ageing

One of the experimental approaches adopted at SQU was ageing of camel meat. Several studies were carried out and it was found that ageing of camel meat for 7 days at 3-4°C improved camel meat quality characteristics. This simple approach is affordable by camel meat producers and does not require a lot of technical know how. It is recommended that this approach be adopted on a wide scale in the camel meat industry.

Electrical stimulation

Electrical stimulation is a technique that has been employed in improving meat quality of beef and mutton and at lower scale in goat. Low voltage stimulation significantly improved meat quality characteristics in camel meat. The technology is simple and commercial gear is available from New Zealand and Australia. It is recommended to be adopted in camel slaughterhouses to improve camel meat quality.

Effect of carcass splitting

Carcass is routinely split in abbatoirs. The effect of splitting was studied in the camel carcasses. There was no effect of splitting and stimulation on meat quality neither alone nor with electrical stimulation.

Effect of cooking

Effect of cooking on camel meat was studied including using different methods and different cooking temperature in comparison with other meat types. Cooking significantly affected mineral content but not protein or lipids in camel meat.

Carcass fat

Intermuscular fat content was lower in camel carcasses than beef and mutton. Levels of polyunsaturated fatty acids were relatively higher in camel muscle than beef. These characteristics are important from a human nutrition point of view. It should be used for probagation of camel meat as a healthy product.

Muscle fiber types

A study was carried out to investigate the histological structure of camel muscle and the different fiber types. It was found out that camel msucle types were similar to those of beef.

Individual muscles

Variation in meat quality and histochemical properties were studied between six individual muscles. Signficant differences were found. This aspect should be taken into consideration in marketing camel meat.

Conclusions

The development of the camel sector should take into consideration important issues such as: camel would be a useful factor in local development and export market; basic and applied research on the camel production capabilities and requirements; improvement of the quality of camel products; enhancing marketability of camel products; parallel improvement of the socio-economic conditions of camel owners; involvement of the local communities in development plans. Being capable of producing high value food under harsh environment and meager resources, the camel is capable of significantly contribute to the wellbeing of its owners and the national economy especially under the current conditions of global climate changes and economic uncertainties.

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common. Grazing on natural rangeland is the main source of camel feed, which is overgrazed and deteriorated in most cases, and no supplementary feed is provided. Apart from high temperature there is usually water scarcity in the areas where camels are reared which puts the animal in a much-stressed condition. In Addition, there are a number of infectious diseases coupled with various external and internal parasites that cause the additional stresses to the camels. Thus, the growth of camel under traditional management is so slow that the female camel can not reach puberty before five years, and age at first calving is seven years and calving interval is two years. Calf mortality is usually more than 50% on average. Lactation length is 282 days, number of days open is 199, and the longevity ranges from 20 to 25 years. Considering milk production, lactation yield ranges from 1090 to 2165 liters, and 3.5 to 5 liters per day per camel and 7.5 liters at peak lactation.

Live weight of camels on average is 400 kg for male, yielding 211 kg carcass weight. A result from draft trials on camels showed that an adult working camel could be exposed to a draft force level of 1.77-KN without reduction of its draft force output. This means that a single camel can replace a pair of oxen in terms of draft power capacity.

Generally, camels are slaughtered when they are too old resulting in a very tough meat and the meat known to have suffered from dripping under room temperature. Among the internal parasites Cephalopodan was dominant (82%) followed by *Trichuris* spp. (63%) and hydatids (34.8%). Ticks and mange mites were important ecto-parasites.

These results generated so far could further be used for developing sound research and development projects based on the facts obtained from on-farm trials, hence, subsequent results will eventually have better acceptance by the end users. In addition, it is noteworthy that the preparation of abridged abstracts from the past camel research results at Haramaya is on progress. The abridged abstracts will be made available to users soon using all appropriate and effective means of communications as possible.

On-going Research

There are eight research activities currently ongoing among which- one belongs to animal breeding and genetics, two in animal health, two in nutrition, one in management and three invalue addition. The research activities - are listed below:

- Assessment of camel health condition as per the perception of pastoralists;
- Abortion and calf mortality of camels in eastern Ethiopia;
- Traditional calf rearing systems and associated problems;
- Preservation of raw camel milk and inhibition of pathogenic bacteria by its natural anti-bacterial system;
- Buttermaking from camel milk by blending it with milk from cattle, sheep and goats;
- Study on the supplementation effect of sorghum stalk, elephant grass and selected concentrate feed on milk yield of lactating camels;

- Assessment of some critical mineral elements in the diet and blood serum of camel and non-conventional mineral sources and mineral supplement of camels in eastern Ethiopia; and
- Assessment of phenotypic and genetic diversity of camel population in South Eastern Hararghe, Ethiopia.

Gaps and Challenges

- Genetics and breeding: Very little is known about local camel breed characteristics in terms of production potential, production and adaptability performance of local camel types under various production environments;
- Available feed resources and various feeding methods and their effects on the milk and meat yield and quality and improvement of camel production is not adequately addressed particularly under Ethiopian condition;
- Problems of animal health and various diseases and health hazards not sufficiently studied and documented in relation to various camel products such as milk and meat products;
- Camel milk, meat and live animal marketing situation are not properly studied and as such little is known about the socio-economic condition of camel production, camel products and by-products utilization and other related socioeconomic benefits seem not sufficiently utilized by the users;
- Properties of camel milk and meat in terms of yield, quality, particularly therapeutic values and conservation/preservation methods are not well defined under Ethiopian condition;
- Climatic changes and the attributes of camels to these changes associated to various socio-economic values are not well assessed;
- Little is known about camel meat and meat quality enhancement that will add value in the food chain under Ethiopian condition;
- Little is done on the possibilities of making various milk products like butter, cheese, ice-cream, etc. using various coagulants from locally available herbs;
- Regarding the possibilities of using camel for entertainment, exploiting different by-products coming from camels at various stages and expediting means of making better use out of these products, etc; and
- Identification of potential camel breeds that could be used for traction, draft power and possibly for racing will have to be looked into.

Development Initiatives

There seems to be changes in the various components of camel production systems, environment, and demands in camel products, consumption patterns, and marketing of camel products apart from the dramatic changes in environments, which have apparently made camel production increasingly important in arid and semi-arid areas of Ethiopia.

The current five years national strategic plan for development emphasizes the need for complete economic transformation almost in all sectors of which livestock production

cannot be exception. Similarly, the traditional pastoral system of camel production should essentially be transformed to commercial-oriented type of production. This would obviously call for improved technologies involving improved skills and knowledge of production apart from other complementary improvements in the available resources, infrastructures, and utilization of these resources to produce the desired products from camel herds. This would definitely require different research and extension approaches with a defined vision, mission, goals, and objectives that would assist and enhance the transformation of production systems in pastoral systems of camel production. Unlike the previous system, camel research should be an independent program that would be organized under the Ethiopian Institute of Agricultural Research (EIAR), having its centre in Somali Region operating mainly in Somali Region including other parts of Ethiopia where camel husbandry is being practiced. The composition of these bodies leading the National Camel Research Center (NCRC) will include all stakeholders involved in camel production activities, government bodies, clan elders of pastoralists, intellectuals, and researchers in areas of camel husbandry practices and the like. The number of members of the NCRC, modalities of the selection procedures and related details of the establishment of the NCRC are discussed in the following sections.

Key Activities

The main activities of NCRC will include the following subjects:

- To assist and pursue the camel research and development activities in Somali, Afar and Oromia Regional States and other regions of Ethiopia, in collaboration with local, regional and international institutions working in a camel development activities in various places in Ethiopia;
- Conduct and assist research activities aimed at increased camel products in terms of milk, meat, draft power, and enhancing the quality of these products primarily to the best interest of the local and International consumers;
- To undertake applied research activities on priority issues of camel health to increase production and productivity;
- To undertake - applied research activities on camel breeds for increased milk, meat and other camel related products;
- To conduct research and promote the technologies that improve the rangeland production and nutrition of camels for improved camel products in both quantity and quality aspects;
- To carry out research and development efforts that improve and promote the medicinal values and cosmetic properties particular anti-aging factor of camel milk both at national and international levels;
- Develop the scientific and technological methods that improve and promote the industrial qualities of skin, hair and other products of camel in various camel producing areas in Ethiopia;
- Looking into the possibilities of using camel for entertainment and tourist attractions mainly through developing camels for racing;
- To promote and enhance camel production and productivity through effective utilization of research results and generated appropriate technologies, extension activities will be

intensified through the extension and outreach department of the NCRC. Establish link or networking with various research institutions in and outside the country to facilitate communications and information exchange and technological advancement related to camel industry improvement and promotion;

- Provide training on specific but various topics, for example, laboratory techniques, socio-economic survey, data analysis, systems analysis, and modeling. Workshops may be organized by experts and camel keepers coming from different places of pastoral areas of Ethiopia periodically so as to enable them get opportunities to exchange experiences among themselves and getting experiences from the experts as well;
- Identifying specialized institutions working on various areas on camel products at international levels in various places and seeking a collaborative way of working together;
- Generate problem-solving and development supporting research results and disseminate the results to the different users using various and appropriate means of communications;
- Assist the national and regional research institutions, identify research priorities in camel production and industry promotion, provide financial support and monitoring; and
- Assist research institutions with twinning arrangement and requisition of research grants.

Research Areas

Camel Production and Management

Basically, animal production is a function of the genotype and environment to which an animal is subjected to survive and give various animal products. Hence, camel production and management research involves detailed studies on the animal genotype and its environment in which the animal is managed to provide various products as a result of the interaction of the animal with its environment. The various animal genotypes will be monitored with different environment factors so as to find out the best genotype and environmental combinations that would give the desired and acceptable products in terms of both quantities and qualities at any given time. The camel production, reproduction, and management improvement have further subcomponents as discussed below.

Camel genetics and breeding

Breeding, feeding, biotechnology and animal health are crosscutting issues across all the various aspects of camel productivity and products improvement schemes that will be considered in all thematic areas across the board.

The aim of this component is to look into the possibilities of improvement of the yield and efficiency of local camels through various breeding techniques. In economics terms, this means that any increase in output, whatever the product, should be related to the cost of the inputs. In other words, improvement will essentially have only taken place if the value of output exceeds the costs of the inputs. However, there might be other criteria by which the benefits of camel production and improvement schemes can be judged. A national goal might be to optimize production from the available resources of land, feed, or labour. Emphasis may have to be placed on sustainability of

production. Whatever the aim, outputs should not divorce from consideration of the inputs. Thus, the breeding and genetics studies of the NCRC will focus on the practical and applied or even basic research that will lead to improvement of the efficiency of camel production and enhancement of value addition of the various camel products for domestic and possibly international markets.

There are a number of options through which one can genetically change the locally available camels into probably a more productive camel herd. These methods of genetic change would include:

- Substituting one breed for another;
- Crossbreeding; and
- Selection (within a breed or a population, e.g. a herd) and any combination of the above-mentioned methods might be considered in the genetics and breeding research endeavors of camel improvement exercise.

However, the program may start initially by taking an inventory work, evaluation of the herds and study of the merits of the existing camel genotypes in terms of various desired traits. After the inventory, work is completed then improvement through selection, crossbreeding, and other appropriate breeding strategies may be chosen as the case may be, depending on the variability that exists among the different local genotypes. Selection may be a good option from among the main options listed to change the genetics of the local camel. Genetic improvement through selection (within breed) currently seems to be a better and practical way of creating something new as distinct from something already in existence somewhere or here at local level.

Genetic selection, apparently moving forward in small, cumulative steps, allows any necessary changes in feeding and management to be assimilated slowly and steadily. In the long term, selection may provide the most secure option for sustainable genetic improvement. Unfortunately, selection particularly in the tropics, Ethiopia included, is not often given serious consideration simply because its immediate effect is seldom as dramatic, as, for example, changes from crossbreeding. In Ethiopia, there are several genotypes of camels, which are traditionally classified into various groups based on their size and functions. Accordingly, in Somali Region, there are three classes of camels, notably, Galeb, Hoor and Aydimo (Ahmed, 2002), which are small sized, large and medium sized camels, respectively. In terms of milk production, they are perceived as high, medium, and poor milk yielder, respectively. In some studies only two camel types were reported notably Arogg and Ayyon (Tezera, 1998). However, a systematic classification and characterization of these genotypes is not yet conducted and thus far, very little work seems to have been done in this regard. Breed characterization and a systematic study will pursue to evaluate and improve the existing genotypes in terms of productivity and enhancement of value addition in the various camel products. Biotechnologies mainly Artificial Insemination (AI) and embryo transfer techniques may also be included in the future plan of breeding and breed improvement of camel research program of the NCRC.

Reproduction is also an important aspect of improvement of camel production and productivity in the research program. This aspect will include, possibilities of improving the fertility level of females, conception rates, age at first calving, calving interval, survival rates of calves, etc. using various techniques mainly by monitoring various combinations of genotypes and feeding schemes in the camel research program.

Feed resources and nutrition of camel

Rangelands including improved forages which are introduced and currently found to be doing very well in some places like Gode and crop residues constitute major feed sources of camels particularly in the dry arid zone of pastoral areas in Ethiopia and elsewhere in the tropics. The main objective of this component will include study of the rangeland in terms of current condition, as a major feed source, vegetation cover, and botanical composition of available plant population and range dynamics through time.

The chemical composition, nutritive value and digestibility values of the common plant materials will be considered as well. Aspects of range ecology, changes in range ecology and dynamics, environmental deteriorations, constraints and future trends will be addressed in detail. The study will also include the socio-economic conditions of the pastoral regions, current traditional range management practices and associated problems prevailing in the area that would enable one to develop appropriate methods of range management schemes that could easily be adapted by the users.

The supplementary feeding practices of camels and the chemical composition and nutritional values of these various feedstuffs vis-à-vis the production performance of the camel herd will thoroughly be studied. Finally, the supplementary feed stuffs that are locally available which are rich in various nutrients including minerals will be identified, evaluated, may be improved or modified and will be made available for use by the ultimate users/pastoralists.

Rumen ecology and rumen microbiology may also be included in the study of camel nutrition so as to understand better the rumen physiology and functions as the various rumen flora and fauna changes dramatically influencing greatly the nutrients available in the rumen and its utilization by the macro animal. Biotechnology in nutrition targeting improvement of the rumen microbes in association with an efficient utilization of feedstuffs and various nutrients derived from these feed sources may be considered as an essential component of nutrition research program in the centre. Furthermore, the center will conduct research on feeding/grazing management not only on natural pasture but also on improved pasture grown under irrigated conditions. In addition, the center will include in the study various byproducts of the newly introduced cereals like rice bran, rice straw, and the oil crops byproducts.

Camel health

Camel health will be one of the important aspects that will be applied across the entire components of camel research program in the NCRC. There are various diseases prevailing in the pastoral areas that are severely limiting camel production. Notably, infectious diseases, zoonotic diseases, none infectious diseases, internal and external parasites, reproductive diseases, etc. to which the etiology, symptoms, causative agents, controlling and preventive measures will be identified and will be studied.

Even though, the pastoralists are using various herbs and various traditional and cultural practices to subdue these diseases, it is not yet evaluated in terms effectiveness and thus the extent to which these traditional medicine affect the diseases will have to be known. Some of the conventional medicines and various drugs, e.g., acaricides need to be evaluated periodically so as to know and assure their effectiveness against various disease conditions so as to keep animals healthy and have increased production and improved productivity. Provision of annual vaccination and other related services to the pastoralists will also be accomplished through the extension activity of the NCRC.

Well-equipped laboratories in terms of various equipment and related facilities, qualified and skilled work force at various levels, and sustainable supplies of drugs, chemicals, etc. will be required to effectively run the health program.

Products Processing and Preservation

Camel milk

Milk is one of the important products obtained from camels. Camels have good potential for milk production in the pastoral areas. However, the milk production performance of camels has not been systematically evaluated so far particularly under improved feeding conditions.

Camel milk is very different from milk of other livestock species in terms of its functional properties and medicinal values, which makes it good for growing children and orphanages for it is more similar to milk from humans. Camel milk is also different in composition. It has low fat and the fat constitutes mostly poly-unsaturated fatty acids, which are perfectly homogenized for human nutrition. Its lactose is different from cow milk and can easily be digested by persons suffering from lactose intolerance. Proteins of camel milk are no allergens and there are a number of immunoglobulins and protective proteins in camel milk that are antibacterial and antiviral in nature which means camel milk can have therapeutic values which is yet to be fully exploited for the wellbeing of human beings.

Owing to the high ambient temperature where camel milk is produced, there is a need to prolong the shelf life of camel milk. Thus, improved preservation and processing

methods of camel milk should be important focus areas of the camel research in the region.

Therefore, the research activities of this component will be aimed at improving the quantity and quality of milk obtained from the local herd with an underlying principle of manipulation of breeding and nutrition under the pastoral conditions of Ethiopia. Camel milk processing and value enhancement is one of important areas where research efforts will focus on to make it possible to obtain the various milk products e.g. butter, cheese, fermented milk, yoghurt, etc. from camel milk for domestic consumption as well as for export purposes. This in fact, requires developing appropriate technologies that would include the churning and related equipment, and churning methods that would successfully enable butter making and other related milk derivatives from camel milk.

Investigations on the medicinal values of camel milk against various diseases, cosmetic values especially anti-aging properties of camel milk can also be pursued with the collaboration of Haramaya University and other collaborative universities and research institutions at national and at International levels as well.

Improvement of camel meat

Meat is other important product that is generated from camels. Little work is done in terms of quantity and quality of meat obtained from camels particularly in Ethiopia. Research activities will have to be designed in order to assess and evaluate the production of camel meat in the arid areas of Somali Region. Improve the qualities and quantities of meat through manipulation of various combinations of genes and different levels of nutrition in the pastoral systems of Somali Regional State in particular and elsewhere in Ethiopia in general.

Looking into the possibilities of enhancing the economic and use values of the various aspects of camel byproducts e.g. meat, offals, visceral organs and their contents, hides, hormones and glands, hooves and bones, etc. would represent an important aspect of the camel future research strategies in the Somali Regional State as well as elsewhere in Ethiopia where camels are raised.

Camels can be used as a source of draft power for various crop-farming activities in the various regions. This also calls for due consideration and evaluation of the traditional methods of harnessing animals vis-à-vis power generation from the camel to do the required work. It is important to evaluate the equipment and feed supplied to the animal and the qualities of work performed by the animals and finally identify the problems and constraints related to the whole plowing systems and do the research work to improve the plowing systems.

Camels can be used not only for transportation purposes but as racing animals for recreation as well. The later use is becoming increasingly important and a very lucrative business in some Arab countries. This indeed requires developing especial

equipment as well as feeding and management packages that will suit the racing camel hence, it can be included in the future camel research program

Possibilities will also be looked into whereby means of making the NCRC a centre of tourism attraction for recreation as well as a center serving for therapeutic treatments against various diseases to people coming from different parts of the world.

Socio-economics and Marketing

To understand more the pastoralists and their way of life in terms of their cultural norms, values and their important means of life, various socio-economic studies associated with the historical perception of pastoral community, norms and values including way of life of the pastoralists will have to be conducted. These include Sociology and Anthropology of the pastoralists, available resources, and way of utilization of these resources including camels and camel products. Marketing of milk and milk products, live camel marketing, camel meat marketing, etc. and study on improvement of marketing of camel products and looking into the possibilities of improving marketing infrastructures and facilities in the various regions where camel marketing is practiced. The marketing study would also address the issue of identifying possible means of creating a link with International markets for livestock particularly for live camels and camel products as well.

Extension

Extension is basically pursuing a major activity that facilitates to link the research work and the pastoralists by using appropriate communication methods and means of reaching the pastoral communities. The main activities of the extension component include:

- Allowing the pastoralists to take part in the processes of identification of the research problems before the actual research work is undertaken and to deliver the research results back to the pastoralists in a very comprehensible manner.
- Establishing pastoralist research group linked to the center:

Conclusion and the Way Forward

To transform the camel production systems from the current traditional way of production system into commercial market-oriented form of production it requires enabling environments such as reallocation of resources and improvement of research capability, effective organizational set up of the research and extension activities working at various levels in the country. Similarly, linking the research and extension activities including the achievements attained need to be communicated to the same kind of activities being undertaken elsewhere in order to share experiences and improve the productivity of camels in various places in the country.

Camels: Past, Present, and Future the Israel Experience

Levy, A., van Creveld, C*. and Yagil, R.***
**HemdatHadarom College, Netivot, Israel*
*** Ben-Gurion University of the Negev, Beersheva, Israel*

History

Although there is a "NEW trend" today to use camel milk and its products for food and for curing diseases it has been known for thousands of years. When the landmasses were joined, thousands of years ago, camelids originated in what is now known as North America (Epstein, 1971). From there they migrated to the south, the southeast and to the east. It is possible that they were seeking refuge from predators because where they did not find refuge they disappeared.

The ones that went south found refuge in the harsh heights of the Andes in South America, were the oxygen is extremely low, and it is very cold. Predators cannot survive. As the fodder, which is available in other deserts, is similar, we can consider the place as the "Desert in the Sky." These "New World" camelids are the llama, alpaca, guanaco, and vicuna. The camelids that moved east found refuge in the very cold, often covered by snow, Gobi Desert, the "desert in the cold." These animals evolved into the two-humped Bactrian camels.

Those, which went southeast found refuge in the hot, arid desert of the Sahara, where they evolved into the one-humped dromedary. This article will focus mainly on the one-humped desert camel.

Historically it is known that when people were hungry and ill and turned to the Prophet Mohamed for help he sent them to his camel shepherd where they drank their milk (and urine) and became healthy (Khan, and Sahihal_Bukhari, 1974). A book was written comparing the Koran and Talmud. In the chapter on "Camels" it is written that when persons needed help G-D gave them the she-camel to drink its milk for "curing all illnesses and poverty" – this was published in New York in 1863 (Weill, 1863). Camels are also mentioned in the bible when taken by the Jewish people when Moses left Egypt and by the Magi when they were led to the birth of Christ.

Present – Camel Science

Camels were not heard of for many years, relegated to the nomadic peoples. In 1969, Prof. Yagil started looking into the mechanisms, which allowed camels to survive the harsh climate in the desert (Yagil, 1985). During his research, he discovered that camel milk has special properties, tghus, can be used to feed children in Africa. These data appeared in the publication of the FAO in both English and Arabic (Yagil 1982). The

problem was that whenever it was suggested that camel milk could provide essential food in Africa the NGOs and government organizations had no knowledge of camels so preferred introducing cattle in these areas, which did not survive the drought periods.

Camel Dairy Farming

For this reason Prof. Yagil formed a group of academicians who set up a model camel farm in the southern part of Israel in a desert area having only about 20mm annual rainfall. There they farmed the camels themselves while still teaching in the medical school 200 km away. Methodology was perfected in milking camels, getting 10-15 liters milk daily for periods of 18 months (Yagil, 1999). The group also made ice creams (BBC, 2000) and medicinal creams (Yanani, 2001).

Medicinal Properties

Further studies into milk composition revealed the "secrets" of medicinal properties of the milk (Merin et al, 1998). The idea that camel milk could cure diseases was vocally refuted as "not-possible" and crazy, even by camel scientists. However, this changed after publications on use of camel milk for treating diabetes and other diseases (Zagoriski et al, 1998; Shabo et al 2005).

When it was observed that in many places in Africa there was a negative selection of milking camels our group decided we must overcome this. The accepted practice was to present the poor milkers to the male within the first few weeks after giving birth and keeping others, better milk givers, to meet with male after one year's lactation. In this way every year the bad producers gave birth, while the good milkers once every two years. Even though embryo transfers (ET) were known in cattle no person was prepared to develop this methodology for camels – there was not a big enough market. Therefore, our group relied on our knowledge of camel anatomy and physiology to develop ET in camels (Yagil and creveld, 1990). When the methodology was then introduced to the Emirates we went back to our activities on camel milk, hoping that the original goal would be followed. Unfortunately, it was not, it remained for racing camels and research.

Other research projects were carried out on the pharmacokinetics of drugs. Observing that sick camels are dehydrated we carried out the series of researchprojects on water-deprived camels (Ben et al 1991). It appeared that subcutaneous and intramuscular injections of antibiotics into dehydrated camels did not attain active blood levels. Only IV injections did but they are very seldom done in camels of the pastoralists.

Another finding was that dehydrated camels did not receive pharmacological levels of Febantel, an anthelminthic widely used in Africa (ben et al, 1996). The reason for this is that orally dosed Febantel must be absorbed and activated in the liver before

returning to the intestines where it is active (Ben et al, 1996).. The liver function in dehydrated camels is severely compromised so the drug remains inactive (Agil, 1999).

Expo 2000 in Hanover

The organizers of the EXPO 2000 in Hanover, Germany, invited 200 projects from around the world, ones that had in the past, and will have in the future, significance for humankind. Our project on "Camel Milk for Food and Economic Security" was chosen to appear in the special building "The Global House and was also chosen to be one of two of the 200 projects to appear on stage for the gala opening evening. There the worldwide audience was introduced for the first time to "modern" camel farming, camel milk, ice cream, and medicinal creams.

Kazakhstan

A group of Kazakh veterinarians trained on our farm and we worked in Kazakhstan, eventually setting up a dairy farm with 1000 milch camels in Almaty. In 2000, the Kazakh ministry of agriculture met with American counterparts to discuss future livestock development. Prof. Yagil was asked to represent the Kazakh ministry of agriculture in presenting the "future of camel dairy farming in Kazahstan" (Agil, 1999).

Africa

Our group worked with the German GTZ and Israeli government in training in Israel and giving courses in various parts of Kenya and Ethiopia.

Future

The future is bright for camel farmers.

The **functional foods** from camel milk are not only nutritious and healthy but also tasty. There is a big worldwide market. We must be on our guard that the rich countries do not take over the markets but that Third World countries with camel populations have their fair share.

The **medicinal properties** of the camel milk will be used for treating many diseases, based on the wonderful composition of the milk. This will attract a large market.
The recurrent cycle of **famine** in the Sahel of Africa (Owenderg, 2011) can be relieved with use of camels, which are indigenous to the areas.

Problems

Although the future for camel dairy farming seems guaranteed, great problems are confronting their economic development. The pastoralists are losing their traditional grazing areas; urbanization is closing in and governments are trying to settle the pastoralists, either by enforcing compulsory schooling for the children or by building settlements and pressuring the people to live there. As camels are nomadic, they are being discarded.

Our groups success in farming with zero grazing, by growing hardy crops suggests a way to combine settling while maintaining their camels, and heritage and marketing their products. It must be stressed that marketing of camel milk and products is being taken over by rich countries and so the pastoralists with a heritage of camel farming may be left behind. We should make provisions to protect them.

Conclusion

Camels have had a useful past in human survival in marginal areas are having a good present development and will have a very good future.

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The Status of Camel Research and Development in Kenya

Kisa Juma Ngeiywa
Deputy Director of Veterinary Services (DDVS) / Livestock Expert
ASAL Based Livestock and Rural Livelihoods Support Project (ALLPRO)
Ministry of Livestock Development Kenya
Tel: + 254 20 2396433 (office); +254-722-376237 (mobile)
E-mail: kisajuma@yahoo.com

Background Information

The camel population in Kenya is 2,971,111 (Kenya Population and Housing Census of 2009). Majority of the camels are in North Eastern Province (52%) and Rift Valley Province (33%). Camels are very valuable in the Arid and Semi Arid Lands (ASALs) which is over 75% of Kenyan land mass. They produce valued milk, even during severe droughts when other livestock species are dying, and do not degrade the rangelands compared to cattle, goats, donkeys and sheep. The milk contributes about half of the nutrient intake of most camel keepers. Nearly all the camels in Kenya are the one-humped, which is uniquely adapted to hot and arid environments, mostly in Africa. Camel keeping has spread to nontraditional districts and keepers. The threats posed by the recurrent and pronounced droughts have awakened pastoralists to pay more attention to camel keeping than ever before leading to introduction of camels to new areas and new communities such as the Maasai, Keiyo, Kamba, Borana, etc.

During the colonial era and early post independence period camels were traditionally kept under the extensive nomadic pastoral system. The United Nations' Educational, Scientific, and Cultural Organisation (UNESCO) identified the huge untapped potential of camels in 1970s and recommended through the Integrated Project in Arid Lands (IPAL) camel research and development as practical alternatives for rehabilitation of the already degraded lands. Numerous technical and scientific reports were written under the IPAL programme (UNESCO, 1985), which was inherited by the Kenya Agricultural Research Institute (KARI) in 1988 and was expected to continue with the camel research (UNESCO, 1988).

The public and private sectors did very little in technical knowledge dissemination, sharing, transfer, or research (Ngeiywa, 2007) despite the potential awaiting the exploitation of existing knowledge (Bornstein, 2010). In fact, livestock development did not focus on camels until recently, for example, Kenya Meat Commission (KMC) and stock routes were established primarily for cattle marketing (Kenya Meat Commission, 1950).

Turkana Resource Monitoring and Evaluation (TREMU) programme made long-term observational study and data collected from 35 project camels based at Lorugum station (Njanja, 2011). The Turkana Camel Project (TCP) created awareness and sensitized livestock keepers and other stakeholders on camel production and healthcare (77,000 km^2).from 1987 to 1992.

The Food and Agricultural Research Management (FARM-Africa) embarked on a camel improvement project in 1988 that carried out extension services through the mobile outreach camps (MoCs) in Laikipia, Samburu, Marsabit and Moyale districts and some satellite work in East Pokot and Mandera districts (Houten H., 2002). The MoC model simulated the pastoral way of life revolving around the camel. The project introduced the school camel milk project, held several awareness creation workshops, demonstrations and supported students (MSc and PhD levels).The project promoted camel keeping in Samburu, Narok and Kajiado districts (Ngeiywa, 1993).

Materials and Methods

Selected camel research and development initiatives in Kenya are reviewed with special focus on the proceedings of the Kenya Camel Forum (KCF) i.e. an annual weeklong platform for camel stakeholders to actively interact in a co-learning process since 1995 implemented by the Kenya Camel Association (KCA)

Synopsis of Camel Topics in Various KCF Proceedings

The 16th KCF - 2011 Theme: Exploiting camel potential in changing climate and attaining Kenya vision 2030

Presentation title	Author(s)
Camel value chain support by VSF-Suisse	Chuchu, S;
Facts on climate change in Kenya / Africa	Kinuthia, M;
The current status of camel (*Camelus dromedarius*) calf management among pastoral communities of northern Kenya	Kuria, S.G.; Tura, I.; Walaga, H.K.; Lesuper, J.
Camel mastitis	Maichomo, M;
Evaluation of camels trypanosomosis control strategies in Marsabit and Isiolo	Mdachi. R;
Prevalence of camel trypanosomosis in Isiolo	Munga, L;
Camel development in Kenya	Ngeiywa K. J;
Popularisation of camel milk in Kenya	Ngeiywa K J;
Congenital hereditary bilateral sublaxation of the carpal and fetlock joints in a dromedary camel	Njanja, J C;
Vision and camel milk and meat value chain up grading strategy in Kenya	Tura, I;
Potential of solar energy for milk processing in Kenya	Wayua, F;

The 15th KCF - 2010 Theme: Camel science and development for sustainable livelihoods

Presentation title	Author(s)
Dromedaries are resistant to Foot and Mouth Disease (FMD), Bactrians are not. A review.	Wernery, U;
Brucellosis and Q-fever in camels from a one health perspective	Schelling, E;
Combination of participatory approaches and molecular diagnostics to investigate epidemiology of Haemorrhagic Septicaemia in camels (*Camelus.*	Gluecks, I.;
Priority camel diseases in some parts of Kenya	Ngeiywa, K. J.;
Clinical observations on the wryneck syndrome or torticollis in the camel population of Kenya and Sudan	Dioli, M
Prevalence and treatment of fractures in young single-humped camels (*Camelus dromedarius*): 75 cases (2008-2009)	AL-Sobayil, F. A; Ahmed, F. A. & Gahlot
Control of camel trypanosomiasis: a review of the current methods and their limitations	Murilla, G.;
The use of Noroquine in treating camel trypanosomosis in Somaliland	Mohamed, A S;
Evaluation of camel milk parameters in mammary health	Wernery, U.
Nutritive values of some browse trees consumed by camels in Butana area	Amina, M; Daw Elbait
Effect of Cu – supplemented salt licks on total and TCA-soluble plasma copper concentrations in Omani camels	El Huda, N, Osman, F. D; Mua, B M; Abu Samra, M T
Impact of long term feeding Atripex halimus (saltbush) on camels milk performance under arid conditions	Safinaz M. Shawket
Effect of feeding system on milk yield of camel kept around the urban area in Sudan during summer	Hassabo, A A
A comparative study of the food habits of camels and cattle on a ranch in Laikipia, during the drought of 2009	Field, C R
Modified methodology for viscosity elimination and cryopreservation of dromedary camel semen under different glycerol level	El-Bahrawy, K A;
Lactation curves and prediction of daily and accumulated milk yields in Rendille camel types in Northern Kenya	Aloo, F.;
Genetic and non-genetic factors affecting the prevalence of mastitis in dromedary camels	Sibtain, A
Microbial biodiversity of camel milk and fermented camel milk products: technology, hygiene and safety	Meile, L.;
The hygienic quality of camel milk marketed from North Eastern Province Kenya and how it can be improved	Wanjohi, G.M.; Gitao, C G; Bebora, L C
Biodiversity and genotyping of staphylococci isolated in raw and fermented camel milk in East Africa	Njage, P. M. K;
The prevalence and antibiotic resistance of common pathogens in camel milk from North Eastern Province	Akweya, B. A;
Camel milk pollution (heavy metals, pesticides and radionuclides) in Kazakhstan	Konuspayeva, G; Faye, B; Jurgenz, S; Loiseau,
Fermented camel milk commercialization: challenges, constraints and developmental prospective	El Zubeir, I.E.M.;

The 11th KCF - 2006 Theme: Role of the camel in food security and peace promotion

Presentation title	Author(s)
Challenges in marketing dairy products: a case of camel milk	Gabbow, M H;
Mineral supplementation in milking camels: A Manyatta based study in the Rendille area of Marsabit district, Kenya	Kuria, S G;
Role of camel in peace promotion among pastoralists communities of Kenya	Lanyasunya, P;
An overview of camel diseases and treatment	Matu, G.;
The untapped potential of camels in food security and peace promotion	Ngeiywa, K J and Wamwere, G N

The 10th KCF - 2004 Theme: Progress, achievements, challenges and the future of KCA

Presentation title	Author(s)
Collaborative approach in testing of processing and preservation technologies for milk, meat and hides/skins and assessment of viability of small-scale dairy processing units in northern Kenya	Adongo et al.;
Assessment of viability of small-scale dairy/meat projects	Bruntse A. N.;
Camel milk as human food and source of income	Bruntse, A & Younan. M.
Camel rearing as an income generating activity: The economics of camel rearing	Field ,C.R. and Haji, H
Camel experiences in Eritrea	Kebbede, T;
Preserving camel milk with the lacto-peroxydase-system	Kenyanjui, M & Younan, M
Mineral supplementation in the Rendille milking camel herds	Kuria,, S G,
The future of the KCA: progress, achievement and challenges	Mahmoud, A. H;
Camel diseases and drugs	Matu, G;
Alternative uses of the camel: The camel as a draught animal – an underutilized potential in Kenya?	Muckle, T B;
Facilitation of livestock marketing	Ngeiywa, K J;
Research on traditional veterinary medicine among the Rendille, Gabbra and Somali communities	Wamwere, G N;
The most infectious diseases in camelids	Wernery, U;
Economic aspects of infectious mastitis	Younan, M.;
KCA five year strategic plan	Kigotho, J

The 9th KCF - 2003 Theme: Camel health in relation to milk

Presentation title	Author(s)
Milk and meat/hides preservation technologies	Bruntse A.N.;
Condensed camel' s milk: a new approach to food security in Kenya	Field *et al.*;
Long term input of veterinary drugs to a herd of dairy camels.	Field C. R. and Gollo, A
The cost efficiency of treating lactating camels against Helminthiasis	Field C. R. and Gollo, A
Pastoralist experience of camel health and milk production	Field, C R;
Camel milk production in North Somalia and North Kenya	Kenyanjui *et al.*;
Sustainable improvement of camel milk production and trade in Gardo district, Puntland state, north east Somalia	Kenyanjui, M;
Milk and meat preservation project	Lemunyete L.;
Genetic diversity and relationships of indigenous Kenyan camel	Mburu et al.;
Novel observations on camel milk	Werney, U;
Mastitis: Production, losses. economics and public health hazards	Zubeir, E.;

The 8th KCF - 2002 Theme: past, present and future research and extension on the camel: Does it fulfill the needs of the camel owner?

Presentation title	Author(s)
Camel breeds and breeding in northern Kenya	Hulsebusch et al.;
Monitoring udder health	Abdurahman, O.
Sarcoptic mange	Bornstein, S.;
Camel milk processing and products	Brunste, A. N and Adongo, A
Trypanosomosis in camels in Kajiado	Chemuliti, J,;
Analabs diagnostic laboratory supporting camel production	Dolan, T.;
Humane slaughter and animal welfare	Egessa, J.;
Ethno-Veterinary Medicine	Wamwere, G J N;
Feeding colostrum to camel calves	Farah, Z;
White gold of the desert	Kinyanjui, M;
Breeding strategies for camels	Kuria, S G;
Animal-level factors for Trypanosoma evansi infection in camels in eastern and central parts of Kenya	Ngaira, J. M., Bett, B. and Karanja, S. M.
Reaching camel owners	Simpkin, P & Field, C R
Camel milking processing challenges	Wangoh, J.;
Lack of treatment concepts for camels	Younan, M.;

The 7th KCF - 2001 Theme: Economic opportunities of the camel

KCF presentation title	Author(s)
Camel worm infections	Ngeiywa, K J
Camel Abscesses	Kihurani, D
'Shimbir' unknown camel disease	Yusuf, H M
Abortions in camels	Njanja, J C
Camel nutrition	Field, C R
Pakistan camels in Kenya	Field, C R
Taarifa fupi ya maendeleo ya Ngamia Tanzania	Lukumai, A I
Role of camels as risk mitigation measure in the Pokot pastoral economy	Pokot Development Programme
Economic opportunities of the camel: their potential in Laikipia District	Field, C R
Camel meat production and processing: Ol Maisor Ranch, Rumuruti Laikipia	Evans, J
Camel meat processing	Kisima Camel Improvement Group
Early diagnosis of camel trypanosomiasis using suratex®	Kihurani, D
Economics of alternative diagnosis of camel trypanosomiasis	Chemuliti, J
Economics of camel treatment against trypanosomiasis	Nyamweya, M and Shah, A
Economics of camel calf treatment	Younan, M
Camel safaris – OL Maisor Ranch	Evans, J
Maralal International Derby	Gasgoine, M
Characterization of Kenyan camels and breeding strategies of the camel keeping communities	Kuria, S G
Training of Paravets in camel keeping communities	Ngeiywa, K J

The 6th KCF - 2000 Theme: Camels in the New Millennium

The 5th KCF - 1999 Theme: Camel Keeping in new and Changing Environment

The 4th KCF - 1998 Theme: The Role of the Camel in Drought Preparedness and Mitigation

KCF presentation title	Author(s)
Drought preparedness and the camel's role in drought mitigation	Field, C R
Combating nutritional stress: what options are practical	Waita, John
Camel Diseases after El Nino – what happened and what might be expected	Mohamed Dirie
Camel marketing	Said Aflow

The 3rd KCF - 1997 Theme: Camel Husbandry and Health: Concepts and Practices
The 2nd KCF - 1996 Theme: Recent Advances among Camel keepers in Kenya
The 1st KCF - 1995 Theme: Camel Husbandry: Problems - Solutions - Recent advances – Co-operation and Planning

Presentation title	Author(s)
Condensed camel' s milk: a new approach to food security in Kenya	Field, C.R.; Denge, Tullu; and McLeod, A
The benefits of controlling camel trypanosomiasis	Lemunyete, R M;
Camel marketing and economics: Camel purchases	Mahmoud, S. A;
Foraging behavior of camels	Masibho, R;
Camel skin diseases encountered in some Kenyan rangelands	Ngeiywa, K J;
Recent research advances in camel endoparasites	Njanja, J.C;
Recent advances in diagnosis and treatment of camel trypanosomiasis	Nyang'ao, J.M.;
Milking management and breed experiments	Simpkin, P;
FARM-Africa's Camels at Mogwooni Ranch	Simpkin, S P;
Camel Racing in Africa	Walker, C D A;

Discussion and Conclusions

Before the Kenya Camel Association (KCA), camel advocacy work was almost nonexistent. The Association promotes camel development through information dissemination among the camel owners, research workers, academicians, and companies supplying camel related products. It encourages practical application of research findings for the benefit of camels and their owners, and facilitates applied research on camel health and production problems.

Previously camel research findings were not widely accessed and/or understood by many people due to use of technical terminologies that were not friendly. Furthermore, the camel was neglected in the past as they were considered unimportant livestock suitable only for pastoral lifestyles. Very little was therefore done in the field of technical knowledge dissemination, sharing, transfer, or research. Consequently, a huge gap between the researchers and/or academicians and both the livestock keepers (primary beneficiaries) and their service providers (frontline extension workers) existed. This is what the annual Kenya Camel Forum (KCF) addresses.

The expanding camel keeping must be transformed to modern commercial and competitive production and marketing system through value-addition based on

scientific procedures. This will lead to improving camel health and production, enhanced market access for camels and camel products, increased awareness and sensitization on camels leading to recognition, acceptance, and use thereof, community and other stakeholder participation and involvement in camel research and development.

The Sessional Paper No 2 of 2008 on Kenya National Livestock Policy recognizes camel production and the high potential for camel rearing in most of the ASAL districts and the need to 'popularize camel milk and meat consumption countrywide. The Government of Kenya and partners have goodwill for camel development.

Camel research and development have increased tremendously in scope and actors since the mid 1980s as evidenced by topical issues discussed during the weeklong annual KCF since 1995. The camel beginner's workshops and camel keeping districts reports during the KCF have helped to popularize camel research and development in Kenya.

Other key camel research and development in Kenya include work on traditional and modern veterinary care for the dromedary; camel milk popularization; camel sector stakeholder workshops, Collaborative study on constraints on camel meat and milk marketing and strategies for its improvement in northern Kenya; post-harvest handling for value addition to enhance safety, quality and marketing of camel milk in Laikipia and Isiolo Districts of Kenya and perceptions of camel milk quality in Garissa and Wajir.

Camel health problems are among the most important factors limiting camel production and productivity, thus the ongoing training of the camel keepers and their camel service providers that include most of the field veterinarians who are deficient on knowledge and skills to handle the camel.

Research and extension initiatives in camel breeding will go a long way in supporting camel production and improvement. The long period to puberty for camels and the impediments to artificial insemination in this species are challenges that need attention.

The challenges and constraints limiting camel production and productivity include camel being poorly understood and highly underestimated by many, camel diseases, limited long-term research on production, poor marketing systems, inadequate husbandry and management practices, lack of entrepreneurs to promote production and processing of the wide range of camel products through value adding and limited consumption of camel and camel products by majority of Kenyans. Initiative was undertaken by Vital Camel Milk Ltd® dairy plant that processes camel milk and value added products as health food in Nanyuki, Kenya since 2005.

The future of camel extension in Kenya is promising but greater attention and emphasis must be focused, through research and development. The priority camel issues are diseases, marketing constraints, husbandry, droughts, conflicts, and animal welfare concerns. These problems require concerted efforts (synergy) and high-level collaboration in the entire Eastern Africa region (has the highest population of the dromedary camel in the world).

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Status of Camel Research and Development in Sudan

Atif Elamin Abdelgadir[1] and Adil Salim Elsheikh Elgarrai[2]
[1]Department of Preventive Medicine and Public Health, Faculty of Veterinary Medicine, University of Khartoum, Sudan
[2]Camel Research Center, Faculty of Veterinary Medicine University of Khartoum, Sudan

Introduction

In pastoral production system of East Africa, camels produce milk, meat, blood, hair and hide. They are also used for riding, draught purposes and as pack animals (Knoess, 1977; Schwartz and Dioli, 1992). On the other hand, camels serve as investment, provide employment, and cash income. Furthermore, in recent years there have been attempts to market camel milk. For instance, camel milk is now being marketed in an industrial manner in Saudi Arabia, and on small scale in Mauritania, Somalia, and in a limited scale in Northern Kenya. It is also started to be sold as a health food in Europe (Schwartz and Dioli, 1992; KÖhler-Rolleston, 1993)

Sudan comes second after Somalia regarding camel population with an estimation number of 3,000,000 camels. There has been many research activities in camels in the seventies and eighties of the last century that contributed to the understanding of camel production and production constraints, although most of such reaserach activities were academic, concentrated on camel diseases and rarely applied. Outcomes from such research endeavors paved a way for the establishment of a Camel Research Centre (CRC) in 1995 in the Faculty of Veterinary Medicine, University of Khartoum. The mission of this centre is to plan, design, execute, and document the past and future research activities in all fields related to camel production. The current paper attempts to highlight the different research works that has been conducted in the Sudan.

Animal Health

In relation to camel health many trypanosomiasis and other health related topics has been under investigation in the Sudan. The titles are listed below.

Camel trypanosomiasis

- The interaction of *Trypanosoma evansi* and *Haemonchus longi*stipes in camel;
- Urine odour change in diagnosis of camel trypanosomiasis;
- Some biochemical of trypanosomiasis infection and treatment in camel;
- The effect of drugs and their combination (Etidium and Quinapyramine) on *Trypanosome evansi;*

- Evaluation of trypanocidal activity of some Sudanese medicinal plants against experimentally induced *Trypanosoma evansi* infection;
- The curative effect of various dose rates of the drug (Cymelarsan) on *Trypanosoma evansi* isolate; and
- Molecular diagnosis of *Trypanosoma evansi* infection in camels

Other diseases

- Studies on camel mastitis: epidemiology, aetiology, diagnosis, clinical picture and composition;
- Studies on brucellosis in camel;
- Studies on camel contagious ecthyma disease virus;
- Studies on natural infection of camels Eimeria species;
- The role of *Clostridium perferingense* in camel calf diarrhea;
- Infectious agent and nutritional factors associated in infertility; and
- Pharmacological studies of the assumed intoxication by camel liver consumption

Animal production

The following topics related to camel production mainly in the area of milk and meat of camels has been under investigation.

- Composition of camel meat and milk;
- Hygiene and quality of camel meat and milk;
- Processing and technology of camel meat and milk;
- Effect of the number of lactation on chemical composition of camel milk;
- Distribution of vitamin C in different tissues and plasma of the camel; and
- Effect of camel milk on plasma lipids profile in induced hypercholestolemic and hyperglycemic

Camel Research in Sudan (2006-2011)

Atif (2007) investigated drug resistance of camel trypanosomiasis on 13 isolates of *Trypanosoma evensi* from camel rearing states using standardized test in mice. The results showed that isolates from South Kordofan state were very sensitive to Quinapyramine sulphate. However, the isolates from Butana and Gadarif states showed resistance in all infected mice. Regarding Cymelarsan, the isolates in all states showed sensitivity to the drug, however isolates in Butane showed some degree of resistance (4 out of 6 isolates were cured). The two drugs in all above-mentioned states were given subcutaneous. Quinapyramine sulphate killed 18 infected mice (6 mice for each state) when the drug was given intrapretoneal. Double dose was used for assessing drug resistance against Quinapyramine sulphate on 36 mice (6 control and 6 tested group for each state). The result reveled that 18 mice (6 mice for each state) were died. Polymerase Chain Reaction (PCR) was used on 13 isolates of *T. evensi*

from all states of the study area, and the result showed that PCR was very sensitive in detecting differences in Butana and Gadarif state (all isolates were similar). Nine of the isolates were resistant to Quinapyramine sulphate and 7 isolates were sensitive to Cymelarsam. One isolate (out of 4 isolates) tested by PCR in Southern Kordofan state was different and the isolate was sensitive to both drugs.

A study by Amel (2010) was carried out in the Red Sea state to investigate incidence rate of camel abscesses using clinical and pathological investigations. It was found that 630 (9.05 %) of the examined camels had abscesses, and superficial abscesses constituted 444 (6.46 %). The most frequently affected sites were ventral superficial cervical nodes, fore limbs and hind limbs. At Port Sudan, slaughter house 16.29% (44 camels) abscesses were found in lungs, 8.88% (24 camels) in the liver parenchyma and 37.45% (202 camels) in the lymph nodes. From 459 samples collected from Red Sea state, 365 (79.50%) samples were positive for bacteria growth. Gram positive bacteria were identified as 140 (25.08%) *Staphylococci spp.*, 75 (15.44%) *Streptococcus spp.*, 54 (9.67%) *Bacillus spp.*, 39 (6.98%) *Micrococcus spp.*, 22 (3.94%) *Corynebacterium spp.*, 12 (2.15%) *Enterococcus spp.*, 7 (1.25%) *Kurthia spp.*, and 2 (0.35%) *Actinomyces spp.* Gram negative bacteria isolates were identified as 92 (160-48%) *Escherichia spp.*, 30 (5.37%) *Proteus spp.*, 19 (3.4%) *Klebsiella spp.*, 18 (3.22) *Enterobacter spp*, 15 (2.68) *Moraxella spp*, 11 (1.97%) *Vibrio spp.*, 7 (1.25%) *Acinetobacter spp.*, 7 (1.25%) *Citrobacter spp.*, *Pasteurella spp.* and 1 (0.17%) *Pseudomons spp.*

A study by Mohamedeen (2006) was carried out in North Kordofan state to determine the prevalence of camel mastitis using questionnaire survey and bacterial isolates as well as to evaluate White Sidle Test and Somatic Cell Count for the diagnosis of the disease. Prevalence of sub-clinical mastitis was 45.37 %, while clinical mastitis was 0.93%. The dominant bacterial isolate was *Staphylococcus aureus* (22.75%).The study confirmed the strong relationship between Somatic Cell Count and White Side Test.

Some research works have been done on Anatomy and physiology of camels. For instance, Mortada (2007) stated that based on his histological observations and mophometric data, female camels are considered as seasonal breeders, and, breeding season or the season of highest ovarian activity is in autumn.

Elsadlig (2008) investigated the morphology and histochemistry of the fetal membranes and placenta of the dromedary camel. The result showed that the dromedary placenta consists of maternal part, which is represented by the endometrium, and fetal part, which is represented by the chorio – amnioticallantoic membranes. In all of the specimens examined, the dromedary foetus is found implanted in the left horn. Nevertheless, 60% of the corpora lutea is found in the right ovary. The amniotic lining epithelium consists of two types of cells; the dark tall columnar cell, which constitute the majority of the cell population, and the lighter some what round cells, which are usually scarcely seen and scattered at intervals.

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Theories of the Dromedary Entry into Africa Based on the Archeological Evidence: a new concept

Ashraf Sobhy Saber
President of the Egyptian Association of the History of Veterinary Medicine,
Department of Anatomy & Embryology
Faculty of Veterinary Medicine
Sadat City, Menoufiya University, Egypt

Domestication and Theories of Camel Entry into Africa

Evidence of early domestication of the camel is difficult to interpret. Camel dung, hair, and bones, probably of the Bactrian variety, have been found in deposits of ca. 2600B.C. at Shar-i Sokhta in Iran. Further north southern Turkmenia camel bones are found from the fourth millennium B.C. Since the bones of camel do not change at domestication in the manner seen in other species, it is difficult to determine whether they were domestic or residue of camel hunting. Artifacts, such as figurines and reliefs, or the discovery of camel dung at occupation sites, provide surer evidence of domestication than bones alone.

The proposed time of camel domestication is before 2000 B.C. in central Arabia, where prehistoric rock paintings of them as game and riding animals have been found (Free, 1944; Zeuner, 1963; Bulliet, 1978 and Ripinsky, 1985). Epstein (1971) taking into consideration the earliest Egyptian and Mesopotamian archeological evidence, dates domestications as early as 4000 B.C. Walz (1956). However, believed that camels were domesticated perhaps during the 13-12 century B.C. but not before 2000 B.C. and from this center of domestication, domestic camels spread to the north and to Africa.

On the contrary, Mikesell (1955) and Bulliet (1978) believe that the center of domestication was more likely southern Arabia, where the early manpresumably lived on the coast or along river valleys such as the Wadi Hadhramaut.

Youssef (2008) believed that the camel was first domesticated during the Bronze Age, around 4000 years ago, because the abundance of camel bones found at sites as Umm Al Nar.

On the other hand, camels are mentioned in the Bible, Genesis, chap, 12, as being used by man in Abraham's time, i.e. about the 18th Century B.C.

Here two questions may be raised: Did camels entered Africa in its wild form or domesticated form? and from the north route or the south one?

The Hypothesis of the North Entry of Camels into Africa

This hypothesis is based on the archeological findings in Negev Desert, Transjordan, Palestine, Syria, and Iraq (Figs. 1-10). All of these findings are for domestiacted camels as they had saddle on their back or led by riders.

There is no doubt that camels have been used on a large scale in North Africa from the first centuries A.D., but controversy surrounds their origin. There is a theory held by Gautier (1966) and Gsell (1914) tell that before the camel was introduced into North Africa during the Roman period, but archeological and textual evidence indicates that the camel was present before the arrival of the Romans (Chrnot, 1953 and Demougeot, 1960). In Egypt, it is widely accepted that domesticated camels were present for many centuries before Christ, but only in small numbers, as it is close to Arabia and Middle East (Saber and Khattab, 1998).

The Wild Camel Entry

Bones of an Upper Pleistocene *Camelus* have been found in the northwestern **Negev**, they are of particular interest because they are larger than those of all the Old World camel species are since the Plio-Pleistocene, and they are very much larger than the few fossil camels already known from the Middle East. It is suggested that they represent the only *C. thomasi* yet identified outside Africa (Grigson, 1983). In the Mount Karkom, which is located in the Negev Desert of Israel (Occupied Palestine), there are many archeological artifacts including 40000 pieces of individual rock art. Among the drawings of the ibex, lizards, beasts, we can distinguish also camels (Fig 1). These pre-historic engravings dated about 6000 B.C. It is believed that this place may be the cult center and pilgrimage site for the desert people of this place.

Fig 1. Camel stone engraving.Negev, karkom, Israel (occupied Palestine) &Giant Camel bone, found in the village of ElKowm, Syria

In Syria, near the village of El Kowm in the central part of Syria, a Swiss-Syrian research team leaded by Professor Jean-Marie Le Tensorer of the university of Basel found more than 40 bone fragments of giant camels. The big species has been found as far as 150 000 years ago. But fossills from other species of the camel have been unearthed at the site dating to one million years ago (Le Tensorer. 2006) (Fig 1)

Moreover, the presence of remains of large-sized wild camel (*C. thomasii*) in Marocco in association with Palaeolithic man in Acheulian and Mousterian times (80 000- 15 000 B.C.) as mentioned by Zeuner (1963), as well as the findings in Negev Desert and Syria may proof the early entry of wild camels into Africa.

Wild camels appear to have survived in North Africa into the Neolithic period. However, their complete absence from the early Saharan rock drawings and from writings and tomb and temple paintings of dynastic Egypt indicates that by historical times wild camels had died out in North Africa. The domesticated camels enter Egypt after that time. This may lead us to support the north route of domesticated camels entry via Sinai i.e. the north route of entry.

The domesticated camel entry

The one-humped camel or dromedary (*Camelus dromedarius*) is already sporadically attested in the Early Dynastic Period, but it was not regularly used until much later. Foreign conquerors (Assyrians, Persians, Alexander the Great) brought the camel on a greater scale to Egypt. Certainly in the Ptolemaic Period and perhaps already under the Persians (525-343 BC). The use of domesticated camels by the Romans is shown on some Roman coins depicting camels and memorize the victory of the Romans over the Nabataeans in 58 B.C.(Fig. 2) as well as in camel figurine and vessel fragment.

Many archaeological findings prove the camel presence in **Egypt** such as:

- a pot for ointment found by Moller (1906) at Abusir-el-Melek, about 20 miles south of Cairo;
- At Abydos, 75 miles south of Cairo, Petreie (1903) found a pottery head (5x4 inches) which seems certainly to be that of a camel;
- Schweinfurt (1912) described an engraving from Gezireh near Aswan, which is combined with a hieratic inscription, both being heavily painted, If date is correct or not, is a matter of question (suggested date is 2350-2180 B.C., in the sixth dynasty;
- There is a gap until the 19th dynasty (ca.1170 -1090 BC). From this period a pottery dromedary statuette burdened with two jars was found in a northern tomb at DierRifeh near Assiut, about 200 miles south of Cairo;
- A rock carving was found in Upper Egypt and in Gabal El-Owainat in south Egyptian-Libyan desert which date back to 200-700 B.C (Fig. 2);
- Another finding was mentioned by a glazed dromedary figure on painted water jars was found at Benha. Its black painting on blue glaze is regarded as suggestive of an age prior to the 26th dynasty, and Von Borsing assigns to it a Ramesside age. The figure was excavated by Freiherrvon Bissig in 1909;

- A 3.5 ft cord of camel hair from Egypt dated around 2500 BC. Buillet (1978) believes it is "from the land of Punt, perhaps the possession of a slave or captive, and from a domestic camel."
- A bronze figurine from the temple of Byblos in Lebanon. It is in a foundation with strong Egyptian flavoring, and is dated before the sixth Egyptian dynasty (before 2182 BC). Although the figure could be taken as a sheep, the figure is arranged with items that would strongly require it to be a camel; for example, a camel saddle, camel muzzle);
- Two pots of Egyptian provenance were found in Greece and Crete, both dating 1800-1400 BC, but both in area so far removed from the range of the camel as to suggest its presence in the intermediate areas (e.g., Syria or Egypt) during an earlier time. Both have camels represented, and one literally has humans riding on a camel back;
- Painted vessel fragment depicting a woman atop a camel, found in Egypt about A.D. 364-476.Height x width x depth: 12.5 x 18.5 x 2 cm Pottery. It is kept in Museum of Fine Arts, Boston (Fig 2);
- Toy camel carrying pack; made of lead from the Roman time, said to be from Egypt; first century CE. Kept in the British Museum, London; and
- Pusch (1997) described shreds belonging to a dish made of local Nile clay and depicting the remains of an incised representation of a dromedary were found at the site of Qantir/Piramesses, Nile delta, Egypt. He said that this object must be dated to the 18th or early 19th Dynasty (Ca, 1300 B.C).

Fig 2. Roman coins depicting camels (Dromedary) with olive branch (3) & Painted vessel fragment depicting a woman on top a camel. Egyptian about A.D. 364-476 pottery. Museum of Fine Arts, Boston (4) & Rock drawings of the dromedary camel found in Gabal El-Owainat Egypt-Libya (200-700 B.C.) (5)

In the fifth century B.C., the Persians brought camels to **Nubia**. Unlike horses, camels are notorious animals for enduring the harsh desert environments and they are capable of carrying heavy imports for long distance travels. However, the Kushites did not

tame the camels as much as the Nobatians. (Nobatians are desert Nomads who conquered Kush around the third century CE.) At their royal graves, the Nobatians extensively slaughtered and buried camels with the deceased camel owners A camel figuren from Nubia is found.

At the beginning of the Roman period, the dromedary had acquired the place it holds in Egyptian trade today. Many figurines showing it as a beast of burden were found.

In **Libya,** we can trace the spread of camel through the rock and cave paintings of camels and camel and hunterinAcacus Mountains, Sahara (Fig 3)

In **Algeria**, the palaeontological evidence for the presence of wild dromedary (or possibly a very closely related evidence form, *C. thomasii*) is found in north-west Africa at Palikae (also called Ternifine) in western Algeria (Zeuner, 1963).

- In "Tassill-n-Aljer" (a mountain range in the Sahara desert in southeast Algeria) in some caves many rock paintings for camels and riders were also discovered. These caves date back to 1200 B.C. (Fig. 3)

In **Jordan,** on Jebal Umm Ishrin, Wadi Al-Rom there are many Rock drawings depicting camel caravans and camels (Fig 4). In Petra, a camel drawn on a mosaic floor, which is about 300 years B.C. Moreover many camel figurines were also found and kept in different museums.

In **Syria**, In addition to the fossilized camel bones discovered in 2006, some depiction from Tell Halaf (described by Oppenheim, 1931) proves the presence of the domesticated camel, saddled, and with the rider on the top of the hump.

- Some camel figurine from the Nabatean period (about 1st century B.C.) were also discovered in Homos and Hamah and were kept in Metropolitan and Louvre museums, as well as the National Museum in Damascus.It dates from about 900 B.C. (Fig 5).

Fig 3.Rock Painting of Camel and Hunter (6) & Rock Painting of Camel from WadiTashwinet, Tadrart Acacus, Libyan Sahara (7) & Rock art for a dromedary from "Tassill-n-Aljer "in Algeria & Rock Painting of Camel and Hunter (8)

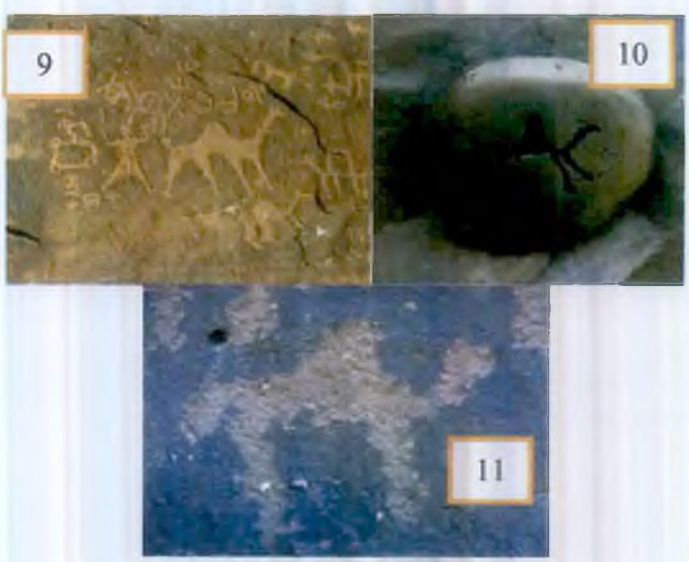

Fig 4. Thamudic inscriptions carved 2000 years ago by Arabian tribe of camel caravan on Jebal Umm Ishrin, Wadi Rum, Jordan, Middle East (9) & Rock art on rocks depicting camel, found in Petra, Wadi Rum and the eastern desert (10) & Rock art on rocks depicting camel, found in Petra, Wadi Rum and the eastern desert (11)

Fig 5. Silver figure of a camel and riders from the Nabataean period (ca 1st century B.C. - 1st century A.D.) found in Levant or Syria , kept in Metropolitan Museum, New York (12) &Camel-shaped vessel, from Homs, Syria, Terracotta (1st BCE). Height 14 cm Inv. National Museum, Damascus, Syria (13)

- A final piece of strong evidence is textual from Alalakh in **Syria**, as opposed to archaeological: a textual ration-list. There is an entry for 'camel fodder' written in Old Babylonian. Not only does this attest the existence of camels in northern Syria at this time, but the animal involved is clearly domestic.

There is some evidence that the domesticated dromedary was known in **Babylonia** before first Semitic invaders of the lands around the Euphrates. By about 2000 B.C. dromedary-using Semites were settled in Chaldea on the south side off the Euphrates.

- The Assyrians had plenty of quarrels with Arabs, who made full use of their ability to withdraw on their dromedaries into the desert where the horse-riding Assyrians could not follow (Zeuner, 1963). Reliefs from Nimrud illustrate fights with Arabs under Tiglathpileser III (745-727 B.C.) until the final destruction of the sheikhdoms by Ashurbanipal (668-626 B.C,). A depiction from series of well-carved scenes from the reign of Assurbanipal show Assyrian cavalry triumphing over Arab camelry (Fig 6); and
- Another proof of the presence of camels in Iraq is a camel figurine found in Nineveh, Mesopotamia (Iraq), which is related to the Period of Sennacherib (704-681 BC). It is kept in the British Museum, London (Fiog 6)

Fig 6. Assyrian relief showing the use of camel in wars against Arabs (7th century B.C.) . Note the two riders on the top of the camel (14) & Man on crouching camel Bronze figurine. Period of Sennacherib (704-681 BC) from Nineveh, Mesopotamia (Iraq), British Museum, London, Great Britain (15).

The Second Hypothesis of the South Route Entry into Africa

The second hypothesis of the south route entry of camels into Africa is based on archeoligical findings in many stops along this route such as Egypt, Sudan (Nubia), Ethiopia, Somalia, Yemen, Arabia, Oman, and Gulf area.

The dromedary appears first to have been domesticated in the southern Arabian Peninsula. Between 3000 and 2500 B.C, it is suggested that coastal peoples there switched from hunting camels to herding them for their milk. The camel subsequently spread to Somalia between 2500 and 1500 B.C., and then northward and across to Egypt in the first millennium B.C. This expansion may have been connected with the growth of the incense trade.

As advocated by Bulliet (1975), camels were present in Africa during pre-Roman times. They first entered Africa through southern Arabia and the Horn of Africa. Bulliet supports his contention with a number of facts:

First, Somali camel husbandry is very similar in its focus on milk production to the southern Arabia management type and in marked contrast to Saharan patterns of utilization that concentrate on using the animal as a beast of burden.

Secondly, Bulliet contends that it is unlikely that camel husbandry could have spread into Somalia from the north, i.e., via the Sudan, since differences in climatic regime would have interfered with the camel's reproduction (Farah et al, 2004). By contrast, the climate in Somalia (including northeastern Kenya) and southern Arabia is very similar, especially concerning the monsoonal rainfall scheme, which is a determining factor in the camel's breeding season.

Thirdly, there are technological parallels between camel saddles in Somalia and the island of Socotra, which Bulliet presumes to be a staging point in the spread of the camel from Arabia to Somalia. This last presumption is supported by Socotran rock drawings of camels that are tentatively dated to the 10th century B.C. (Köhler-Rollefson, 1993).

The findings of archaeological excavations and research in **Somalia** (as the first stop after crossing the red see from Yemen) show that this civilization had an ancient writing system that remains un deciphered, and enjoyed a lucrative trading relationship with Ancient Egypt and Mycenaean Greece since at least the second millennium B.C., which supports the view of Somalia being the ancient Kingdom of Punt.

Ancient Somalis domesticated the camel somewhere between the third millennium and second millennium B.C. from where it spread to Ancient Egypt and North Africa.
Somalia has been inhabited by man since the Paleolithic period. Cave paintings dating back as far as 9000 BC have been found in northern Somalia. The most famous of these is the LaasGeel complex, which contains some of the earliest known rock art on the African continent. Inscriptions have been found beneath each of the rock paintings, but archaeologists have so far been unable to decipher this form of ancient writing. During the Stone Age, the Doian culture and the Hargeisan culture flourished here with their respective industries and factories. (Wikipedia, History of Somalia, 3/6/2011).An ancient rock art depicting camel was found in LaasGeel, Somali (Fig 7)

Altogether, Bulliet's scenario, which draws on such a wide variety of arguments, is credible and appealing. The presence of a "colony" of domesticated dromedaries of southern Arabian origin in the Horn of Africa during the 1st and possibly as early as the 2nd millennium B.C. could also account for occasional pre-Ptolemaic incursions into areas further north, such as Sudan and Nubia. It is possible that a population of domesticated dromedaries existed in a circumscribed area in the Horn of Africa much earlier than 1st century B.C., and that occasionally camels or at least knowledge of and

In Beles, **Yemen,** a camel skeleton was found denoting its presence in this area (Peters, 1997) (Fig 8). Two alabaster stelae kept in Louvre Museum, France depicting camel and camel riders (Himiarite art that dated back to 115 B.C.) confirm the presence of domesticated camel in this area.

Verification of an early date for the introduction of the camel into Africa via Somalia will require systematic surveys and excavations to document the movement of an Arabian population into the Horn of Africa as well as the recovery of camel bones or pertinent artifacts from correlated stratified deposits (Köhler-Rollefson, 1993).

Fig 8.Ceramic camel figurines found in Muweilah (19) &Terracotta camel figurine, Salut, Oman dated back to close the late 2nd – first half of the 1st millennia BC (Early Iron Age period on Omani Peninsula) (20) & Camel Skeleton from Beles, Yemen (after Peters, 1997) (21).

Conclusion

- The archeological findings of large-sized camel bones in Syria, Negev and Marocco suggest the entry of wild camels (*Camelustomasii*) through North Africa via Sinai;
- In the same time the camel rock drawings and camel figurine found in Iraq, Syria Jordan, and Egypt support the north route of domestic camel entry into Africa from these areas.
- The presence of archeological findings in Yemen, Somali, and Nubia support the south route of camel entry into Africa after crossing the Red Sea. They spread then after northwards into Egypt and North Africa;
- The presence of archeological findings of camels in the gulf area, Oman, Yemen and Arabia along the course of the shores of the Arabian Gulf, the Indian Ocean and the

Red Sea may suggest the journey of the domesticated camels around Rub al Khali desert, northward to enter Africa through Sinai (east side of the Red Sea); and

- Camels were then spread along the Nile and/or Red sea southwards until Nubia and Somalia, a hypothesis which I support although the archeological findings are not satisfactory.

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The Mineral Nutrition and Imbalances in Camel: A Constraint in Pastoral Areas

Bernard FAYE[1], Mohammed. BENGOUMI[2], Rabiya SEBOUSSI[3]
[1]CIRAD, UMR SELMET, F-34398 Montpellier, France CIRAD-ES, Montpellier, France and Camel & Range Research Center, P.O. Box 322, Al-Jouf- Sakaka, Saudi Arabia
[2]FAO subregional Office, Tunis, Tunisia
[3]353 Rue des merles, Bouchervilles, J4B5Y5, Quebec, Canada

Introduction

The camel is adapted to the life in the dry areas and their vegetation characterized by their high heterogeneity in term of nutritive value with an important seasonal variation (Chehma et al., 2008). The length of the camel neck and legs permitting to access handsomely to tree foliages, he did not compete with the other herbivorous. The camel consumes woody plants (wattle) rich in nitrogen and minerals. The camel is also known for its thirst, heat, and protein deficiency resistance. It has developed in harsh conditions some remarkable physiological abilities (Faye, 1997) which contribute to its reputation. It is known also that this species is able to intake salty foodstuff and water without imbalance of the metabolic functions (Bengoumi, 1992).

From around twenty-five years, several applied and basic studies were performed on the mineral metabolism of the dromedary camel by several research teams, notably in Sudan (Abu Damir, 1998; Elrayah et al., 2010), Ethiopia (Faye et al., 1986), Morocco (Bengoumi et al., 1998a), Djibouti (Faye, 1993), India (Ghosal and Shekhawat 1992), in Arab Emirates (Wensvoort, 1992) or in France (Faye et al., 1995). The results have shown some peculiarities, which increase the ability of this species to be adapted to desert conditions, not only characterized by its aridity, but also by seasonal low availability of mineral resources. Indeed, mineral deficiencies— and sometimes mineral toxicity, which are widely present in domestic species notably in Africa (Van Schillorn et al., 1990), may occur in camel both for major or minor elements (Faye and Bengoumi, 1994). Thus, imbalances in mineral nutrition of camel widely exist, even if it is neglected by the veterinarians.

General Comments on Mineral Nutrition

The minerals are essential for all organisms. They contribute to the bone structure (calcium, phosphorus, magnesium), to the electrolytic balance (sodium, potassium), to the protein structure (iron in myoglobin and haemoglobin, copper in céruloplasmine), nervous and muscle activities (calcium, potassium) or to the enzyme activities (zinc, selenium) as well as vitamins (cobalt). According to the level of requirements, it is classical to distinguish major elements as calcium, phosphorus, magnesium, potassium, and minor or trace elements as iron, copper, zinc, selenium, manganese, cobalt, fluorine and others. Specific mineral deficiency could conduct to diseases as well as

their excess in the diet could provoke toxicity. The mineral imbalances could affect bone metabolism, provoke growth disturbances, loss of appetite, reproductive failure, immunodepression, abnormal feeding behavior (pica, osteophagy) or other symptoms. Elsewhere, numerous interactions between minerals were observed conducting sometimes to secondary deficiency or potentialization of the toxicity. The mineral imbalance could be linked to lack or excess of specific minerals in the diet, to poisonous plant, to bad feeding management or to environmental pollution. The environmental pressure on animals increasing, as well as the analytical tools improving, it is possible to determine also the presence of undesirable metals (cadmium, lead, mercury, and boron) accumulated in camel meat, milk or blood in order to assess their impact on camel health and production.

The camel, as all the herbivorous in pastoral areas is mainly dependant on the mineral composition of the natural rangeland. According to its biological adaptation to arid conditions where the electrolytic balance plays an important role, the failure in mineral nutrition could have dramatic consequences. Thereafter, a short review of the current knowledge in mineral nutrition is proposed by including main and trace elements.

Sodium and Chloride

The ability of the camel to intake a big quantity of halophyte plants is well known. Those resources are abundant in desert areas. This appetite for salty forages is explained by the adaptability of the species to the phyto-ecological context. Camel presents a high salt tolerance. Sodium and chloride concentrations in blood are higher in camel than in other herbivorous (Bengoumi, 1992; Kaneko, 1989). Increasing plasma sodium and chloride concentration is linked also with the water shortage, as they play a role in the osmotic pressure regulation. Hypernatremia and hyperchloridemia are observed in dehydrated animal with decrease of sodium glomerular filtration and increase of sodium and chloride excretion in urine (Bengoumi et al., 1993): after a 10-days dehydration, natremia increases of 20% and the tubular excretion in kidney increases of 90% leading to higher concentration of sodium (up to 64%) in urine (Mac Farlane, 1964). These effects are related to the increase of the plasma antidiuretic hormone. Aldosterone increases during dehydration (Riad et al., 1994). Therefore, the camel is able to intake diet with high level of salt and to regulate the plasma concentrations at a high level, which allow a metabolic resistance when transitory dehydration occurs.

The role of those electrolytes explains the camel preference for halophyte plants and the necessity for the farmers to assume a seasonal salty supplementation (salty cure). Therefore, the camel is sensitive to the salt deficiency. The sodium deficiency provokes skin necrosis, especially on the low parts of the limbs inducing severe lameness. The salt requirements for the camel are higher than in other species (around 20g/100kg body weight or 24 g/kg of dry matter). Requirements for milk production are estimated to be 2,5g/kg of milk. No supplementation is recommended for pregnancy.

Potassium

Potassium plays an important role in osmotic balance between cells and interstitial fluid. In camel, well adapted to dehydration/rehydration process, the metabolism of potassium is essential in the swelling-ability of red cells in case of rapid rehydration (Gharaibeh and Rawashdeh, 1993). Ten days dehydration leads to an increase of potassium in blood (+3%) and in urine (+14%) for the same reason than sodium. The anti-diuretic hormone (ADH) appears to play a major role in its metabolism (Yagil and Berlyne, 1976)

Calcium and Phosphorus

Vitamin D3 plays a central role in phosphor-calcic metabolism, notably by stimulating the intestinal absorption of food calcium and phosphorus. Thus, the plasma concentration in vitamin D3 (and more precisely in 1,25 dihydroxycholecalciferol which is its main metabolite) in camel is 10 to 15 times higher than in other ruminants, indicating a best assimilation of calcium and phosphorus (Riad *et al.*, 1994; El-Khasmi et al., 2011) (table 1). Indeed, the apparent absorption coefficients (AAC) assessed by different trials are 40 and 60% respectively for calcium and phosphorus in camel *vs* between 15 to 30% (Faye and Bengoumi, 1997) for sheep and cattle calcium and on 40% on average (with a variability of 10 to 70% according to the mineral origin) for phosphorus. The absorption ability is reinforced in milking camel and at the end of gestation. The metabolites of the vitamin D3 increasing the calcium rate in milk, those camel metabolic peculiarities allow the improvement of the calcium transfer to the camel calf. However, phosphorus deficiency has been observed in camel. In North Africa, the *Kraff* disease due to such deficiency is described with arthritis and peri-articular exostosis leading to gait failure, then paralysis. In Tunisia, the symptoms of *Kraff* occur when the ratio Ca/P is up to 6/1 in the fodder *vs* 1, 25/1 in healthy animals (photo 1). Severe phospho-calcic deficiencies could also provoke failure of feeding behaviour (pica, osteophagy) (photo2) often responsible of secondary diseases as botulism. In dehydrated animals, some slight changes in blood concentration are observed with a decrease of calcium and phosphates (Mabrouk et al., 2010).

Photo 1. Coastal bone deformation in camel affected by *Kraff* disease *(photo A. Mabrouk)*

Photo 2. Osteophagy in a camel affected by *Kraff* disease *(photo A. Mabrouk)*

The maintenance requirements are estimated to 4 g/100 kg B.W. or 3.3 g/kg D.M. for calcium and 2.5 g/100 kg B.W. or 2.1 g/kg D.M. for phosphorus. For lactating camel, the needs are 1.1g phosphorus and 1.9g calcium per litre of milk.

Table 1. Plasmatic concentration of principal metabolite of vitamin D3 in different herbivorous species

Type of animal	Level of 1,25 (OH)2 D (in pg/ml)	Reference
Non pregnant camels	835 ± 45	Riad, 1995
Ewe	50 – 60	Ross *et al.*, 1989
Cow	10 – 100	Horst *et al.*, 1983

Magnesium

Few data on magnesium metabolism in camel are available. Blood magnesium is generally stable, but camel seems to have no difference with other species. The normal value in adult camel is between 2.6 and 3mg/100ml (Barri et al., 2005). However,

some cases of deficiency are reported, notably in Djibouti on animals grazing the trees from the mangrove (Faye and Bengoumi, 1994). Some cases of hypomagnesaemia provoking reversible paresis with magnesium chloride supply have been described in India (Chandel, 1989). The maintenance requirements for magnesium are estimated to 3 g/100 kg B.W. or 2.5 g/kg D.M.

Copper and Caeruloplasmin (Cp)

Copper is one of the trace elements, i.e. a mineral in very low quantity in the animal organisms, but with fundamental necessity for some metabolic functions. So, copper is a component of cytochrome oxidase, lysil-oxidase, tyrosinase, and Cp, molecules that contribute to different enzymatic functions for oxygen using or protein metabolism. Some comparative results are available in the literature for different species of herbivorous (table 2). In almost all the cases (Faye, 1993), the copper rates in the camel blood appear higher. This difference could be attributed to the feeding behavior of camelids, which take off preferably the forage trees (including legumes) in the field, which are richer in nitrogen and in minerals. Indeed, as the interaction between nitrogen and copper is positive, the camel has a better copper status than typically grazing animals.

Table 2. Comparison of plasma copper concentrations in different species sampled (nb of animals into bracket) in the same country (in µg/100ml)

Camel	Cattle	Goat	Sheep	References
83(19)	64(29)	-	82(32)	*Moty et al, 1968*
95.3(19)	73.8(71)	78.9(24)	85(1)	*Tartour, 1975*
92.6(17)	86.2(30)	-	94.5(36)	*AbuDamir et al,1983*
94.3(122)	86.8(29)	-	88.3(34)	*Shekhawat, 1983*
45(8)	37.2(9)	41.8(8)	24.7(20)	*Faye et al, 1984*
107(53)	64,5(432)	95.1(173)	89.2(425)	*Faye et al, 1986*
60.7(52)	73,8(59)	94.5(118)	87.2(80)	*Faye et al, 1991*

However, in experimental situation, reverse facts are observed (Bengoumi *et al.*, 1998a): compared to cattle receiving quantitatively and qualitatively identical diet, camels show a lower copper rate in the blood (fig. 1).

The apparent absorption rate measured by the difference between the intake and the excreted part seems lower in camel when a supplementation is missing (75-80%) than in cattle (85-86%), but the ratio is reverse when copper supplementation is available (65% for camel *vs* 61% for cattle). Those results could suggest that the copper requirements in camel are lower than for other ruminants. However, in case of specific supplementation, the camel seems to present a better ability of apparent absorption, using this favorable provisory nutritional context as anticipation for deficient period.

In Ethiopia, the copper deficiency that occurs in the Rift Valley (Faye et al., 1991) was never observed in camel, contrary to other ruminants. Even in camel with very low copper level in serum (Faye, 1993) did not present copper deficiency symptoms.

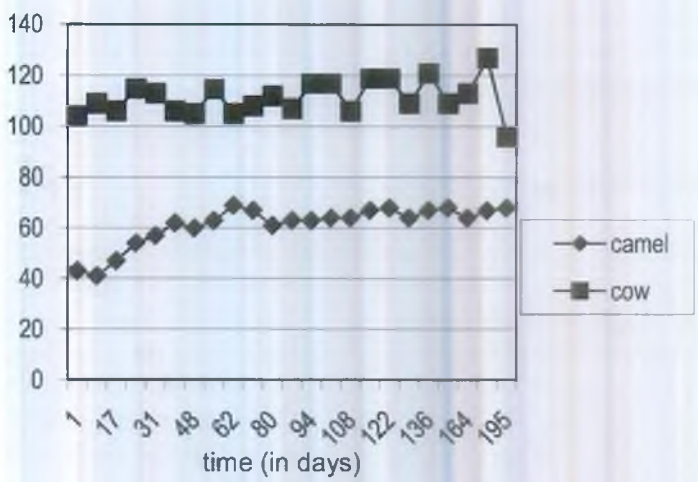

Figure 1. Compared change in plasma copper concentration in camel and cattle (in µg/100 ml) having identical basal diet and mineral supplementation (Bengoumi et al., 1998a).

Cp is a ferroxidase that is present in the plasma of all the mammals. It contains more than 95% of the circulating copper and plays multiple roles in the iron metabolism. In all domestic species as for camel, a significant correlation between plasma copper and Cp is observed. However, compared to other ruminants, the camel Cp shows two peculiarities: on one hand, the correlation coefficients are less good (table 3); on the other hand, the most appropriate correlation is not linear (Essamadi *et al.*, 1999a). On the most species, the oxidatic activity of Cp decreases when the animal shows a copper depletion. In case of severe deficiency, the decreasing of this oxydatic activity in camel is not linear. At reverse, the oxidatic activity is maintained in spite of low copper plasma level.

Table 3. Correlation coefficients Copper-Caeruloplasmin in cattle and camel according to different authors

Correlation value Cu-Cp (r value)	Number of analyses	Animal status	References
Camel			
0.67	115	Cu-supplemented	Essamadi *et al.*, 1999
0.84	95	Cu- injection	Bengoumi *et al.1998*
0.79	95	Cu-supplemented	Bengoumi *et al.1998*
0.60	95	No- suplementation	Bengoumi *et al.1998*
0.67	95	Zn-injection	Bengoumi *et al.1988*
0.68	107	Cu-defficient	Faye *et al.*, 1986
0.72	52	No-supplementation	Faye et Mulato, 1990
Cattle			
0.87	115	Cu-supplementation	Essamadi *et al.*, 1999
0.87	48	No-supplementation	Chacornac *et al.*, 1986

Recent studies on the purification of camel Cp seem to show that the structure and characteristics of this molecule are different from other ruminants (Essamadi *et al.*, 1999b). Elsewhere, the plasma Cp significantly increases in copper supplemented animals. Some comparative studies show a better response of camel with a more important increasing than in cattle having identical supplementation (Essamadi *et al...*, 1999a).

Those observations could suggest that the camel is able to maintain its metabolic activities linked to Cp in spite of deficient status, and to react more rapidly to a transitory mineral complementation. Reversibly, the precision and the convenience of the Cp measurement in camel plasma could be debatable in case of copper deficiency.

The maintenance requirements for copper are estimated to 15 mg/100 kg B.W. or 12.5 mg/kg D.M.

Zinc and superoxide dismutase (SOD)

Zinc is an essential biological element, which is included in several enzymatic systems having action in protein synthesis (notably keratogenesis) and immune functions. Therefore, zinc deficiency provokes skin affections and immunity depression. Superoxide dismutase is an intracellular enzyme, copper or zinc-dependant: zinc stabilize the enzyme and copper is necessary for its catalyse (Panemangalore and Bebe, 1996). The enzyme SOD acts as an anti-oxidant and protects the tissues against the peroxidation of the lipids. In general, there is a positive correlation between SOD activity and plasma zinc and copper level (most of the studies involve human or mouse). Few data are available on domestic herbivorous and one reference only for camel (Bengoumi *et al.*, 1998b).

In this last study where camel is compared to cattle, a positive correlation between plasma zinc level and SOD activity is observed in cattle with a low but significant coefficient ($r=0.396$, $p < 0.05$). In camel, this correlation is significant but negative ($r=- 0.369$, $p<0.05$).

Elsewhere, the results involving intra-erythrocytes SOD activity show observed values similar to human and quite different from other cattle. In the former trial where the animals received a copper-zinc supplementation, this negative correlation could be explained by the competition between copper and zinc on the SOD enzyme sites. Contrary to cattle, plasma zinc concentration does not increase in supplemented camel, that allow copper to invade the enzyme sites. At reverse, in cattle, plasma copper and zinc increase simultaneously in case of supplementation and the competition between those 2 elements is not so strong.

The most important point concerning zinc is in fact:

- from one hand, the absence of effect of a diet enriched with zinc on the zinc plasma status, contrary to other species; and
- to another hand, the low normal plasma zinc level compared to other animal species (in camel, normal values are between 35 and 45 µg/100 ml *vs* 70 à 120 µg/100ml in other species) (Faye and Bengoumi, 1994; El-Rayah et al., 2010).

This implies that:

- in camel, zincemia is not a good indicator of the mineral status in this element and of the SOD activity;
- the camel is able to maintain intracellular enzymatic functions zinc-dependant in spite of a low circulating zinc level; and
- Zinc requirements in camel seem lower than in other species.

At reverse, as the zinc plays an important role for the skin protection, the low level of plasma zinc could have a relationship with the high sensibility of camel to skin diseases (mange, ecthyma, camel pox, dermatitis, skin necrosis, ringworm)(photo 3). The immune level in young camel could be debatable also because the role of zinc in immune process. Indeed, the mortality rate in young camel remains quite important. Current experiments are achieved in order to measure the zinc level at the skin for estimating the role of local zinc status in the skin immunology (Driot et al., 2011).

The maintenance requirements for zinc are estimated to 50 mg/100 kg B.W. or 60 mg/kg D.M.

Photo 3. Acute ringworm in a camel (photo A. Thevenot). Skin disease sensitivity could be linked to zinc deficiency

Selenium and glutathion-peroxidase (GPx)

The requirements of herbivorous in selenium are very low (1 to 2 mg/day), but this element acts in numerous biological oxidative process. Notably, it contributes to the cells protection and has a positive effect for the cancer protection in human. A selenium deficiency in the diet is linked to a former

common disease in the modern farms affecting the calves, the white muscle disease, which shows a muscular degenerative process (notably the heart), added with a characteristic discoloration which gave the name to the disease.

Recent data are available and a review was published (Faye and Seboussi, 2009). For a long time, selenium deficiency has been suspected to occur in camels kept in zoological parks affected by cardiopathy or myopathy (Finlayson et al., 1971; Wisner and Schotke, 1975; Decker and McDermid, 1977) but no clinical descriptions and laboratory analysis have been made in these reports to confirm the role of selenium. In China also, Liu et al., (1994) suspected selenium deficiency in cases of sway-back in Bactrian camel. However, selenium deficiency with characteristic clinical signs has been recently reported in Emirates. Selenium deficiencies affect generally young animals and are responsible for white muscle disease, a degenerative muscle disease affecting muscle including the heart. Indeed, the most important lesions are degenerative myocarditis and discoloration of skeletal muscle. In the UAE, soils and feedstuffs are generally considered deficient in selenium, and many cases of degenerative myocarditis (Photo 1a and b) are observed with histological lesions similar to those in cattle (El-Khouly et al., 2001; Seboussi et al., 2004) (photo 4). Selenium deficiencies have been also described in Morocco (Hamliri *et al.*, 1990a and b).

Photo 4a. Degenerative myocarditis lesions in the heart of a one-month old camel calf (*Photo: R. Seboussi*)

Photo 4b. Degenerative myocarditis lesions in the heart of a one-month old camel calf (*Photo: R. Seboussi*)

To our knowledge, the first trial achieved to assess the effect of selenium supplementation on the plasma selenium status was reported by Bengoumi et al., (1998c). In this experiment, the selenium status of camels was compared with that of cattle with similar weight and receiving daily 2 mg Se *per os* under sodium selenite form for two months. The results showed a sharper increase of plasma selenium occurring in camels (10 times the plasma level before supplementation) compared to cows (twice the starting level) (figure 2). As the magnitude of the decrease of plasma selenium concentration after stopping supplementation was similar to the previous increase, it was supposed that plasma (or serum) selenium concentration in camel was an extremely sensitive indicator of selenium intake. The fast selenium depletion at the end of the supplementation period seemed also to indicate a better efficiency of selenium absorption and excretion in camel compared to cow.

For its transport in blood, selenium is linked to specific protein (selenoprotein) including glutathione peroxidase (GSH-Px). In the comparative study of Bengoumi et al., (1998c), the increase of GSH-Px activity was similar in camels and cows for the supplementation period with a higher correlation in camels ($r = 0.94$) than in cows ($r = 0.68$). As for other species, GSH-Px is a good indicator of the Se status of camel. However, after the end of the supplementation, GSH-Px activity continued to increase in camels' blood while it was stable in cows' (Figure 3).

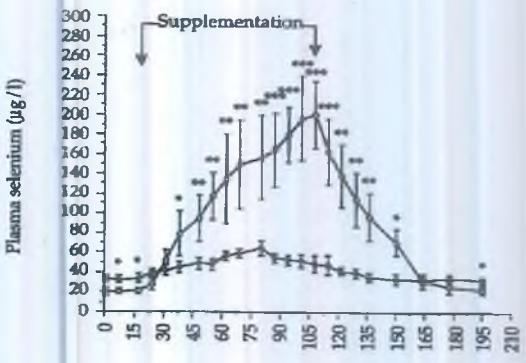

Figure 2. Comparative change in plasma selenium concentration in cow) (and dromedary camel (o) receiving 2 mg/day selenium under sodium selenite form (Bengoumi et al., 1998b).

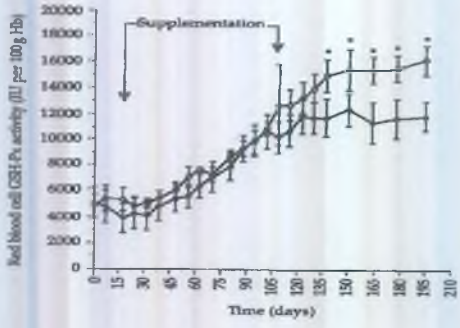

Figure 3. Comparative change in GSH-Px activity in cows (•) and dromedary camels (o) receiving 2 mg/day selenium under sodium selenite form

A similar figure was observed by Seboussi et al. (2008). The erythrocyte GSH-Px activity being closely related to the half-life to the red blood cells, the enzymatic activity was higher in camels than in cows when selenium was depleted because of the longer survival of camel erythrocytes (Yagil et al., 1994).

At our knowledge, only experimental selenosis has been reported (Faye and Seboussi, 2008, Seboussi et al., 2009). The first clinical disturbs appeared with a selenium supplementation of 8 mg/day. The clinical symptoms observed in camel were in accordance with previous signs reported in chronic poisoning in other species, especially the foot lesions (photo 5). The question of the Se poisoning threshold in camel has not been clearly determined. The levels listed in other species are higher than the dietary levels in the studies performed on camel (Seboussi et al., 2009b), i.e. 0.051 to 0.095 mg/kg LW, which seems to show a high sensitivity of camel species to Se toxicosis. The levels of selenium requirement and toxicity could be very close.

Photo 5. Fissured pads with necrosis on foot of camel receiving 16 mg Se/day (*Photo R. Seboussi*).

As the whole, the metabolism of selenium in camel is quite comparable to that of the other herbivorous with similar diseases in case of deficiency or toxicosis, comparable values in serum and organs and comparable way of excretion. However, some specificity could be observed: the richness of camel milk in selenium, the role of faecal excretion in case of intoxication, the apparent sensitivity to toxicity, and the high concentration in blood with high Se supplementation. Selenosis appeared with 0.05 mg/kg LW Se supply only. Severe intoxication occurred with 16 mg Se supplementation, i.e. 0.10 mg/kg LW. These values were 5 times lower than those for sheep and cattle. Based on these results (Seboussi et al., 2009 a, b and c), it seems essential to limit Se supplementation in camel at 0.01-0.02 mg/kg LW, i.e. approximately 4-8 mg per day for adult animals or 0.5-1 ppm in the diet. Recent result has shown that camel diet enriched in barley could improve the selenium status of the camel in case of risk of deficiency (Althamna et al., 2011).

Fluorine

The requirements in fluorine are low and usually the supply is widely sufficient in the diet. However, fluorosis, i.e. fluorine toxicity has been described in camel in Egypt (Karram *et al.*, 1989) and in Morocco (Diacono et al., 2007) essentially in areas with phosphates deposits (hydrotelluric fluorosis) and phosphate manufacturing plants (industrial fluorosis).

Fluorine is characterized by its high chemical affinity to calcium and calcified tissues, including bone and teeth (photo 6). The main lesions due to fluorine intoxication are modification of color, structure, and orientation of teeth, and structure and texture of bones. Fluorosis has an important impact on animal health and welfare. The precocious grinding of teeth is responsible for the low production level of milk and meat and precocious animal culling. Meanwhile, the severity level of intoxication is variable towards different factors. The major extrinsic factors are fluorine content in feed and water, exposition duration, feed characteristics—quantity, nature, and solubility of fluorine compounds and phosphor-calcic balance, season and stress.

Photo 6. Specific teeth lesion in a camel affected by fluorosis (*photo M. Bengoumi*)

The fluorine plasma concentration is the expression of the fluorine intake, and the normal value is under the limit value of 0.3 ppm (Kessabi et al., 1984. This value increased significantly in case of intoxication but the normal level is higher in adult because the fluorine fixation is more important in bones and teeth during the growth in young animal than in mineralized bones of adult animal.

Other Minerals

The requirements for iron, manganese, cobalt, molybdenum, sulphur are similar than for other ruminants. Deficiency or toxicity was rarely described in camel, and analysis not commonly achieved except for iron (Shekhawat et al., 1987). Only anemia (iron deficiency) linked to parasitic disease as trypanosomosis was described (Ibrahim *et al.*, 1992), but the symptoms were not linked to low mineral concentration in the diet. The molybdenum and the sulphur in excess in the diet could provoke a secondary copper deficiency (Faye and Bengoumi, 1994) as for other ruminants. The sulphur is also an essential element for animals used in wool production. One case of sulphur intoxication in camel was described in Egypt (Karam et al., 1989).

Conclusion

The camel mineral metabolism seems to anticipate mineral under-nutrition periods of its life. It signs its adaptation to this feeding restriction by different ways: increasing the absorption capacity in case of deficiency, higher ability to store some minerals, higher tolerance to some electrolytes, and maintenance of basal enzymatic activities in spite of deficient situations. However, in some cases, it seems to be more sensitive to some excess or to imbalances. In fact, the adaptation to desert means an addition of small metabolic improvements which do not bring a comparative advantage when they are considered one by one, but which give a sense to the reputation of this species when they are considered as the whole. It explains probably that the camel is able to survive in the conditions of the desert areas.

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Phenotypic Characterization of Camels in Afder, Jijiga and Shinile Zones of Somali Regional State

Hassen Abdurehman, Muhyadin Mohammed, Sisay Tilahun, and Barre Abdurehman
Somali Pastoral Agro-pastoral Research Institute
Jijiga, Ethiopia

Introduction

Morphological or phenotypic characterization has been suggested and used to describe and classify breeds of farm animal species (FARM-Africa, 1996; Capote *et al.*, 1998; Herrera *et al.*, 1996; Lanari *et al.*, 2003; Nsoso *et al.*, 2004). Morphological data are cheap and easy to obtain, in comparison to molecular data. The advantages of morphological data are that it is relatively easily obtained, requiring relatively inexpensive instrumentation in comparison to molecular instruments (Desalle and Grimaldi, 1991). Furthermore, the generation of morphological data through the comparison of individuals is greatly facilitated by easily identifiable homologous structures based on variation in shape, number, relative position, size, and structure.

In an effort to establish standard methodology in the phenotypic characterization of traditional livestock breeds in Africa, the inclusion of several parameters at various levels of studies have been illustrated (Baker, 1992; Matheron and Planchenault, 1992). The existence of substantial animal variability, like among the indigenous breeds of Africa (Matheron and Planchenault, 1992), necessitates the collection of extensive data beyond morphological traits to characterize indigenous animal population. In addition to physical characteristics, phenotypic characterization of livestock breeds should also include information on population size, flock size and composition, production performance estimates and information on the production environment and husbandry conditions, which are known to play a vital role in trait expression.

Therefore, this study was aimed at identifying and documenting the similarities and differences between traditionally distinguished types of indigenous camel breeds of Somali region in Ethiopia through phenotypic characterization of their morphological traits such as coat color, shape of nose, shape of ears and different body measurements.

Materials and Methods

Description of Study Area

This study was conducted in Jijiga, Shinile, and Afder zones of Somali region of Ethiopia. The study areas thus geographically lie i.e. Afder (Latitude 5°15'N longitude 43°00'E), Jijiga (latitude 9°21'N Longitude 42°48'E) and Shinile (Latitude 09°41'N Longitude 41°51'E).

Sampling

The sampling process was structured in a multistage cluster sampling method conforming to the hierarchical administrative set-up of the region. The distribution of each of the locally known camel populations was delimited relative to the administrative boundaries of districts (*wereda*). Sampled *weredas* were selected based on a relatively large camel population size and accessibility. Overall, the survey was conducted in three zones and each zone represents a *sampling unit*. Each of the zones consisted of a number of kebeles and further consisted of clusters of districts within which a number of camel herds are occurred. That is, sampling sites were clustered within each sampling unit. Thirty kebeles were selected from the sampling units. Data have been collected from camel herds that were available in a number of villages by walking across in a defined transect trajectory in each of kebele.

Data collection

Trait checklist was used for collecting data from individual animals and body measurements have been performed on 420 camels from six camel types. Information on coat color, shape of nose, shape of lips, and shape of ears were recorded.

Body measurements were taken from camels of both sexes (with male to female ratio of 1:5) different body condition, and varying age (4-30 years). Accordingly, 20 different body measurements were taken from each camel. Measurements were taken using measuring tapes while the animals were either standing at ease on a level surface or sitting in sterna recumbence depending on the measurement taken.

After recording the body measurements, the estimated live weight for each animal has been calculated according to the formula given by Evans *et.al.* (1995):

*Live weight=shoulder height*heart girth*abdominal girth (all in meters)*50*

Data Analysis

The data collected from the field and secondary sources were analyzed by descriptive statistics such as Mean, standard deviation (SD). Min, Max, Percentage, etc.

Result and Discussion

Phenotypic characteristics

Camel breed types and their distribution

The indigenous camel breed in Somali regions falls under six traditional categories namely Aydin", "Ayun", "Cagwayn", "Hoor", "Ayro," and "Geellab." As it is shown in Table 1, 33.3% and 66.7% of "Aydin" camel breed type is found in Jijiga and Afder areas of Somali region, respectively.

Similarly, "Ayun" breed type is found in Jijiga (52.7%) and Shinile (47.3%). Majority of "Cagwayn" (97.4%) and "Hoor" (99.4%) breed types are found in Jijiga and Afder, respectively. whereas very small number of "Cagwayn" (2.6%) and "Hoor" (0.6%) are found in Shinile and Jijiga areas respectively. However, almost all "Ayro" and "Geellab" breed types are found in Shinile and Afder zones accordingly.

Table 1. Distribution of local camel breeds types

Type		Study location			Total
		Jijiga	Shinille	Afdher	
Aydin	Count	15	0	30	45
	%	33.3	.0	66.7	100.0
Ayun	Count	29	26	0	55
	%	52.7	47.3	0	100.0
Cagwayn	Count	38	1	0	39
	%	97.4	2.6	0	100.0
Hoor	Count	1	0	167	168
	%	0.6	0	99.4	100.0
Ayro	Count	0	56	0	56
	%	0	100.0	0	100.0
Geelab	Count	0	0	51	51
	%	0	0	100.0	100.0
Total	Count	83	83	248	414
	%	20.0	20.0	59.9	100.0

Physical characteristics of camel breeds

As far as phenotypic characterization of these six indigenous camel breed types is concerned, obtaining general and/or specific physical features that can be employed to describe and differentiate these breed types is very crucial. Hence, 4 phenotypic descriptions (Coat color, shape of nose, shape of lips, shape of ears) and different body measurements such as SH, HG, AG, etc has been measured and identified for each of the sample animals. Accordingly, the following analysis summarizes the morphological traits/physical features with breed type.

Coat color

Six different categories of colors (i.e. White, cream, brown, grey, black and red) have been used to differentiate one type from the other. However, the results revealed that most of the studied local camel breed types have more or less similar physical features (white, cream, brown, and grey, black). As shown in the local breed and coat color (Table 2), "Aydin" local camel breed types have cream (22.2%), brown (22.2%), and grey (20%) coat colors. "Ayun" breed types were found to have white and black coat colors where as "Cagwayn" breed types also fall under two coat color categories of cream (44.7%) and white (36.8%). On the other hand, "Hoor," "Ayro" and "Geellab" camel breed types tend to have Brown and black coat colors, i.e. 55.4%, 46.6% and 45.1% respectively.

Table 2. Coat color of local camel breed types

Type		Coat color					
		White	Cream	Brown	Grey	Black	Red
Aydin	Count	7	10	10	9	8	1
	%	15.6	22.2	22.2	20.0	17.8	2.2
Ayun	Count	16	4	11	6	16	0
	%	30.2	7.5	20.8	11.3	30.2	0
Cagwayn	Count	14	17	1	4	2	0
	%	36.8	44.7	2.6	10.5	5.3	0
Hoor	Count	21	45	93	0	9	0
	%	12.5	26.8	55.4	0	5.4	0
Ayro	Count	12	1	17	1	27	0
	%	20.7	1.7	29.3	1.7	46.6	0
Geelab	Count	3	6	10	9	23	0
	%	5.9	11.8	19.6	17.6	45.1	0
Total	Count	73	83	142	29	85	1
	%	17.7	20.1	34.4	7.0	20.6	0.2

Shape of Nose

As summarized in Table 3, the percentage local breed type falling under each of the shape of nose category has been identified for the six local camel breeds. Accordingly, majority of "Aydin" (54.5%), "Ayun" (78.2%), "Cagwayn" (81.6%), and "Ayro" (62.1) and "Geellab" (54.9%) breed types have a flat shape of nose where as only "Hoor" (52.4%) has a concave nose shape while 28.6% and 19% has a flat and convex nose shapes respectively.

Table 3. Shape of noise of local camel breed types

Type		Shape of noise			Total
		Flat	Concave	Convex	
Aydin	Count	24	17	3	44
	%	54.5	38.6	6.8	100.0
Ayun	Count	43	5	7	55
	%	78.2	9.1	12.7	100.0
Cagwayn	Count	31	6	1	38
	%	81.6	15.8	2.6	100.0
Hoor	Count	48	88	32	168
	%	28.6	52.4	19.0	100.0
Ayro	Count	36	17	5	58
	%	62.1	29.3	8.6	100.0
Geelab	Count	28	17	6	51
	%	54.9	33.3	11.8	100.0
Total	Count	210	150	54	414
	%	50.7	36.2	13.0	100.0

Shape of Lips

As per the results shown in Table 4, apart from "Hoor" camel type; which has 49.4% pendulous and 45.8% tight, the remaining 5 camel breed types ("Aydin", "Ayun", "Cagwayn", "Ayro" and "Geellab") have tight shape of lips.

Table 4. Shape of lips of local camel breed types

Type		Shape of lips		
		Tight	Pendulus	Gaping
Aydin	Count	31	11	2
	%	70.5	25.0	4.5
Ayun	Count	38	13	1
	%	73.1	25.0	1.9
Cagwayn	Count	28	3	2
	%	84.8	9.1	6.1
Hoor	Count	77	83	8
	%	45.8	49.4	4.8
Ayro	Count	35	21	2
	%	60.3	36.2	3.4
Geelab	Count	39	10	2
	%	76.5	19.6	3.9
Total	Count	248	141	17
	%	61.1	34.7	4.2

Shape of Ears

According to the results of this study, 60%, 79.6%, 62.9%, 66.1%, 67.2% and 62.7% of Aydin", "Ayun", "Cagwayn", "Hoor", "Ayro" and "Geellab" camel types tend to have pointed shape of ears while the remaining 40%, 20.4%, 37.1%, 33.9%, 32.8% and 37.3% of these respective indigenous camel breed types tend to have round shape of ears.

Table 5. Shape of ears of local camel breed types (not cited)

Type		Shape of ears		Total
		Round	Pointed	
Aydin	Count	18	27	45
	%	40.0	60.0	100.0
Ayun	Count	11	43	54
	%	20.4	79.6	100.0
Cagwayn	Count	13	22	35
	%	37.1	62.9	100.0
Hoor	Count	57	111	168
	%	33.9	66.1	100.0
Ayro	Count	19	39	58
	%	32.8	67.2	100.0
Geelab	Count	19	32	51
	%	37.3	62.7	100.0
Total	Count	137	274	411
	%	33.3	66.7	100.0

On the other hand, if we look at the way coat color, shape of nose, shape of lips, and shape of ears are related with each other and with local camel breed types, there is a significant correlation between local camel breed types and coat color at 0.01 level and shape of nose is significantly correlated with local breed type, shape of ears and shape of lips at 0.05 and 0.01 respectively (Table 6). For the fact that our data is categorical, we have employed Kendali's and spearman's coefficient of correlation. The following table shows how these parameters are related.

Estimated Body weight differences

Generally, Aydin", "Ayun", "Cagwayn", "Hoor", "Ayro" and "Geellab" indigenous camel breed types showed significant difference in Estimated body weights as their mean estimated body weight (as calculated according to Evans formula 1995) is found to be 497.83±13.21, 400.48±12.477, 493.14±22.49, 541.12±5.7, 365.58±15.16 and 534.52±10.33 accordingly (Table 7). When we try to see this difference in terms of location, we find that indigenous camel breed types in Jijiga, Shinile and Afder have relatively higher ELW difference I.e. camel breed types in Afder have comparably the largest mean ELW (539.64kg±4.6) followed by Jijiga (464.477kg±10.90) and lastly Shinile area (366kg±9.68).

Table 6. LBN*CC*SN*SL*SE Correlations

			Name	Coat color	Shape of noise	Shape of lips	Shape of ears
Kendall's tau_b	Local breed name(LBN)	Correlation Coefficient	1.000	.176**	.091*	.045	-.024
		Sig. (2-tailed)	.	.000	.033	.307	.584
		N	416	413	414	406	411
	Coat color (CC)	Correlation Coefficient	.176**	1.000	.046	-.036	.007
		Sig. (2-tailed)	.000	.	.276	.409	.874
		N	413	429	427	420	424
	Shape of noise (SN)	Correlation Coefficient	.091*	.046	1.000	.146**	-.114*
		Sig. (2-tailed)	.033	.276	.	.002	.015
		N	414	427	430	421	426
	Shape of lips (SL)	Correlation Coefficient	.045	-.036	.146**	1.000	-.176**
		Sig. (2-tailed)	.307	.409	.002	.	.000
		N	406	420	421	422	420
	Shape of Ears (SE)	Correlation Coefficient	-.024	.007	-.114*	-.176**	1.000
		Sig. (2-tailed)	.584	.874	.015	.000	.
		N	411	424	426	420	427
Spearman's rho	Local breed name	Correlation Coefficient	1.000	.204**	.106*	.051	-.027
		Sig. (2-tailed)	.	.000	.031	.303	.584
		N	416	413	414	406	411
	Coat color	Correlation Coefficient	.204**	1.000	.048	-.040	.008
		Sig. (2-tailed)	.000	.	.321	.417	.874
		N	413	429	427	420	424
	Shape of noise	Correlation Coefficient	.106*	.048	1.000	.155**	-.118*
		Sig. (2-tailed)	.031	.321	.	.001	.015
		N	414	427	430	421	426
	Shape of lips	Correlation Coefficient	.051	-.040	.155**	1.000	-.179**
		Sig. (2-tailed)	.303	.417	.001	.	.000
		N	406	420	421	422	420
	Shape of Ears	Correlation Coefficient	-.027	.008	-.118*	-.179**	1.000
		Sig. (2-tailed)	.584	.874	.015	.000	.
		N	411	424	426	420	427

**. *Correlation is significant at the 0.01 level (2-tailed).*

*. *Correlation is significant at the 0.05 level (2-tailed).*

Table 7 Estimated Live weight.comparison between local camel breed types

Type	Mean	SD	Minimum	Maximum	SDE
Aydin	497.8383	86.68000	325.04	665.56	13.21858
Ayun	400.4812	92.53521	234.01	599.29	12.47745
Cagwayn	493.1401	140.46673	320.40	652.50	22.49268
Hoor	541.1239	72.86754	253.85	774.07	5.70743
Ayro	365.5842	115.51294	360.75	663.30	15.16759
Geelab	534.5214	72.34723	266.11	648.96	10.33532
Total	487.1366	113.83470	32.40	774.07	5.64258

Body size differences

For this study 20 different body measurements for all animals (SH, HG, AG, NCT, NCB, NL, HtL, HC, TL, LW, HW, AKL, KEL, EJC, FFL, FFW, HL, H_W, EL and EW) were taken and out of which mean SH, HG and AG difference between indigenous camel breed types has been considered for analysis. The above mean comparison table shows that mean SH, HG and AG difference for "Aydin", "Ayun", "Cagwayn", "Hoor", "Ayro" and "Geellab" indigenous camel breed types.

Similarly, their mean Shoulder height, heart girth and abdominal girth in "cm" was observed to be (186.5±1.5, 205.6±1.9 and 257.6±3.3), (176.4±1.1, 193.2±1.9 & 231±3.8), (180.6±4.2, 207.1±1.8 & 265.2±5.3), (189.3±0.7, 209.03±1.1 & 272.7±1.5), (175.9±1.3, 188.3±4.2 & 221.8±3.8) and (190.3±1.0, 208±2.8 & 269.3±2.4) for "Aydin", "Ayun", "Cagwayn", "Hoor", "Ayro" and "Geellab" respectively (Table 8).

Table 8. Shoulder height heart girth abdominal girth

Type		Shoulder height	Heart girth	Abdominal girth
Aydin	Mean	186.5778	205.6512	257.6977
	N	45	43	43
	Std. Deviation	10.57761	13.10195	21.83982
	Std. Error of Mean	1.57682	1.99803	3.33054
	Minimum	160.00	176.00	216.00
	Maximum	200.00	233.00	290.00
Ayun	Mean	176.4909	193.2545	231.6000
	N	55	55	55
	Std. Deviation	8.81680	14.28184	28.40944
	Std. Error of Mean	1.18886	1.92576	3.83073
	Minimum	160.00	161.00	171.00
	Maximum	196.00	221.00	301.00
Cagwayn	Mean	180.6154	207.1538	265.2051
	N	39	39	39
	Std. Deviation	26.69478	11.86445	33.22981
	Std. Error of Mean	4.27459	1.89983	5.32103
	Minimum	175.00	176.00	182.00
	Maximum	200.00	225.00	302.00
Hoor	Mean	189.3697	209.0368	272.7791
	N	165	163	163
	Std. Deviation	9.41731	15.05787	19.45746
	Std. Error of Mean	.73314	1.17942	1.52403
	Minimum	106.00	102.00	209.00
	Maximum	220.00	245.00	310.00
Ayro	Mean	175.9310	188.3448	221.8276
	N	58	58	58
	Std. Deviation	10.11489	32.10976	29.64239
	Std. Error of Mean	1.32815	4.21622	3.89224
	Minimum	162.00	90.00	58.00
	Maximum	200.00	268.00	250.00
Geelab	Mean	190.3265	208.0816	269.3469
	N	49	49	49
	Std. Deviation	7.26403	19.77039	16.80346
	Std. Error of Mean	1.03772	2.82434	2.40049
	Minimum	170.00	112.00	219.00
	Maximum	203.00	230.00	301.00
Total	Mean	184.7275	203.3022	257.2211
	N	411	407	407
	Std. Deviation	13.36481	20.07743	30.93224
	Std. Error of Mean	.65924	.99520	1.53325
	Minimum	160.00	90.00	58.00
	Maximum	220.00	268.00	310.00

Production performances

Some production performance evaluation traits like age at first calving, number of offsprings delivered and milk yield was studied and the results obtained reveals (Table 9), Mean age at first calving for Aydin", "Ayun", "Cagwayn", "Hoor", "Ayro" and

"Geellab" indigenous camel types is found to be 5.11±0.19, 4.41±0.08, 5.11±0.2, 5.46±0.05, 4.5±0.98 and 5±0.81 respectively while their mean number of offspring delivered is 3±0.46, 3.69±0.30, 5.6±0.69, 2.7±0.14, 3.11±0.24 and 2.6±0.19 accordingly. Similarly, the mean milk yield (lt) of these respective indigenous camel breed types per milking time has been found to be 1.45±0.20, 2.42±0.32, 3.8±0.37, 1.72±0.08, 1.92±0.17, and 1.55±0.16.

Table 9. Mean AFC, NOD, MY and MF comparisons

Type		Age at first calving	Number of offsprings delivered	Milk yield(Lts)/Milking time	Milking frequency/day
Aydin	Mean	5.1143	3.0000	1.4500	2.2222
	N	35	32	10	9
	Std. Deviation	1.13167	2.65184	.64334	.44096
	Std. Error of Mean	.19129	.46878	.20344	.14699
	Minimum	3.00	1.00	1.00	2.00
	Maximum	9.00	13.00	3.00	3.00
Ayun	Mean	4.4146	3.6905	2.4211	2.1667
	N	41	42	19	18
	Std. Deviation	.54661	1.96913	1.41680	.70711
	Std. Error of Mean	.08537	.30384	.32504	.16667
	Minimum	3.00	1.00	.50	1.00
	Maximum	5.00	8.00	5.00	3.00
Cagwayn	Mean	5.1176	5.6923	3.8000	2.4000
	N	34	26	5	5
	Std. Deviation	1.17460	3.54140	.83666	.54772
	Std. Error of Mean	.20144	.69453	.37417	.24495
	Minimum	4.00	2.00	3.00	2.00
	Maximum	9.00	15.00	5.00	3.00
Hoor	Mean	5.4640	2.7073	1.7292	2.3382
	N	125	123	72	68
	Std. Deviation	.56145	1.63332	.74559	.53561
	Std. Error of Mean	.05022	.14727	.08787	.06495
	Minimum	4.00	1.00	.50	1.00
	Maximum	7.00	8.00	3.00	4.00
Ayro	Mean	4.5333	3.1190	1.9242	2.6176
	N	45	42	33	34
	Std. Deviation	.66058	1.61097	1.02409	.85333
	Std. Error of Mean	.09847	.24858	.17827	.14634
	Minimum	2.00	1.00	.50	.00
	Maximum	6.00	8.00	5.00	4.00
Geelab	Mean	5.0811	2.6216	1.5588	2.2500
	N	37	37	17	16
	Std. Deviation	.49320	1.18676	.68196	.44721
	Std. Error of Mean	.08108	.19510	.16540	.11180
	Minimum	4.00	1.00	.50	2.00
	Maximum	6.00	5.00	3.00	3.00
Total	Mean	5.0757	3.1788	1.8846	2.3667
	N	317	302	156	150
	Std. Deviation	.83093	2.14766	.99165	.63897
	Std. Error of Mean	.04667	.12358	.07940	.05217
	Minimum	4.00	1.00	.50	.00
	Maximum	9.00	15.00	5.00	4.00

Conclusion

This study showed that there is a morphological and estimated live weight difference between breed types and within types in different locations. It was found that majority of the types where within brown, cream, and black coat colors, flat shape of nose, tight shape of lips, and pointed shape of ears. On the other hand, the study showed that "Hoor" type had the highest mean values of ELW followed by "Geellab", "Aydin", "Cagwayn", "Ayun," and "Ayro." Similarly, "Ayun" type had the least mean age at first calving while "Hoor" had the highest mean age at first calving. "Cagwayn" type had the highest mean milk yield (lt) per single milking time as compared to their indigenous camel breed types. However, the present information on the morphometric characteristics of these indigenous camel breed types could be complemented with genetic characterization using biochemical and DNA markers. This could aid field assessment, management, and conservation of these types of camel populations, where the objective is to obtain phenotypically pure local genetic resources for future selection and breeding improvement strategies.

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Materials and Methods

The study area

Goat milk samples for butter making were collected from pastoralists in Somali Regional State specifically from Hodle Kebele of Jigjiga Woreda. Jigjiga Woreda is one of the six administrative woredas of the Jigjiga Zone located at 750 km East of Addis Ababa at $9^0$21'N latitude and $42^0$48'E longitude. The Woreda is characterized by unreliable and erratic rainfall with a precipitation ranging from 300 to 600 mm per annum, high ambient temperatures (> 30 ^{0}C), sparsely distributed vegetation dominated by cactus and *Acacia* species, and bushy woodlands (Bekele, 2001). The altitude of the woreda ranges from 500 to 1500 m above sea level. This area is among the lowlands of the country where large camel population is found and known for its camel milk production.

Camel milk samples for butter making were collected from Erer. Erer is situated approximately 25 km, east of the town of Harar at an altitude ranging from 1300 m above sea level in the south to 1600 m above sea level in the north. It also represents one of the major camel milk producing areas in the country and has a semi-arid climate. The mean annual temperature of Erer is 21.75 ^{0}C. Shrubs and thorny bushes of *Acacia* and cacti origin dominate the vegetation (Bekele *et al.*, 2002).

Sample collection

Milk samples were collected from camels and goats from 15 and 35 households, respectively. The camels used for milk collection were at their second stage of lactation and third parity whereas the goats were at their second stage of lactation and fourth parity. After collection, the milk samples were brought to the Dairy Laboratory of Haramaya University by placing it under icebox.

For fermenting the milk 15 airtight plastic Jeri Can containers (10 liter capacity) were filled with four liters of either pure camel milk or camel milk blended with goat milk at different proportions and the milk samples were kept in the laboratory at room temperature (22 ^{0}C) until the required level of acidity, i.e., pH of 4.13, was attained. Forty liters each of camel and goat milk were collected from the areas mentioned above three times at a rate of 15 liters of milk at a time.

Treatments

The experiment had five treatments, i.e., T1, T2, T3, T4, and T5. T1 was 100 % camel milk, T2 was mixture of 75 % camel milk and 25 % goat milk, T3 was 50 % camel milk and 50 % goat milk, T4 was 25 % camel milk and 75 % goat milk and T5 was 100 % goat milk, which was used as a control. The experiment was repeated three times for each parameter.

Butter making

Butter was made by churning the fermented whole milk samples—pure camel milk, pure goat milk and their blends. Churning was done at a temperature of 28 ^{0}C for pure camel milk, 14 ^{0}C -22 ^{0}C for the blends and between12 ^{0}C–18 ^{0}C for pure goat milk (Farah and Ruegg, 1991). Four liters fermented milk placed in a plastic bottle Jerry can churn of 20 liters capacity. Churning was done manually by hanging the churn from a height (pole) and agitating the milk with up and down. At the end of the churning process, butter grains were skimmed off, kneaded in cold water, and washed to remove visible residual of buttermilk (FAO, 1990). Butter yield was determined by measuring the weight of butter using a sensitive balance.

pH and temperature

pH of milk samples used for butermaking was measured using digital pH Meter (Crison Basic 20, Barcelona). Well-mixed 40 ml milk sample was put into a beaker and the pH was measured by immersing the pH meter electrode into the milk sample. Buffer solutions of pH 4 and 7 were used to calibrate the pH Meter (Richardson, 1985). Temperature of the milk samples was measured using a thermometer.

Butter yield

Butter yield was determined by weighing the manufactured butter using a digital balance.

Data analysis

The data generated was analyzed by the analysis of variance technique for CRD using the General Linear Model (GLM) of SAS (1999). When analysis of variance showed significant differences, least significant difference (LSD) was employed to detect differences among treatment means. Significant differences were declared at 5% significance level.

Results and Discussion

Butter making process

Butter is reported to be difficult to make from camel milk under normal conditions. This is because its fat globules are firmly bound to the proteins of camel milk and the difficulty of obtaining camel milk butter was further attributed to the different churning behavior of camel milk fat in comparison with cow milk fat; the difference in availability of k-casein in camel milk (Ramet, 2001). The fat in camel milk is distributed as small micelle like globules in the milk (Yagil and Etzion, 1980). Knoess (1979) reported that butter could be made from camel milk after 15 to 20 minutes by conventional churning method. On the other hand, Shalash (1979) reported that it could take up to about four hours by traditional churning method to make butter from camel

milk. Butter can be made by churning fresh or soured camel milk at 24 - 25 ^{0}C (Farah *et al,* 1989).

In the present study, butter was made from camel milk and its blends with goat milk by manipulating operating parameters, viz., churning temperature, churning pH, degree of agitation, volume of milk and method of churning (degree of agitation) of milk during the traditional churning method. The churning temperature was adjusted by adding either cold water or hot water into the milk. The volume of the milk in the churn was high it required high degree of agitation results increased churning temperature of the milk in the churn container becomes the butter grains melted and decrease butter yield.

Butter making efficiency

Pure camel milk (T1) took significantly longer ($P < 0.001$) time (11 days) to ferment as compared to the other milk samples (Table 1). In the contrary, pure goat milk (T5), took a significantly shorter ($P < 0.001$) time (3 days) to ferment as compared to other milk samples. With increased proportions of goats' milk in the blend, the fermentation time kept on decreasing (Table 1). The longer fermentation time observed in pure camel milk (T1) in the present study is in line with earlier reports. The fermentation time of goat milk (T5) is similar to the fermentation time of 3 days reported for cows' milk at Holetta and Selale in the central highlands of Ethiopia by Zelalem *et al.* (2007).

Pure camel milk (T1) required significantly higher ($P < 0.001$) temperature for churning as compared to the other milk samples (Table 1). Whereas the churning temperature of pure goat milk (T5) was significantly lower ($P < 0.001$) than all the milk samples (Table 1). With increased proportions of goats' milk in the blend, the churning temperature kept on decreasing (Table 1). The churning temperature applied for 100 % camel milk in the present study is in agreement with the finding of Farah *et al.* (1989) who reported that butter could be made from camel milk by churning fermented camel milk at 20 – 25 ^{0}C.

The pH of milk required for churning pure camel milk (T1) was significantly lowers ($P < 0.001$) than the other milk samples (Table 1). In the contrary, the pH of goat milk (T5) required for churning was significantly higher ($P < 0.001$) than the others milk samples (Table 1). With increased proportions of goats' milk in the blend, the churning pH kept on increasing (Table 1). The pH of camel milk used during churning in the present study is in line with the churning pH of 4.6 reported by Farah *et al.* (1989) for camel milk.

The yield of butter obtained from 100 % camel milk (T1) was significantly lower ($P < 0.001$) than the other milk samples (Table 1). The yield of butter obtained from the blended milk samples (T3 and T4) was significantly higher ($P < 0.001$) than the other milk samples (Table 1); whereas no significant ($P > 0.001$) difference was observed in yield of butter between T2 and T5 (Table 1). With increased proportions of goats' milk

in the blend, the yield of butter kept on increasing (Table 1). Compared to goat milk butter, camel milk butter is white in color and is stickier and greasy in consistency.

The white color of camel milk butter could be attributed to the low carotene content in camel milk. The possibility of making butter from pure camel milk observed in the present study is supported by some authors who reported that butter could be made from camel milk using traditional methods (Shalash, 1979). While others categorically stated that, the preparation of butter from camel milk is not easy unlike milk of other animals owing to the unique properties of its milk fat. The fat in camel milk is distributed as small micelle globules and apparently bound to the protein in the milk (Yagil and Etzion, 1980).

The churning time of 100 % camel milk (T1) was significantly ($P < 0.001$) longer than the other milk samples (Table 1); whereas, the churning time of 100 % goat milk was significantly ($P < 0.001$) shorter than the others (Table 1). With increased proportions of goats' milk in the blend, the churning time kept on decreasing (Table 1).

The reason for the different churning behavior of camel milk fat in comparison with goat milk fat can partly be attributed to the high melting point of camel milk fat. This seems to shift the ideal ratio of solid to liquid fat in the fat globules at a given temperature towards a point higher than that of goat milk fat. The different churnability observed in camel milk could also be attributed to the reported small size of camel milk fat globules (Yagil, 1982). Small globules have a larger surface in relation to their mass that tends to increase their resistance for creaming up of butter from camel milk

Table 1. Butter making efficiency of camel milk by blending it with goat milk

Parameters	Milk Type				
	T1	T2	T3	T4	T5
F time (days)	$11.33^{a} \pm 0.58$	$9.00^{b} \pm 0.00$	$6.00^{c} \pm 0.00$	$4.00^{d} \pm 0.00$	$3.00^{e} \pm 0.00$
Ch T (°C)	$28.00^{a} \pm 1.0$	$22.00^{b} \pm 1.0$	$17.00^{c} \pm 1.0$	$14.00^{d} \pm 1.0$	$12.00^{e} \pm 1.0$
pH Mdch	$4.13^{e} \pm 0.002$	$4.43^{d} \pm 0.01$	$4.65^{c} \pm 0.01$	$5.16^{b} \pm 0.059$	$5.65^{a} \pm 0.02$
Ch time (min)	$121.67^{a} \pm 2.08$	$80.33^{b} \pm 1.53$	$29.00^{c} \pm 1.00$	$19.00^{d} \pm 1.00$	$13.00^{e} \pm 1.0$
Yb (g/liter)	$49.26^{d} \pm 8.41$	$70.66^{c} \pm 3.72$	$101.93^{b} \pm 4.79$	$128.71^{a} \pm 1.96$	$76.65^{c} \pm 12.67$

**F = fermentation; Ch T = churning temperature; pH Mdch = pH of milk during churning; Yb = yield of butter; Ch time = churning time: T1 = 100 % camel milk type; T2 = 75 % camel + 25 % goat milk type; T3 = 50 % camel + 50 % goat milk type; T4 = 25 % camel + 75 % goat milk type and T5 = control (100 % goat milk); Means with different superscript letters in a row are significantly different ($P < 0.001$); values in the table are means ± SD of three replications.*

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Making Butter from Camel Milk

Tesfemariam Berhe, Eyassu Seifu, Mohammed Yusuf Kurtu*
Department of Animal Sciences, Haramaya University
P.O. Box 138, Dire Dawa,, Ethiopia

Introduction

According to the Central Statistical Agency (CSA, 2009), Ethiopia possesses over one million heads of dromedary camels in the sedentary areas. Pastoralists claim that it is difficult to churn camel milk to make butter. This claim was supported by the report of Dickson (1951). Yagil *et al.* (1994) also reported that butter could not be made from camel milk. Different researchers reported that butter from camel milk cannot be made so easily using the traditional churning methods because camel milk shows little tendency to cream up due to lack of protein called agglutinin (Mulder and Walstra, 1974).

The difficulty of making butter from camel milk is also attributed to the fact that the fat in camel milk is firmly bound to the protein (Khan and Appena, 1967) and distributed as small micelle-like globules in the milk (Yagil and Etzion, 1980). Moreover, fat globule membrane of camel milk fat is thicker than cow milk fat (Knoess *et al.*, 1986). Despite this, in the Algerian Sahara the pastoralists make butter from camel milk called *Shmen* or *Semma* by traditional agitation method (Yagil, 1982).
In the Northern Kenya, pastoralists make butter from camel milk by heating several stones on a fire and placing the stones into a container filled with raw camel milk. As a result, fat globules form and appear on the surface of the milk (Farah and Streiff, 1987). The amount of butter so obtained is very small and is used for medicinal purpose or as hair pomade. Similar method is also reported to be applied traditionally by Bedouins in the Sinai Peninsula for making butter from camel milk (Yagil, 1982).

Owing to the reported difficulty of making butter from pure camel milk, it was hypothesized in this study that the efficiency of making butter from camel milk can be improved by blending it with cow milk. Thus, this study was designed to assess the possibility of making butter from pure camel milk and camel milk blended with cow milk.

Materials and Methods

Milk sample collection

Composite cow and camel milk samples were collected from Haramaya University Dairy Farm and Erer valley, respectively. Four liters of composite samples of cow milk, camel milk and camel milk blended with cow milk were put in a container (Buckets) for spontaneous fermentation at room temperature (22°C-23°C).

Treatment combinations

The experiment was laid-out in completely randomized design with five treatments and three replication, i.e., T1 (100% camel milk), T2 (75% camel milk and 25% cow milk), T3 (50% camel milk and 50% cow milk), T4 (25% camel milk and 75% cow milk) and T5 (100% cow milk).

Buttermaking

After standardizing the buttermaking procedure, the actual experiment was conducted at a pH value of 4.10 and at a churning temperature of 22°C -23°C. The temperature of the soured milk just before churning was adjusted by putting the container filled with soured milk in a vat that contains hot water. The churn was agitated by up and down movement by hanging it on a pole. The fat recovery efficiency was calculated as fat percent of the whole milk minus fat percent of the buttermilk over fat percent of whole milk.

Butter yield and fat recovery

Butter yield was determined by weighing the worked butter using a digital balance (model ADE 210/L, Adam Equipment Co. LTD, UK). The butter fat recovery efficiency was calculated as fat percent of the whole milk minus fat percent of the buttermilk over fat percent of whole milk. It was determined according to O'Mahony and Ephraim (1985):

$$\text{Fat recovery efficiency} = \left[\frac{\%Fat\ in\ whole\ milk - \%Fat\ in\ buttermilk}{\%Fat\ in\ whole\ milk} \right] * 100$$

pH

The pH of milk samples was measured using digital pH Meter (Eutech Instrument pH Model 510, Eutech Instruments Pt.LTD, UK). The pH Meter was calibrated using standard pH buffer. The temperature of milk samples was adjusted to 22°C according to Marth (1978) before pH measurement. Well mixed 50 ml milk sample was used for pH determination by immersing the pH Meter electrode into the milk samples and the pH reading was taken when stable.

Data analysis

The General Linear Model procedure of SAS version 9.0 (SAS, 2002) was used for the analysis of the data generated. Least significant difference (LSD) was employed to detect differences among treatment means.

Results and Discussion

Buttermaking

The up and down type of agitation is easy because it only requires application of more force in the upward direction and the downward movement occurs by the help of gravitational force. This method exerts higher churning force that facilitates butter extraction from camel milk as compared to the conventional back and fro agitation method. The need for vigorous shaking of the fermented milk for production of camel milk butter was reported by Yagil (1982). This might be due to the inherent characteristic of camel milkfat as the fat globules of camel milk are firmly attached to the proteins (Khan and Appena, 1967), have smaller size (Yagil and Etzion, 1980), and have thicker fat globule membrane (Knoess *et al.*, 1986). As a result, high force may be required to separate the fat globule from the protein and to break the thick globule membrane of camel milk fat.

Collection of the butter grains after churning camel milk was best done by using muslin cloth otherwise it was difficult to collect the grains by hand like cow milk butter. This was due to the nature of the fat grains that are very small and are sparsely distributed on the surface of the buttermilk instead of being collected in the form of butter grains and had white color similar to the color of the buttermilk. The white color of camel butter may be attributed to the low beta carotene content of camel milk (Abu-Lehia, 1989) and to high amount of non-fat components such as proteins linked to the fat globules in camel milk butter (Farah *et al.*, 1989).

This study indicated that butter can be made from pure camel milk and resulted in higher recovery efficiency than cow milk and the blends. However, the major problem of buttermaking from pure camel milk was that it took very long time to churn the milk. Thus, research aimed at decreasing the churning time of camel milk by varying the operating parameters such as , churning temperature, method of churning and volume of milk in the churn is needed in future study. Earlier reports also highlighted the possibility of making butter from pure camel milk using traditional methods (Mourad and Nour-Eddine, 2006) and by modern churning method (electrical system) (Farah *et al.*, 1989; Knoess *et al.*, 1986).

Butter yield

There was significant difference ($p<0.05$) between treatments for butter yield. Butter yield of T1, T2, T3, T4 and T5 was 172.04 ± 3, 142.46 ± 16, 114.51 ± 9, 114.36 ± 7 and 113.27 ± 5 g, respectively Butter yield from camel milk (T1) was significantly higher than butter yield from the blends (T2, T3, T4) and pure cow milk (T5). No significant difference in butter yield was observed among T3, T4, and T5. Among the blends, butter yield from T2 was significantly higher ($p<0.05$) than at a blending level with higher proportions of cow milk. The highest average butter yield (172.04 g) was obtained from T1, which is 100% camel milk, and the lowest yield (113.27 g) was obtained from T5, which is 100% cow milk. Blending of camel milk with cow milk at any level did not give better butter yield than pure camel milk (T1).

Table 1. Churning time, yield, and fat recovery of butter made from camel milk and camel milk blended with cow milk

Variables	T1	T2	T3	T4	T5
Yield (g/4 liters of milk)	172.0 ± 3[a]	142.5 ± 16[b]	114.5 ± 9[c]	114.4 ± 7[c]	113.3 ± 5[c]
Churning time (minutes)	120 ± 3.00[a]	105 ± 4.73[b]	90 ± 1.01[c]	75 ± 4.36[d]	55 ± 3.34[e]
Fat recovery (%)	79.8 ± 3.4[a]	70.7 ± 5.7[b]	66.0 ± 4.0[b]	66.3 ± 4.6[b]	65.1 ± 0.9[b]

T1 = 100% camel milk; T2 = 75% camel milk and 25% cow milk; T3 = 50% camel milk and 50% cow milk; T4 = 25% camel milk and 75% cow milk; T5 = 100% cow milk; SD = standard deviation. Means with different superscript letters in a row are significantly different from each other ($p<0.05$). Values in the table are means ± standard deviations of triplicate samples.

Churning time

There was significant difference ($p<0.05$) in churning time among the treatments of T1, T2, T3, T4 and T5. The churning time was short (55 minutes) for pure cow milk while it was twice longer (120 minutes) for pure camel milk. The churning time for the blended milk samples was 105, 90 and 75 minutes for T2, T3 and T4, respectively A churning time of more than 120 minutes for camel milk was reported by different researchers (Shalash, 1979; Yagil, 1982; Ramet, 1990) who indicated churning time of 4, 4 and 5 hours, respectively for camel milk. Moreover, O'Mahony and Ephraim (1985) and O'Connor *et al.* (1993) reported a higher churning time of up to 139 minutes for cow milk that is higher than the maximum churning time observed in the present study.

Butterfat recovery

The butter fat recovery efficiency of pure camel milk (T1) was significantly higher ($p<0.05$) than the blends (T2, T3 and T4) and pure cow milk (T5). However, there was no significant difference ($p>0.05$) among T2, T3, T4 and T5. Butterfat recovery efficiency of T1, T2, T3, T4 and T5 was 79.8 ± 3.4, 70.7 ± 5.7, 66.0 ± 4.0, 66.3 ± 4.6 and 65.1 ± 0.9%, respectively. Fat recovery efficiency of pure camel milk observed in the present study is higher than the values (60%) reported by Purchase (1943) for camel milk. The fat recovery efficiency of cow milk (T5) observed in the present study is closer to the value 67% reported by O'Connor *et al.* (1993) for cow milk churned by traditional method. However, it is lower than values (77% and 69.6%) reported by O'Mahony and Ephraim (1985) and Mwakapala (1990), respectively for cow milk.

Blending of camel milk with cow milk at any level did not improve the recovery efficiency of camel butter. The reason for the lower fat recovery of T5 in the present stucy might be related to the churning temperature used for the cow milk, which was 22-23°C. This churning temperature of 22-23°C was observed to be an optimum temperature for camel milk buttermaking but it seemed high for churning cow milk because it decreased recovery efficiency of cow milk butter.

Conclusion

This study revealed the possibility of making butter from pure camel milk. Higher butterfat recovery was obtained from pure camel milk than pure cow milk and the blends. Although it was possible to make butter from pure camel milk, it took very long time to churn the milk. Thus, further research is needed in order to reduce the churning time and improve butter yield by optimizing the operating parameters viz., pH of the milk, churning temperature, method of churning, and volume of milk in the churn.

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Camel Meat Production and Implications to Ethiopian Meat Industry

Mitiku Eshetu Guya
Haramaya University, School of Animal and Range Science

Introduction

Camel is a good source of meat especially in areas where the climate adversely affects the performance of other meat animals. This is because of its unique physiological characteristics, including a great tolerance to high temperature, solar radiation, water scarcity, rough topography, and poor vegetation. The average birth weight of camels is about 35 kg; nevertheless, it varies widely between regions, breeds and within the same breed. Camels reach live weights of 650 kg at 7–8 years of age, and produce carcass weights ranging from 125 to 400 kg with dressing-out percentage values from 50% to 55%.

Camels carcasses contain 57% muscle, 26% bone and 17% fat with fore halves (cranial to rib 13) significantly heavier than the hind halves. Camel's lean meat contains 78% water, 19% protein, 3% fat, and 1.2% ash with a small amount of intramuscular fat, which renders it a healthy food for humans.

Camel meat has been described as raspberry red to dark brown in color and the fat of the camel meat is white. Camel meat is similar in taste and texture to beef. The amino acid and mineral contents of camel meat are often higher than beef, probably due to lower intramuscular fat levels. Recently, camel meat has been processed into burgers, patties, sausages, and shawarma to add value (Kadim *et al.*, 2008).

Meat Production

Mature life weight of camels may vary from breed to breed, from place to place depending on feed availability, management practices, and purpose of keeping the animal. In Kenya camel bulls with the age of seven and ten years weighs 530 and 800 kg with average dressing percentage of 55% (47.5 to 58.4%) (Farah and Fischer, 2004). The average dressing percentage of eastern Ethiopia camels found to be 54.03 for male camels and 50.65 for female camels (Kurtu, 2004). According to Yohannes *et al.* (2007) meat production potential of a camel found to be 214.02 - 240.28 kg for male and 187.74 – 207.16 kg for female in Babilie and Kebribeyah of Somali Regional State.

According to Tezera and Hans (2000) the average calculated live weight of adult male and female camels were 486 ± 81.3 kg (n=55) and 427 ± 62.2 kg (n=91) in Jigjiga; and 384 ± 80.8 kg (n=18) and 326 ± 62.9 kg (n=31) in Shinile, respectively. The total

estimated camel meat off-take from eighty camels slaughtered for various purposes during twelve months in the studied households were 18,964 kg. On the other hand, total camel meat off-take and per capita per year camel meat consumption as calculated from slaughtering data in towns of Jigjiga (mean of 9 years) and Dire Dawa (Shinile, mean of 13 years) were 105,746 kg and 0.51 kg; and 164,506 kg and 0.82 kg, respectively. There is no preference of sex of a particular animal for slaughtering purpose unlike for cattle, sheep, and goat (Yohannes *et al.* 2007). Camel meat consumption in pastoralists is occasional and festivals like wedding, mourning, physical damage of the animal, for praying and arrival of guests are some of the reasons for slaughtering camel (Yohannes *et al.* 2007; Ahmed 2002; Farah and Fischer 2004).

Export potential

According to some camel specialists from Kenya camel considered as "desert gold." In the recent study conducted on Camel marketing in northern Kenya and southern Ethiopia borderlands, camel trade has grown tremendously due to an expanding market opportunities and market chain. The same source indicated that Moyale is the market center for the export of animals to the Middle East. It is receiving camels from southern Ethiopia, northern, northeastern and coastal Kenya. The camels then make their way to markets in Nazareth and the Middle East (Eric, 2011).

Ethiopia earned USD 211.1 million during Ethiopian fiscal year (July 2010-June 2011) by exporting 16,877 tones of meat and 472,041 head of live animals, recording a 69 % increment from last year's export revenue. According to the data available with Ethiopian Revenue and Customs Authority, live animal export contributed 70% of the earnings while the balance (30%) was obtained from meat export. Of the number of exported live animals, camel accounted for 13% next to cattle (46%) and sheep (35%); whereas, contributed 25% to the revenue generated next to cattle (67%).United Arab Emirates is the largest importer of meat buying 50% of the total meat exported, while Kingdom of Saudi Arabia followed as the second destination, accounting for 30% of the export. Sudan and Somalia stood first and second importers of live animals (primarily for re-export to MENA countries) with each buying 107, 656, and 100, 278 head of animals. Therefore, there are huge market opportunities for camel export and through improved camel production and marketing; the country can fetch more foreign currency (NBIIA. 2011).

Camel Slaughter

The traditional slaughter of camels requires the meat to be "halal," in accordance with Islamic custom. In this type of slaughter, the animals are not stunned. The camel is first put into a sitting position, the head is secured in a caudal position, i.e., turned towards the tail, and the main blood vessels between the neck and the thorax are severed with a single cut. Death occurs immediately. If the cut in the neck is not expertly executed, however, this traditional method of slaughter can be cruel and causes great suffering to

the animal, since death then does not occur immediately, which is a strong argument for prior stunning of the animal (Ulma and Fischer, 2004).

Stunning of camel could be done with a captive bolt pistol. As in horses and cattle, the position where the bolt is fired is the intersection of the diagonals between the inner corner of the eyes and upper ear attachment. In Ethiopia, there is no any information if stunning of camel is conducted before slaughtering. In some slaughter premises, severing of the neck is conducted while the animal is conscious and slaughtered through cruel inhumane practices. In such slaughter method, first the hind leg is cut at hook with knife by chasing after the animal in which the animal made to crouch and drag its hind leg. Then manually immobilized and the neck severed. From animal welfare and ethics point of view, such method of slaughter is unacceptable and unethical as the animal suffer too much before it dies and has effect on the quality of meat too. Such practice of slaughter urges us to develop guidelines on pre-slaughter handling of animals in general and camel in particular with further study on slaughter practices of livestock in the country.

Removal of the skin starts from the backbone and going down both sides of the carcass to the belly. The skin is laid on the ground with the flesh side uppermost. The hump is then split lengthwise and removed. The shoulders are separated and the ribs are cut away from the vertebrae. Next, the gastrointestinal tract is removed. The backbone is then cut out, so that the carcass collapses in on itself. The hind legs are split in the pelvis and divided up into smaller cuts in the joints. Camels are usually slaughtered early in the morning, when the outside temperatures are relatively low. In public slaughterhouses, there is usually a post-mortem inspection for camels as well as cattle. After the post-mortem inspection, the meat is taken away very quickly by dealers in special meat transport cases on handcarts or donkey-drawn carts (Ulma and Fischer, 2004).

Camel Meat Composition

The dressing percentage of camel carcass varies between 52 % and 77 % and there is a difference in the percentages of protein, water, fat and ash of meat from various parts of the body (Shalash, 1979). The age of the animal also affects the components of the meat. The fat and ash content of camel meat is lower than that of beef. Skeletal muscles contained 69–76% moisture; 19·4–20·5% protein; 4·1–10·6% fat, and 1·0–1·1% ash. In proximate composition, camel meat is generally similar to beef. The meat protein tended to have a higher percentage of the amino acid profile than literature values for other red meats, and lower values for tryptophan, aspartic acid, and tyrosine (Dawood and Alkanhal, 1995). Differences were observed between skeletal muscles and organs in nutrient content. Organs have higher percentages of ash, sodium, and iron than skeletal muscles. Among organs, kidneys contained higher quantities of moisture, calcium, and sodium but lower values of protein, magnesium, and potassium than liver and heart meats.

A study conducted by Kadim *et al.* (2006) on Omani Arabian Camel to assess the effect of age on quality of camel meat found muscles of younger camels (1 to 3 years) had significantly ($P< 0.05$) lower shear force value, ultimate pH and higher sarcomere length, fragmentation index, expressed juice, cooking loss, and lightness color by 48%, 3.4%, 43%, 25%, 28%, 14%, and 16% than those collected from older camels (6 to 8 years), respectively. Values of middle age camels (3 to 5 years) camels were in-between. Age is an important factor in determining meat quality and composition.

Babiker and Yousif (1990) analysed chemical composition and quality of camel meat and found that *L. dorsi, Semitendinosus* and *Triceps brachii* muscles from the camel had similar moisture, protein and fat content, but significantly different ash content. These muscles had also similar sarcoplasmic and myofibrillar protein concentrations. *L. dorsi* muscle had the highest content of collagen but a higher solubility of hydroxyproline than *Semitendinosus* and *Triceps brachii* muscles. It also had a brighter red colour. Water-holding capacity was not significantly different between the three muscles studied. Shear force and connective tissue strength were lowest in *L. dorsi*, intermediate in *Semitendinosus* and highest in *Triceps brachii.*

Analysis the fatty acid composition of lean raw meat taken from the hind leg of seven young (1–3 years of age) male camels using capillary gas-liquid chromatography revealed that saturated fatty acids account for 51·5% of the total fatty acids, while the monosaturated and polyunsaturated chains constitute 29·9 and 18·6%, respectively. The major fatty acids are palmitic (26·0%), oleic (18·9%) and linoleic (12·1%), with smaller amounts of other fatty acids, both normal and branched, that range in chain lengths from C_{14} to C_{22}. The fatty acids of dromedary fat are dominated by saturated even-numbered chains with smaller amounts (5·4%) of odd-numbered normal and branched chains. The main fatty acid of the hump fat is palmitic (34·4%) followed by oleic (28·2%), myristic (10·3%) and stearic (10·0%) (Tarik *et al.*, 1994).

Fatty acid pattern of hump and abdominal fat is not affected by age but the melting point and fatty acid composition of both hump and abdomen fats varied between the age groups and calves younger than one year have lower melting point and higher percentage of unsaturated fatty acids (Kadim *et al.*, 2002).

Camel meat is healthier as they produce carcasses with less fat as well as having less levels of cholesterol in fat than other meat animals (Al-Ani, 2004). Camel meat is also relatively high in polyunsaturated fatty acid in comparison to beef (Dawood and Alkanhal, 1995). This is an important factor in reducing the risk of cardiovascular disease, which is related to saturated fat consumption. Camel meat is also used for remedial purposes for diseases such as hyperacidity, hypertension, pneumonia, and respiratory disease (Kurtu, 2004). Quality of meat from young camels is comparable to beef (Kattami, 1970; Knoess, 1977; Kadim *et al.*, 2006). The author could not find information on Ethiopian camel meat composition.

Camel Meat Preservation and Processing

Preservation of camel meat is a common practice in pastoral and agro-pastoral communities of Ethiopia. *Olobe, mofo (Solayisa)* and *darreein* are the common types of preserved meat from camel meat. *Olobe* and *Darreein* are the two types of traditionally processed camel meat in Afder. These products are prepared to extend the use of meat for longer period especially for dry season and for cultural reasons. Of the three types *Olobe* is the popular one and available in urban market. These products are also prepared during crises when large numbers of animals are dying. *Olobe* can be kept safe for human consumption for more than one year. *Olobe* has different shelf life according to different respondents from Afder, Kebribeyah, and Babilie (Tezera, 1998; Yohannes *et al.,* 2007) and this may be due to differences in method of preparation of *Olobe.*

Olobe is prepared from lean meat by slicing it into thin strands before sun drying. At the same time, the hump is melted in separate pan and then the sliced dried lean meat is cut into pieces and added to the melted fat. Spices and butter might be added to improve flavor and aroma of the product. *Olobe* can be stored as either lean meat separately or fatty part and lean meat mixed. Lean meat *olobe* called *muremure,* which is commonly sold in market and exported to Hargeyisa from Jigjiga town (Tezera, 1998).

Mofo is another form of processed camel meat and prepared by digging a hole on the ground with medium fire and wood lodge put parallel to the hole. Lean meat is then sliced and relatively dried and put on lodges transversely and the fatty part added over it. The ground hole with meat and fat inside is sealed first with leaves or grasses and clothes and finally with soil. After few hours, it is taken out and stored in closed container for future use (Tezera, 1998).

Conclusion

Ethiopia has 2.4 million heads of camel of which 93% are found in Somali and Afar regions. The current trend shows that more emphasis needs to be given to camel production in the face of climate change and vulnerability of pastoral and agro-pastoral community to drought and food insecurity to exploit the vast arid and semi-arid areas of the country. Moreover, camel is the main livestock suitable to friendly utilize arid and semi-arid feed resources that otherwise would be unutilized. Camel has good potential for meat production and healthy quantity and quality meat could be produced through market-oriented camel production by improving the traditional camel rearing system.

Currently, there are good market opportunities for live camel export to Middle East and North Africa. This is a high time to improve camel production and marketing system there by to improve the livelihood of pastoralists and agro-pastoralists through market-oriented camel production. Attention needs to be given to pre-slaughter handling of

camels from animal ethics and humane treatment point of view as well as to harvest wholesome quality meat products. Further research is suggested in the area of traditional camel meat preservation and its quality attributes. Systemic selection needs to be conducted to get early maturing camel breeds so that quality and quantity camel meat could be produced in short period by reducing the prevailing late maturity. Feed supplementation to natural browsing is essential to improve the low daily weight gain and research could be conducted to evaluate use of locally available potential feed supplements. Survival of calves is another area that needs attention from camel rearing community to reduce the current high calf mortality especially that of male calves. Pastoral extension package could be developed to diffuse improved technologies regarding camel production and management.

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Viral Agents for Etiologies of Emerging and Respiratory Disease of Camels in Ethiopia

Gelagay Ayelet, Dejene Milkessa, Wossene Negash, Shiferaw Jenberie, and Esayas Gelaye
National Veterinary Institute, P.O.Box 19, Debre Zeit, Ethiopia

Introduction

Odeh *et al.* (1999) and Bekele (2002) indicated that although camels seem to suffer from fewer diseases than other domestic animals and epidemics are rare. The animal is however; affected by many other diseases, some of which are unknown to date. Infectious and parasitic diseases appear to be the major constraints that are hampering the potential performance of camels. Trypanosomiasis, camel pox, contagious skin necrosis, pneumonia, mange mite infections, and internal parasites are among the major health problems previously reported in camels in Borena areas (Richard, 1979; Demeke, 1998). However, conventional intervention measures seemed to be difficult due to the very reason that the animals are reared in marginal areas where veterinary services are not available or very limited (Dirie and Abdurahman, 2003).

Of the many diseases of camels that are rampant in the region, the recently emerged camel disease with still unknown causes is the single most important disease with huge mortality. The 1995 camel disease outbreak of Ethiopia with severe respiratory involvement drew attention of the nation and certain international agencies and has affected the whole camel population, is worth mentioning. By then the disease had a highly contagious nature with high morbidity rate of over 90% and variable rate of mortality (Roger *et al.,* 2001). Diseases are still flaring up in the region though the causative agents involved seemed to vary. However, researchers who made studies on camel respiratory diseases in Ethiopia agree that *Manhaemia haemolytica*, *Pasteurella multocida*, *Parainfluenza* virus, and *Morbilli*-like viruses are the major incriminated agents causing repeated outbreaks in the country (Bekele, 1999; Rogers *et al.*, 2001).

Various lower respiratory tract diseases have been reported in camels although the definitive etiology of most respiratory diseases is not determined. A variety of viruses has been associated with outbreaks of respiratory disease among camels. Adenovirus (AdV), IBR viruses, influenza viruses A and B, PIV 3 and RSV were identified so far in respiratory infections of camels (Dioli and Stimmelmary, 1992; Intisar *et al.*, 2009, 2010a, 2010b). Respiratory infections caused by AdV, PIV or RSV may result in severe lower respiratory tract disease (Corne *et al.*, 1999; Intisar *et al.*, 2010a).

Within the *Morbillivirus* genus and related viruses, several emerging diseases have been recently described. Accordingly, *Peste des petits ruminants* virus (PPRV) was suspected to be involved in the epizootic disease that affected one humped camels in Ethiopia in 1995-1996 (Rogers *et* al., 2001). Although no live virus was isolated, PPRV antigen and PPRV nucleic acid were detected in some pathological samples collected during that outbreak, and that has received a growing attention because of its wide spread, economic impacts and the role it plays in complication of the ongoing global eradication of rinderpest and epidemiological surveillance programs.

An outbreak had occurred in Afar and East Shoa Zone in 2005, in Somali regional state, Borena and Guji Zones of Oromia regional state of Ethiopia, in Somalia and Kenya in 2007, which caused sudden death of many camels. However, there was no report of zoonotic consequence of these diseases while the pastoralist used to eat meat and milk of these diseased and apparently healthy camels. The outbreak was investigated by a team from different laboratories including National Animal Health Diagnostic and Investigation Centre (NAHDIC-Sebata), National Veterinary Institute (NVI-Debre zeit), Central Veterinary Research Laboratory (CVRL-Dubai) and Foreign Animal Disease Diagnostic Laboratory (FADDL-APHIS-USA) that came up with different findings which included trypanosomiasis, hydatid cyst disease, tapeworm, trichuris, sarcocyst, haemonchosis, gossypol toxicity, euphoria toxicity, clostridia toxicity and bacterial disease. However, the researchers pointed out that the above listed health problems may not be the primary cause but could be secondary or may not be associated to the problem. Accordingly, this team highly recommended that detail epidemiological survey and further laboratory investigation to be carried out to come up with the primary causes of the problem. Therefore, identification and characterization of the primary causative agents that is most probably of viral agent/s is highly required.

The camel disease is still mysterious. The disease seems to occur cyclically and is threatening the livelihood of the East African pastoral community, in particular that of Ethiopia. It is the leading problem inflicting high mortality and morbidity among the camel population. Because of the unknown nature or etiology of the mortality, it has been difficult to take appropriate prevention and control measures at a national level. Hence, identification of the causes of the disease will have significant contribution to design and implement cost efficient control and/or preventive measures and will contribute to food self-sufficiency of the people inhabiting the affected areas. Thus, this study was designed to address the problems of pastoralists posed by variety of camel diseases with a particular focus on investigation of viral etiologies of camel emerging and respiratory diseases.

Materials and Methods

Study population

For camel emerging disease study; different tissue and blood samples collected in 2007 outbreaks from different camel rearing areas including the Somali, Afar and part of Oromia region (Guji and East Shoa Zones) and preserved under -85 ^{0}C at NVI were used. Therefore, this study was based on use of the already collected samples and all investigations were done at the NVI laboratories for possible isolation and characterization of viral agents according to published procedures (OIE, 2009).

For respiratory disease study, the local camels (*Camelus dromedaries*) slaughtered at Addis Ababa- Akaki abattoir was used. Most of the camels presented for slaughter were dominantly adult females with few males whose ages were estimated above 15 years. Lorry car was the transportation system used to bring the camels from their local markets (Borena and Bale zones, Fentale and Meiso areas) to the abattoir.

Sampling method and sample collection

The non-random sampling method was used for sampling. At Addis Ababa-Akaki abattoir, on average 8 apparently health camels were slaughtered each day. Before slaughter, camels were examined for any observable disease symptoms. Following slaughtering, pathologic lungs physically observed to have lesions suspected of having viral infections excluding lesions due to parasitic, pyogenic bacteria, foreign body and tuberculoid cases were selected. All carcasses were examined and about 6 grams of camel lung tissue samples were aseptically/carefully sliced and taken using clean scalpel blade and gloved hands from viral infection suspected sampes. Each tissue taken was then put into labeled sterile capped universal glass and plastic bottles and was placed in an icebox containing ice packs and transported to National Veterinary Institute (NVI) virology laboratory for virus processing and cultivation. Fresh tissues were preserved at -85 ^{o}C till processing.

Virus isolation

Five 2007 collected samples and thirty-five pneumonic camel lung tissue samples collected from the abattoir were processed and cultured on vero cell monolayer. About 1gram of each pneumonic camel lung tissue was taken and washed three times using phosphate Buffered Saline (PBS) on petridish. The washed tissue was transferred to mortar, cut into small pieces using scissor, and minced by scalpel blade. The minced tissues were then ground and homogenized using pestle. Nine ml of PBS was added to the ground and homogenized tissues and well mixed, and transferred to test tube and

centrifuged at 3400 rpm for 10 minutes. The supernatant (0.5 ml) was inoculated on to confluent vero cells and incubated at 37 °C for 1 hour. Following incubation, the inoculated cell lines were washed using PBS and about 10 ml GMEM was added and incubated at 37 °C to see the development of cytopathic effect (CPE).

Molecular characterization methods

Viral DNA/RNA extraction methods

After the CPE was observed, to determine whether the isolated virus is DNA or RNA virus, special viral nucleic acid extraction technique was applied. The viral nucleic acid extraction method used during this study was mainly based on viral capsid purification techniques described previously with fewer modifications (Denniston *et al.*, 1981; Nanda *et al.*, 2008). Briefly, 1 ml of tissue or culture suspension samples were suspended in a locally prepared 1 ml viral buffer (30mM Tris/HCl pH 7.5, 3.6 mM $CaCl_2$, 5 mM Na Acetate, 125 mM KCl and 0.5mM EDTA), sonicated at 800 speed and 40 mV using Vibro ^{m} cell 72434 ultrasonicator (Bioblock Scientific, Illkirch, France) and incubated at 37 ^{0}C for 1½ hours to further facilitate cell and nuclear membranes disruption. At the same time, cellular nucleic acids were digested away by treatment of nucleases 10 µl DNase I (100U/ml, Invitrogen) and 10 µl RNase ONE (100U/ml, Invitrogen). The encapsidated viral nucleic acids were recovered in the aqueous phase and viral nucleic acids (DNA and/or RNA) were extracted from the capsid suspended in viral buffer using the nucleic acid extraction kit (Qiagen) (Allander *et al.*, 2001; Nanda *et al.*, 2008).

RNA extraction

RNA was extracted using Qiagen RNeasy mini spin column kit. Accordingly, 460µl lysis buffer RLT was added to a 1.5ml eppendorf tube containing 460µl of infected cultured vero cell suspension. Four hundred sixty µl 70% ethanol was applied to precipitate nucleic acids released from disrupted host/vero/ cells due to lysis buffer RLT followed by homogenization. The homogenized suspension was transferred to RNeasy spin column and centrifuged, viral nucleic acids released bound to the silica membrane; the fluid part passed through the membrane down to the collection tube and the flow through discarded. The nucleic acids bound to the membrane was washed using 700µl wash buffer RW1 followed by addition of 500µl RPE buffer and centrifuged to dry the membrane and the flow through discarded. Finally, the nucleic acids bound to the silica membrane were eluted into eppendorf tube using 100µl RNase free water and the eluted RNA was used for further procedures.

DNA extraction

The viral DNA was extracted from the tissue suspension and cell culture isolates by using DNeasy® mini kit (Qiagen) according to recommended procedures. Brefiely, 180µl of infected cultured cell suspension and 180µl ATL lysis buffer were added to a

1.5ml reaction tube and vortexed. Proteinase K was added and incubated at 56 °C for1.30 hours in water bath. 200µl of each AL buffer and ethyl alcohol were added and the mixture was transferred to QIAamp DNA mini Spin column. The DNeasy Spin column was placed into a 2ml collection tube and centrifuged at 8000 rmp for 1minute where the flow through in the collection tube was discarded. The DNA sample bound to the silica gel membrane was washed and the membrane dried using 500µl of each wash buffers AW1 and AW2 by centrifugation. Finally, the DNA sample bound to membrane was eluted into a 1.5ml eppendorf tube using 500µl elution buffer AE, the eluted DNA was stored at -20 °C till further processing.

Complementary DNA synthesis

cDNA was synthesized using cDNA synthesizing kit (Invetrogen). The cDNA was synthesized based on the manufacturer protocol (Invitrogen) in 20µl reaction volume. Primarily, 1µl 50µM oligodT primer or random hexamer, 1µl 10mM dNTPs, 5µl extracted RNA and DEPC-H_2O to 10µl were added to 0.5ml PCR tube and incubated at 65 ^{0}C for 5 minutes in thermal cycler (Applied Biosystems) and chilled on ice for 3 minutes. Then, 10x RT buffer, 25mM $MgCl_2$, 0.1M DTT, RNase OUT™ (40U/µl) and Superscript™ III RT (200U/µl) were added with the rate of 2µl, 4µl, 2µl, 1µl and 1µl, respectively, and incubated at 25 ^{0}C for 10 minutes (only in cases of random hexamer primer) followed by 50 ^{0}C for 50 minutes and terminated at 85 ^{0}C for five minutes. Finally, 1 µl of RNase H was added to each and incubated at 37 ^{0}C for 20 minutes and the cDNA was stored at -20 ^{0}C until needed.

Degenerate oligonucleotide primed– polymerase chain reaction (DOP-PCR)

A master mix containing 35.1µl RNase free water, 5µl of 10X Dream Taq buffer, 1.5µl of 25mM $MgCl_2$, 1µl of 10 X mM dNTPs, 1µl of universal primer (5'-CTCGAG*NNNNNN*ATGTGG-3') and 0.5µl Taq DNA polymerase was prepared for each reaction. Then 45µl of the master mix and 5µl of the cDNA sample were added to an eppendorf tube. Once all the reagents were mixed, the reaction tube was placed in the PCR machine. The amplification was carried out according to the following programme: A cycle of initial denaturation at 95 °C for 5 minutes, 5 cycles of 94 °C for 1 minutes, 55 °C for 1 minutes and 72 °C for 3 minutes followed by 35 cycles of 94 °C for 1 minute, 55 °C for 1 minute and 72 °C for 3 minute with final extension at 72 °C for 7 minutes. Ten microliters (10µl) of PCR products and 2µl loading dye were mixed and loaded into the agarose gel wells being electrophoresed on a gel (1.5%) which was then analyzed by UV transilluminator and digitally photographed.

Conventional PCR

Conventional PCR was performed for *Parainfluenza virus*1, *Parainfluenza virus* 2, *Parainfluenza virus* 3, *Respiratory syncytial virus* (RSV), and *Adenovirus* using specific primers (Table 1). *Peste des petits ruminants virus* (PPRV) was also

investigated using PPRV specific primers whose forward and reverse primer sequences were NP4 (5'-CCTCCTCCTGGTCCTCCAGAATCT-3') and NP3 (3'TCTCGGAAATCGCCTCACAGACTG-5'), respectively. PCR reaction was carried out in a total volume of 50µl in a 0.2ml reaction tube containing 32.6µl RNase free water, 5µl of 10X Dream Taq buffer, 3µl of 25mM $MgCl_2$, 1µl of 10mM dNTPs, 1µl of each forward and reverse primers, 0.4µl of dream Taq DNA polymerase enzyme and 10µl of the cDNA/DNA.

Table 1. Sequences of oligonucleotide primers used for detection of respiratory viruses in camels

Primer	Gene[a]	Position[b]	Sequence[c]
RSVN3	N	426–451	GGGAGAGGTGGCTCCAGAATACAGGC
RSVN5	N	748–773	AGCATCACTTGCCCTGAACCATAGGC
PIV1PR3	NP	64–89	TCTGGCGGAGGAGCAATTATACCTGG
PIV1PR5	NP	122–147	ATCTGCATCATCTGTCACACTCGGGC
PIV2PR3	NP	360–385	AACTATGTCCAGAGGAGAGGTGCTGG
PIV2PR5	NP	498–523	CCATGCCTGCATAAGCACACTGTAGC
PIV3PR3	NP	416–441	ACCAGGAAACTATGCTGCAGAACGGC
PIV3PR5	NP	624–649	GATCCACTGTGTCACCGCTCAATACC
ADHEX3	Hexon	154–179[d]	CCTACGCACGATGTGACCACAGACCG
ADHEX5	Hexon	343–368[d]	GTGTTGTAGGCAGTGCCGGAGTAGGG

Source: (Osiowy, 1998); [a]N, nucleocapsid gene of RSV; NP, nucleocapsid gene of PIV; [b]Relative to the translation start site; [c]Sequences are shown 5' to 3'; [d]Positions shown are according to the adenovirus type 5 hexon gene sequences

PCR product analysis by gel electrophoresis

The PCR products were analyzed with 1.2% agarose gel (Sigma Aldrich) containing 0.5µg/ml of ethidium bromide. Briefly, 5 µl PCR products mixed with loading buffer (Invitrogen) and loaded to wells in pre-prepared gel and run at 100 volt for about 40 minutes in parallel with DNA 1,000 bp molecular weight marker (Invitrogen) in electrophoresis apparatus using 1x TAE buffer. The DNA band was visualized by UV illumination, documented and the size was determined comparing with the DNA molecular weight marker standard (Osiowy, 1998).

Experimental infection of laboratory animals

A trial for production of the disease in susceptible hosts for understanding of the progress of the disease under laboratory condition in laboratory animals was also attempted. For these purpose 20 mice of 3-4 weeks of age (body weight 12-14 g) and 20 adult guinea pigs were used.

Data management and analysis

Available data on post mortem finding, cell culture results, duration of CPE development and type of CPE observed for each sample were tabulated and finally

organized. Some of those cell culture positive camel samples were tested for six respiratory camel viruses using universal and conventional PCR. Molecular characterization results were recorded and tabulated.

Results

Emerging disease

Four of the five camel tissues that were processed and inoculated on Vero cells have shown visible CPE (Table 2). The CPE from heart, liver and heart blood tissues were observed relatively earlier that is one or two days post inoculation and have similar appearance. The CPE is invasive in character, which invades all the neighboring cells after starting from certain focal cell groups. Very large amount of round floating cells, giant cells, rounded refractive cells; some syncytia formation (aggregates of cells) and ballooning of cells were the main features of the CPE. As time progresses, sloughing of cells, that is the monolayer cells detached from the wall of the flask was seen. Generally, the cells were observed to be severely damaged within seven days post inoculation (PI) (Figure 1).

Table 2. Growth of virus on two cell lines and amplification by DOP PCR.

Animal No	Tissue type	Growth on Vero	Growth on Dubca	Amplification by DOP PCR			
				DNA		RNA	
				tissue	culture	tissue	culture
1	lung	_	nt	+	_	_	_
2	heart	+	+	_	_	++	++
3	liver	+	+	+	_	++	++
4	heart blood	+	+	_	_	++	++
5	lung	+	nt	+	_	++	++

nt= no trial, += weak positive, ++= strong positive and _ = negative

Note the round refractive floating cells and ballooning of cells (Figures 1 a and b), sloughing of cells /detachment of monolayer (Figures a and d) and some syncytia formation (Figures b and e). Figure a: heart blood culture on Vero, 100x magnification after 7 days, Figure b: liver tissue culture on Vero, 100x magnification after 3 days; Figure d: lung tissue culture on Vero, 100x magnification after 7 days; Figure e: liver tissue culture on Vero, 40x magnification after 3 days; Figures c and f: a week old non inoculated Vero cells kept as a control, 100x and 40x magnification respectively. All pictures were taken by separate digital camera (Digital IXUS 200 IS, Canon, Japan).

The virus was also evaluated for its growing effect on cell line after storage under three sets of temperature; +4 ^{0}C, -20 ^{0}C and -85 ^{0}C. In all cases, passaging directly from incubator without freezing and thawing produced more CPE very faster. Passaging from +4 ^{0}C or -85 ^{0}C to new monolayer cell has also indicated promising growth. Without freezing and thawing, as the number of passage increases the CPE was also observed to increases intensively. However, passaging after freezing under -20 ^{0}C and thawing showed no CPE or very rare CPE.

There was also growth observation on camel originated cell line (Dubca). In this case, the same to the case of Vero, round floating cells, giant cells, and rounded refractive cells, some syncytia formation and detachment of monolayer were observed. However, on Dubca cells CPE was observed relatively earlier (24 hours after inoculation) in more extensive manner. The Dubca cell line was fast growing and form monolayer earlier and it became older very soon within five days. Hence, to avoid any confusion the old cells were carefully distinguished from proper CPE formed by comparing the inoculated Dubca cell with the uninoculated control Dubca cell.

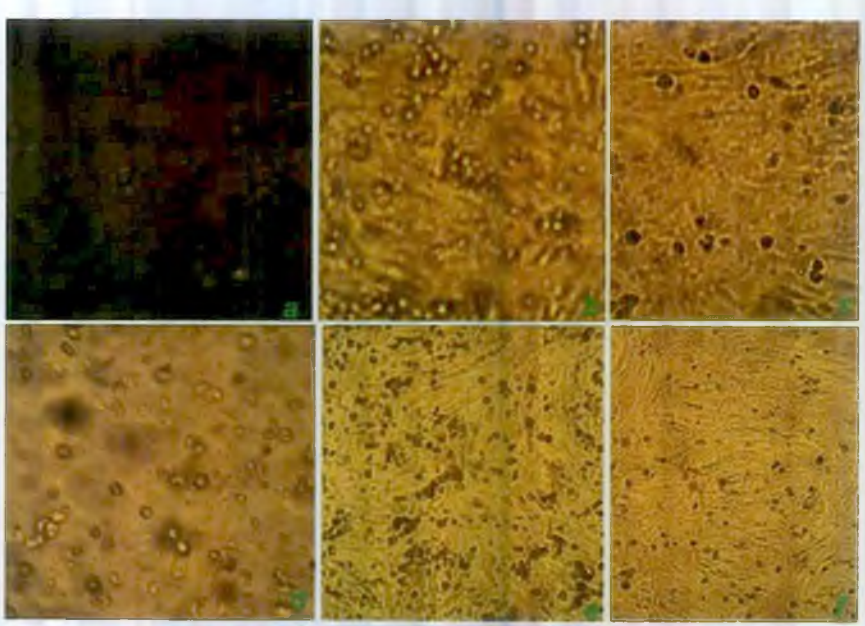


Figure 1. Cytopathic effect of unknown virus from different tissues of camel on Vero cells

Molecular test

Degenerate oligonucleotide primed PCR result

Totally five samples were tested for the presence of RNA and DNA virus with DOP-PCR and the result showed that those five camels were infected with unspecified RNA viruses. In two steps of RT-PCR, the tissue samples and their cultures from which CPEs were observed on cell culture indicated amplification (smear) in DOP-PCR. The tissue (lung) that was negative on culture and its culture also did not show amplification (Figure 2).

Figure 2. PCR reaction for camel virus both for the presence of RNA and/or DNA virus

*Key: **T= Tissue samples; C= Cultured samples; 1 and 5 = lung; 2 = heart; 3= liver; 4= heart blood samples.***

Specific PCR for respiratory viruses

Multiplex RT-PCR detection of respiratory viruses was done to know the presence of nucleic acid from five different respiratory viruses. RNA extracted from the tissue suspension and their respective cell culture suspension was reverse transcribed and amplified under the conditions described in materials and methods. The expected size of amplification was 84-, 164-, and 215-, 234- and 348-bp for PIV1, PIV2, AdV1-7, PIV3, and RSV, respectively. However, no evident specific bands were observed during the test for samples originated from outbreak cases of the disease in camels.

Specific PCR for Morbillivirus

The RNA extracted from all the tissue suspensions and their cultures were checked for the presence of *morbillivirus* nucleic acids using a two-step RT-PCR. The results of the test indicated no amplification for all samples.

Laboratory animal assay

Inoculation from tissue suspensions did not result in any clinical changes in both mice and guinea pigs. The animals were followed for three weeks and they were fast growing similar to their control groups and were shown good health conditions with no clinical problems. They were finally killed for postmortem examination but no differences were observed. The other group of mice, which were challenged with the cell culture suspension after CPE observation, also showed no clinical signs. However, the guinea pigs that challenged with the same culture suspension showed abnormalities. They showed depression, weakness, inappetance, rising and rough hair, rise in body temperature as well as high heart beat and fast and labored breathing starting from the third day of PI. The assay resulted in death of six guinea pigs after 20 days of PI. One group of animals was challenged with culture suspensions directly from incubator while the other group was challenged with the same suspension after storage in +4 ^{0}C for days. In both groups, they showed the same clinical abnormalities that were mentioned earlier. The control animals died between 29 to 32 days post contact without showing any clinical signs of disease.

Respiratory disease

Postmortem examination

During the study period, 389 apparently healthy camels presented to the abattoir for slaughter were examined antemortally of which 35 of them were found pneumonic upon postmortum examinations. However, it should be underlined that these lesions were exclusive of those lesions caused by parasites, foreign bodies, pyogenic bacteria and others including tuberculoid cases. Virally suspected pneumonic camel lung tissues were collected mainly based on the nature of lesions observed and the status of lymphnodes (prescapular and mediastinal lymphnodes). The nature of most frequently encountered and collected pathologic lung lesions observed were acutely and moderately inflamed lungs and a few of them included chronically infected, interstitially pneumonic, hemorrhagic, hepatized, atelectatic and adhesive lung lesions. Postmortem examinations were also assisted by palpation and incision. Accordingly, the total prevalence of virus suspected camel pneumonia was determined to be 8.99% examined.

Virus cultivation and cytopathic effects

Of the 35 pneumonic camel lung tissue samples collected, processed and cultured, 27 samples exhibited morphologic alterations (CPEs) on vero cell monolayer (Figure 3). The presence of viral agents in the pneumonic samples collected were evidenced by initial swelling and rounding of infected vero cells, sloughing of infected cells from cell culture flasks. The most predominant and frequently observed type of CPEs was the aggregation of infected cells together forming networked mesh (syncytia). Morphologic alterations of all tissue samples exhibiting CPE were compared against controls.

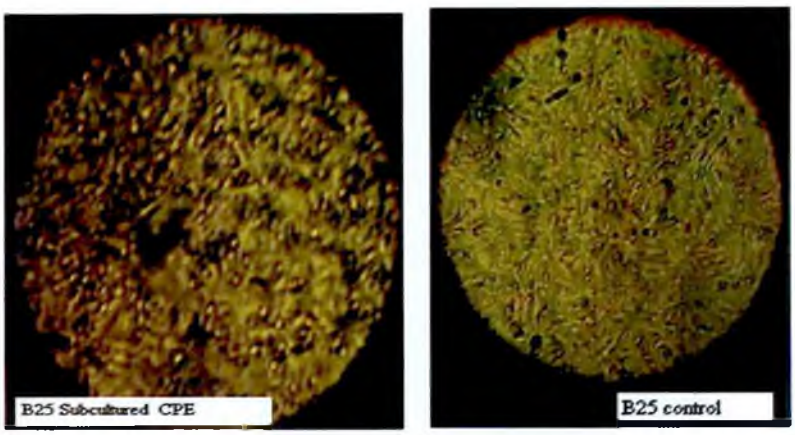


Figure 3. Infected vero cells exhibiting morphologic changes, cytopathic effects (CPEs), (left) with respective controls (right)

Molecular characterization methods

Detection of DNA and RNA respiratory camel viruses by DOP-PCR

Totally six samples were tested for presence of RNA and DNA virus with DOP-PCR and the result showed that five camels were infected with unspecified RNA viruses and only one sample was positive for DNA virus (Figure 4). Lane 4 (on Figures, 4a and b) revealed that the sample was positive on both sides (DNA and RNA extracted samples) implying that the sampled animal was infected by both DNA and RNA viruses.

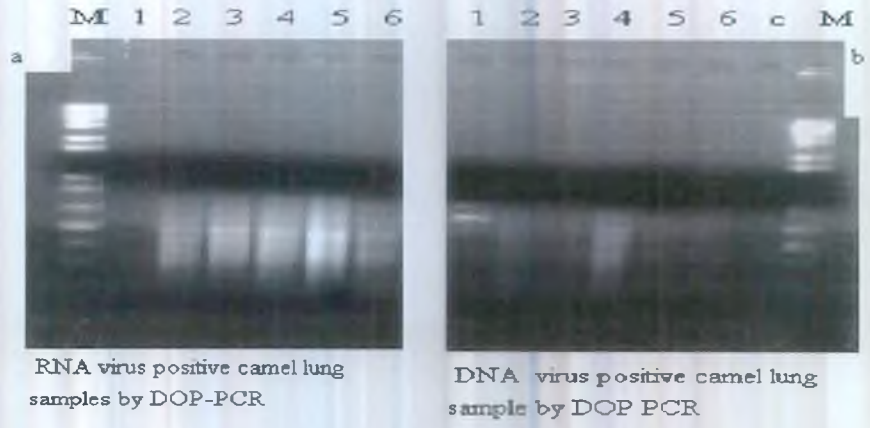


Figure 4. Digital photography of Ethidium bromide stained agarose gel electrophoresed DOP-PCR amplified DNA and RNA products analyzed by UV illumination. Figure 4a Lane 2-6 were positive for RNA virus; Figure 4b lane 4 was positive for DNA virus.
Keys: M= Molecular weight Markers; C= Control (Negative). The molecular sizes of the markers ranged from 100 bps (bottom most) to 1000 bps (top most).

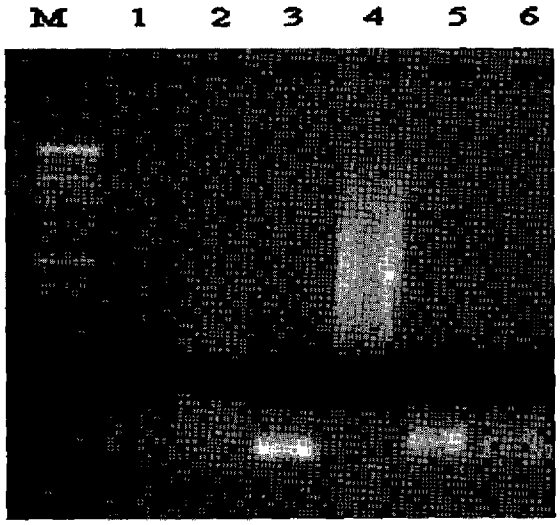
Conventional PCR

Samples were tested for the presence of *Respiratory syncytial virus*, *Adenovirus*, *Pest des petitis ruminants virus*, *Parainfluenza* virus *1, 2 & 3*. All samples tested were negative for PPRV and *Parainfluenza viruses*1-3. However, nine of the ten samples tested were positive for *Respiratory syncytial virus* and two of the six samples tested were positive for *Adenovirus* (Table 2). Finally, further investigative, epidemiological, and molecular characterization studies were forwarded (Figure 5-7).

Figure 5. Digital photography of Eth.Br stained agarose gel electrophoresed PCR amplified RSV products of ten samples analyzed by UV.
Key: M=Molecular weight marker

Figure 6. Digital photography of electrophoresed agarose gel analyzed by UV illumination of viral RNA samples using PPRV specific primer amplified PCR products; lane 1-10 camel samples, P PPR virus positive control sample.

Keys: Pc= Positive control; M= Molecular weight marker



Cytopathic effect positive camel lung sample and PCR : positive for Adenovirus

Figure 7. Digital photography of ethidium bromide stained electrophoresed gel analyzed by UV illumination of six PCR amplified DNA products using *Adenovirus* specific primer.

Key: M= molecular weight marker

Table 2. Summary of conventional PCR results

No. of samples tested	Virus species tested	PCR Results	
		Positives	Negatives
6	Adenovirus	2	4
6	Peste des petits ruminants virus(PPRV)	-	6
10	Respiratory syncytial virus (RSV)	9	1
6	Parainfluenza virus 3 (PIV3)	-	6
6	Parainfluenza virus 2 (PIV2)	-	6
6	Parainfluenza virus1(PIV1)	-	6

Discussion

The isolation of different viruses from camel tissue in different types of cell culture has been documented (Shaker, 2003). Viruses which have been shown to play a role in infections of camelids includes camelpox virus (CaPV), bovine herpesvirus-1 (BHV1), vesicular stomatitis virus (VSV) and border disease virus (BDV) that were propagated in Dubca to determine the viral host range for the cell line. A camelpox virus from Dubai was isolated in Vero (MA104) and Dubca cells, while the susceptibility of various cell lines like BHK 21 (baby hamster kidney cells), E-Derm (equine dermal fibroblasts), HEP 2 (human epidennoid carcinoma cells), L929 (mouse fibroblasts), MDBK (Madin Darby bovine kidney cells) and Vero was recorded for the same virus and found to be susceptible. Pestiviruses, cytopathic genotype 2 bovine viral diarrhea virus was isolated in Egypt from camels and was propagated on MDBK cells. Isolation of camel group A rotavirus in cell culture was also described; the virus was successfully propagated in MA104 cells. Nawal *et al.* (2003) and recently Intisar *et al.* (2010a) reported the isolation of PIV3 from camels lung using MDBK cells.

Emerging disease

In the present study, the concentrated tissue suspensions from outbreak cases of camels were inoculated into Vero cells for virus isolation. Out of 5 samples, 4 showed a progressive CPE and 1 was negative. However, this result may contradict with the report that detected no isolation of virus from pathological tissues of camel in Ethiopia from mid 1990's outbreak cases (Roger *et al.*, 2001). Isolation of a virus from diseased and died camel tissue may indicates the virus as a causative agent for the death or it could also indicate the presence of latent infection in which the cause of the disease might be another agent. However, the former might be true as the isolate was observed to be killer in laboratory guinea pig, the role model of mammalian species that was challenged with virus culture suspensions. The death of control guinea pigs indicate that the disease could be transmitted through contact. Laboratory mice were not

diseased or killed by the same culture suspension that was injected to guinea pigs. The reason might be because of the species selectivity of the virus under study.

The typical CPE of the propagated virus observed included very large amount of round floating cells, giant cells, rounded refractive cells and sloughing with some syncytia formation. From passage 2 to 4, the CPE appeared on day 1 and reached approximately 80% on day 3 post inoculation. In all propagated isolates except in a lung tissue, it was noticed that the cell sheet detached completely within a week and there was no difference in the CPE detected by all tested samples. However, it was observed that the CPE was seen 6 days later than the others were and sloughing of monolayer was rare even after 14 days post inoculation in the lung tissue culture. This might indicate the existence of multiple viral infections in camel tissues.

Different approaches have been used for detection of new viruses non-specifically in the presence of substantial amounts of contaminating host DNA. Physical separation of viral nucleic acids from cellular nucleic acids and the non-specific amplification of the viral nucleic acids have been used (Allander *et al.*, 2001; Nanda *et al.*, 2008). Previous studies reported viral detection methods based upon nuclease digestion of biological samples. A variety of DNA and RNA viruses were detected non-specifically in test samples designed to mimic detection problems that involve virus particles against a background of cellular nucleic acids (Allander *et al.*, 2001; Nanda *et al.*, 2008).

The presence of amplification of viral genetic materials indicates the existence of viral nucleic acids in the camel tissues or their respective culture suspensions from Vero cells. As these tissues were sampled from camels died of outbreaks with unknown causes, virus/es might be the likely causative agent of the death. It could also be the normally occurring viruses as a latent infection in the camel tissue, whereby the main cause of the death was another agent. Although the actual virus needs to be identified, in this research it was ruled out that the etiological agent/s of sudden camel mortality that occurred in 2007 in Southern Ethiopia was not a member of the genus *Morbillivirus* and five respiratory viruses namely AdV, PIV1, PIV2, PIV3 and RSV that are detectable by existing primers. Therefore, the detection of viral nucleic acid in camel in the present study was expected as they are expected to have some pathogens. However, we could expect more than the already detected viral nucleic acid types because there are many viruses for which their specific antibodies were detected in camel (Shaker, 2003; Intisar *et al.*, 2010a). On top of that, many camel infections are not well known and many disease causing viral pathogens are emerging (Dirie and Abdurahman, 2003). Hence the probability of detecting new unidentified viruses might be occurring.

The absence of *Morbillivirus* amplification in this study indicates the actual absence of *morbillivirus* nucleic acid in the sample collected during the outbreak and/or failure in detection limit of the existing primer because the currently used *morbillivirus* primers

might not detect a variant of such viruses. This result might also indicate the reason of the death of the camel at the time could not be *morbilliviruses* that can be detected by existing primers. The output of this study disagrees with the report of outbreak investigation team during the year 2007 in Ethiopia. The study did not coincide with the conclusion of Roger *et al.* (2001) which suspected the PPR virus to be the reason for the death of many camels. However, the present study shows similar indications with the seroprevalence study of Albayrak and Gur (2010) which recorded the absence of PPR virus antibody in camel of Turkey.

Respiratory disease

Respiratory tract diseases are among the emerging health hazards to camels worldwide that are incurring considerable loss of life and production (Abubakar *et al.*, 2010; Kebede and Gelaye, 2010). Respiratory infection is considered one of the main factors that decrease animal production. Camels are known to be less susceptible to various diseases affecting ruminants. However, evidence for a significant role of respiratory infections in camels had been reported. Dioli and Stimmelmary (1992) reported that viruses that have been associated with respiratory infections in camels are *Parainfluenza virus* 3 (PIV3), *Influenza viruses* A and B, *Adenovirus*, *Respiratory syncytial virus* (RSV) and *Bovine herpes virus*-1(BHV1).Various lower respiratory tract diseases have been reported in camels, but the definitive etiology of most respiratory diseases is not determined. With the camel respiratory disease outbreaks, the whole camel population of Ethiopia had been affected and the causative agent is not yet clearly identified which may or may not be associated with these viruses isolated and characterized in other camel rearing countries.

The present study had also determined the overall prevalence of viral pulmonary infection in Ethiopian camelids. The prevalence of virally suspected pneumonia was determined to be 8.99%. On the basis of cell culture results from pneumonic tissue samples collected from camels slaughtered at the abattoir, the overall prevalence by cell culture was calculated to be 6.94%. The duration of CPE development for all samples ranged from 4-14 days. Few CPEs were characterized by larger swelling and rounding up, detaching and floating of singled, paired and clumped infected vero cells. The majority of CPEs were characterized by initial rounding, elongation, syncytium formation.

The six DNA extracted CPE positive samples tested by DOP- PCR and agarose gel analysis of amplified PCR products suggested the presence of DNA viruses in 2 samples. These DOP-PCR detected six samples were tested for *Adenovirus* using *Adenovirus* specific primers provided less visible PCR output. The amplified PCR products of six previous *Adenovirus* tested samples were used as template and tested again for *Adenovirus* using *Adenovirus* specific primers and 2 out of six gave visible positive PCR results forming smears implying *Adenoviruses* played role in camel

respiratory disease. The finding of the present study is the first report of *Adenovirus* in Ethiopian camelids. Serologically, few works on *Adenoviruses* in camels were reported. With regard to serological evidence of *Adenovirus* type 3 infection in *camelidae*, Olaleye *et al.* (1989) reported the detection of *Adenovirus* antibodies in 1.3% of camel sera in Nigeria and Hadia *et al.* (2001) detected *adenovirus* type 3 antibodies in 35.8% of 120 camel sera collected from slaughter houses in Egypt. In Sudan, *Adenovirus* antigen was detected in pneumonic camel lung tissue specimens collected from lungs that showed pneumonia using ELISA. This was the first report of *Adenovirus* antigen detection in camels in Sudan and probably elsewhere which was supported by the previous reports on the association of *Adenovirus* with pneumonia in *camelidae* by Galbreath *et al.* (1994). Similarly, a serological study conducted by Intisar *et al.* (2010b) reported a prevalence of 90% using indirect enzyme linked immunosorbant assay (ELISA) test confirmed by FAT technique on sera collected from abattoir houses in Sudan. The PCR based *Adenovirus* finding of the present study agrees with another consolidative serologic finding of Dioli and Stimmelmary (1992) for *Adenovirus* antibodies in camels and agreed with the present report of *Adenovirus* from the lungs of Ethiopian pneumonic Dromedary camels.

Respiratory syncytial virus is one of the known causes of respiratory infection in human and various animal species (Murphy *et al.*, 1999). In Ethiopia, no information regarding *Respiratory syncytial virus* is available to explore the role of RSV in causing respiratory infections in animals especially camels. This study was also concerned with the investigation of camel *Respiratory syncytial virus* and accordingly, ten CPE positive samples characterized by initial rounding of infected vero cells, elongation, and aggregation (syncytia formation) were tested for RSV. Nine of them revealed better PCR positive results though bands were smeared. Based on RSV characteristic CPEs observed during virus cultivation and PCR positive indications, this is the first attempt to isolate RSV from pneumonic Ethiopian camels though it needs further definitive molecular tests like sequencing left for confirmation. This finding agrees with the findings of Intisar *et al.* (2010b) in Sudan. The established finding of this study also agreed with other serologic findings of Roger *et al.* (2001), Dioli, and Stimmelmary (1992). Antibodies to RSV were detected in 0.6% of apparently healthy camels in Nigeria (Olaleye *et al.*, 1989). In Egypt, camel sera tested for RSV were found positive and indicated the prevalence rate of 9.8 % (Shaker, 2003). Furthermore, Instar *et al.* (2010b) isolated RSV from the lung specimens of Sudan camels by cell culture, RT-PCR, and serological methods.

Conclusion and Recommendations

Of the many diseases of camels that are rampant in the region, the recently emerged camel disease with still unknown causes is the single most important. The disease seems to occur cyclically and no identified causative agents were fully determined yet.

In the current study, virus was isolated from tissue of camels died of the unknown disease using cell culture technique and the nucleic acids of the unknown virus was identified using degenerate oligonucleotide primed polymerase chain reaction. The isolated virus belongs to RNA virus group and it was characterized for its growth characters under different conditions. The isolated virus was confirmed to be out of the well-known viruses of genus Morbillivirus and five respiratory viruses: adenovirus, parainfluenza virus 1-3, and respiratory syncytial virus. This study showed the involvement of *Respiratory syncytial virus* and *Adenovirus* as a causative agent for camel respiratory disease in Ethiopia, *while Peste des petits ruminants virus*, *Parainfluenza* 1, *Parainfluenza* 2 and *Parainfluenza* 3 viruses were not detected. However, the isolated virus should be further characterized and specifically identified; pathogenicity of the isolates in camel should be determined to establish Koch's postulate if possible; and further research should be initiated towards creating possible preventive and/or control options such as the development of diagnostic tests and production of vaccine from the viral isolate.

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Materials and Methods

The Study Area

The study was conducted from November 2007 to April 2008, in Jijiga zone, Somali Regional State, Eastern Ethiopia. The study region is located in the eastern and southern lowlands of the country. Somali region lies between 4 to 11° North latitude and 40° up to 48° East longitude, with mean annual temperature range of 20°C to 45°C, and a rainfall of 200 mm up to 700 mm which has bimodal pattern (September up to October and March up to April) and is erratic. Shrubs, thorny bushes of acacia and cacti types dominate the vegetation. Livestock production system is generally predominated by extensive pastoral or agro-pastoral system in which indigenous animals are allowed to forage freely during daytime and kept in open enclosure during the night. Camels are kept as major stock with cattle and small ruminants.

Study Design, Study Animals and Sampling Procedure

A cross sectional study was conducted on traditionally managed lactating camels in and around Jijiga. Accordingly, 145 lactating animals from 20 camel herds at Jijiga town, Dagahle, Golajo and Gorey villages were conveniently selected depending on accessibility and willingness of the owners and studied. Clinical examinations and milk sample collections were carried out early in the morning at villages and during midday at watering points. Much care was given not to disturb the routine work of herders, particularly during morning milking. Information on each animal such as age, parity, body conditions, and other factors was recorded. Additionally, risk factors such as udder tick infestations, use of anti-suckling device and traditional treatment such as cauterization were also recoded.

Questionnaire survey

Twenty camel owners of the investigated animals were interviewed using semi-structured questionnaire format. The questionnaire has mainly focused on management practices, their knowledge of camel mastitis, importance of mastitis, treatment attempts and responses, extent of veterinary service delivery, and general information on production and reproduction performances of camels. Accordingly, factors that thought to have potential association with prevalence of mastitis and udder health problems were recorded.

Clinical examination of udder and mastitis card test

Animals were individually identified and clinically examined. During clinical examinations, palpation of udder and visual observation of udder lesion, clinical mastitis, udder symmetry, and size as well as observation of milk consistency, color changes, and presence of grossly visible substances were performed. Clinical mastitis was recognized by some pathologic udder, such as swelling, pain, redness, and heat in case of acute mastitis. Whereas, pathological changes of the udder such as hardening of the udder, blockage of the teats, atrophy or fibrosis and abscess formation were regarded as chronic mastitis. Acute mastitis was also recognized by change in milk

Udder Health Problems and Major Bacterial Causes of Camel Mastitis in Jijiga

Abera M., Abdi O., Abunna F. and Megersa B.
Hawassa University
Faculty of Veterinary Medicine, P.O.Box 05, Hawassa, Ethiopia

Introduction

The Camel is a multipurpose animal that makes an important contribution to human survival and utilization of the dry and arid lands (Abdurahman and Younan, 2004). It plays significant role as source of milk, meat and draft power in addition to being financial reserve and social security. Camel pastoralist prefer camel milk to other types of milk due to the fact that it is nutritious, thirst quenching, easily digestible and can be preserved much longer (Mohammed, 1993). Camel milk contains all the essential nutrients similar to that of cow's milk, and rich in protein, fat and vitamin C. The high vitamin C content has significant importance to human diet particularly in dry areas where green vegetables and fruits are not readily available (Farah, 1993).

There are few studies concerning etiology, occurrence, and pathogenesis of mastitis in Camelidae (Abdel Gadir *et al.*, 2006). Recently, however, cases of mastitis in camels have been reported from a number of camel keeping countries including Somalia (Abdurahman *et al.*, 1998), Sudan (Obied *et al.*, 1996), Kenya (Younan *et al.*, 2001), Israel (Guliye et *al.*, 2002) and from different parts of Ethiopia (Almaw and Molla, 2000; Woubit *et al.*, 2001; Bekele and Molla, 2001; Abdel Gadir *et al.*, 2006).

As in other dairy animals, clinical mastitis in camel is self-evident and can be detected without special tests, by examination of the udder and milk. Detection of sub-clinical mastitis is, however, difficult and depends on various test procedures aimed at detecting the etiology and indicators of inflammation in the milk. These include microbial examination, somatic cell count, California mastitis test, Adenosine Triphosphate (ATP), N-acetyl-D-glucosaminidase (NAGase) and Serum Albumin (Abdurahman, 1995; Guliye *et al.*, 2002; Abdel Gadir *et al.*, 2006). The use of mastitis card test is not well documented for camels regardless of its merit in dairy cattle. A simple, rapid and feasible test can be used in the field for remote and mobile camel herds. As camels are important dairy animals in arid areas, information on the udder health situations has vital importance for any needed interventions. Hence, the present study was intended to determine the prevalence and major bacteriological causes of camel mastitis using clinical examination, mastitis card test and subsequent bacteriological isolations.

color, presence of pus, red blood cells, flaks, and clots.
Apparently normal udder quarters of lactating animals were examined using mastitis indicator paper (Bovivet®, indicator paper, Kruuse, Denmark) to detect the inflammatory indictor (change of pH) in the milk. All milk samples from each quarter of sampled animal were screened using mastitis card test. It was carried out by adding drops of milk sample to the test card and observing for possible color changes. A change of color from yellow to green or bluish green on the indicator paper was considered as positive for sub-clinical mastitis.

Milk sample collections and bacteriological isolations

Microbiological examination of the milk samples was performed serially to identify major bacterial agents associated with mastitis. Due to resource scarcity, milk sample collection and bacteriological examinations were carried out only to those quarters showing mastitis positive. The samples were collected aseptically after the teat ends were cleaned and rubbed with cotton moistened in 70% ethanol. Then, milk samples were collected in sterile test tubes. Samples were labeled and packed in ice-cooler box following collection and transported to Jijiga regional veterinary laboratory.

Bacteriological examination of milk samples were carried out with indicator paper, followed standard methods (Quinn *et al.*, 2002). Briefly, a loop full of milk sample was cultured on blood agar and MacConkey agar to detect any gram-negative bacteria. Inoculated plates were incubated aerobically at 37°C for 24 hours. Presumptive identification of bacterial isolates was carried out based on colony morphological features, gram staining reactions, hemolytic reactions, catalase test and other biochemical tests (NMC, 1990). The bacterial isolates were transported to Hawassa University, Faculty of Veterinary Medicine for further characterizations and species identifications. Briefly, *Staphylococci* were identified based on their growth characteristics on mannitol salt agar, coagulase production, catalase and oxidase tests. *Streptococci* isolates were evaluated based on CAMP reaction, hydrolysis of esculin and sodium hippurate, catalase production and sugar fermentation tests. Gram-negative isolates were further tested using triple sugar iron (TSI), IMViC test, urea and oxidase reactions.

Data Analysis

Biological data and other information were recorded on Microsoft Excel spreadsheet as database. The data were tabulated, and the frequency of mastitis and possible effect of exposure variables (tick infestation, use of anti-sucking device, udder lesion, age groups and parity) was evaluated using Fisher's exact test. Linear relationship was assessed between parity number and overall mastitis prevalence. Data were analyzed using the statistical data analysis of STATA version 8 (Stata Corp. College Station, TX). Age of the camels and parity number were grouped into two categories, 5-10 and > 10 years and 1-2 and >2, respectively. Udder tick infestation was considered when more than two ticks were present as well as presence of tick on teat.

Results

Twenty interviewed camel owners have responded that camel mastitis is the major problem and a disease they do not know. They locally call '*Andho barar*' for acute mastitis and '*Jid*' for chronic mastitis, but they are not aware of sub-clinical mastitis. Majority of the camel owners (80%) use anti-suckling devices locally known as '*Maris*' to prevent calf from suckling. They apply tree bark fiber or strip of cloth and tie around the teats. As animal health delivery to their camels is so poor, all respondents indicated that they treat mastitis cases by a combination of phytotherapeutics and modern drugs as well as cauterization of udder skin (15%). Particularly, experienced (elder) camel owners indicated that they know traditional ways of treating camel mastitis using traditional remedies and drugs. For instance, local plant roots or plant leaves are chopped down, boiled and applied to the udder and teat when hot. However, the outcome of such traditional remedy is not well known. Herders reported that phytotherapy gives only temporary relief, and subsequent relapsing of inflammation is common. Conversely, the consequence of cauterization is well understood among most herders in that it brings about udder lesions and further complications. Furthermore, camel milking is a labor intensive and two individuals usually carry out the duty. Unclean hands of milkers with possibility to disseminate mastitis pathogen from infected animal to susceptible animals are also potential risk factors.

In this study, 145 lactating camels were examined clinically as well as sub-clinically using mastitis test card with subsequent bacteriological examinations. Clinical and sub-clinical mastitis were prevalent in 8.3% and 20.7% of the studied animals, respectively (Table 1). This gives an overall mastitis prevalence of 29.0% at animal and 17.9% at quarter levels. Most of the clinical mastitis cases were chronic (9 out of 12), while acute cases were only 25%. Additionally, some animals had lesion on the teat and udder (5.5%) and varying degree of tick infestations (8.3%). Three camels (2.1%) had only single teat, while 8 (5.5%) and 38 (26.2%) had two and three teats, respectively. This gives an overall blind teat prevalence of 33.8% and 10.9% at animal and quarter levels, respectively. Taking clinical mastitis and blocked teats into account, the study revealed that only 57.9% of the camels have four teats for milk production. The prevalence of sub-clinical mastitis was detected by indicator paper with subsequent bacteriological examinations.

The association of tick infestation, udder lesion, parity and age of the animal with the prevalence of mastitis was assessed and illustrated in Table 2. Accordingly, majority of tick infested camel udder (66.7%) and udder with lesion 62.5% were positive for mastitis. Hence, mastitis prevalence was significantly higher ($P < 0.05$) in animal with udder/teat tick infestations, udder lesion and animals in age band above 10 years of age compared to other groups. Furthermore, the occurrence of camel mastitis in relation to parity number was investigated in the studied camels and showed a strong positive linear relationship ($R^2 = 0.95$) between overall mastitis prevalence and parity number (Figure 1). As a result, prevalence of mastitis was as high as 66.7% in those camels

with seven and above parity number (Table 4). Udder abnormalities and deformation were observed among the investigated animals (7 out of 145) with abnormal symmetry and size of quarters and teats. These udder deformities were not associated with mastitis prevalence. Of the 80 quarter milk samples cultured, 55 (68.8) yielded bacteria while growth was not observed in 31.2% of the samples (Table 3). Forty-five bacterial isolates were identified from 55 positive samples. Cultures of ten quarters yielded mixed organisms, in which case further species identification was not preceded beyond colony characterization and gram staining. Gram-positive *cocci* were the most dominant bacteria comprising 54.5% of the isolates. *Staphylococcus* species (49.1%), *Bacillus* species (20.0%), *Streptococcus* species (5.5%) and *E. coli* (7.7%) were the major isolates.

Table 1. Prevalence of udder health problems at animal and quarter levels

Udder health problems	Animal level			Quarter level		
	No	Positive	%	No	Positive	%
Clinical mastitis	145	12	8.3	580	12	2.1
Sub-clinical mastitis	145	30	20.7	505	80	15.8
Total mastitis cases	145	42	29	580	92	17.9
Blind teat	145	49	33.8	580	63	10.9
Udder lesions	145	8	5.5	-	-	-
Udder deformities	145	7	4.8	580	8	1.4
Bacteriological	30	28	99.3	80	55	68.8

Table 2. Prevalence of sub-clinical mastitis with respect to exposure variables in studied lactating camels (n=145)

Exposure variables	Mastitis No (%)	Non-mastitis No (%)	OR (95% CI)	P-value
Tick infestation*				
Tick free	22 (16.7%)	111(83.3%)	1.0	
Infested	8 (66.7%)	4 (33.3%)	10.1 (2.8, 36.5)	0.000
Udder lesion				
Without lesion	25 (18.4%)	112 (81.6%)	1.0	
With lesion	5 (62.5%)	3 (37.5%)	7.5 (1.7, 33.3)	0.010
Udder deformities				
No	27 (19.6)	111 (80.4)	1.0	
Yes	3 (42.9)	4 (57.1)	3.1 (0.7, 14.6)	0.138
Age group (year)				
5-10	5 (10)	45 (90)	1.0	
> 11	25 (26.3)	70 (73.7)	3.21 (1.2, 9.0)	0.021
Parity number				
1 – 2	1 (4)	24 (96)	1.0	
> 2	29 (24.2)	91 (75.8)	7.7 (1.0-59.0)	0.023

** Tick infested udder is regarded as udder with more than two ticks or presence on teat, where as udder with less than that or no tick at all is regarded as tick free*

Table 3. Bacteriological findings of quarter milk samples (n=80).

Bacteria Isolated	Number	Percent
Staphylococcus aureus	21	26.3
Coag negative Staphylococci	6	7.5
Streptococcus agalactae	3	3.8
Bacillus species	11	13.8
Escherichia coli	4	5.0
Mixed flora	10	12.5
No growth	25	31.3

Table 4. Prevalence of camel mastitis with respect to increasing parity number of lactating camels (n =145)

Parity number	Number of animals	Sub-clinical mastitis (%)	Clinical mastitis (%)	Total mastitis (%)
1	11	0 (0)	0 (0)	0 (0)
2	14	1 (7.1)	1 (7.1)	2 (14.3)
3	25	4 (16.0)	1 (8.0)	5 (20.0)
4	41	7 (15.9)	3 (7.3)	10 (24.4)
5	28	7 (25)	4 (14.3)	11 (39.3)
6	20	7 (35)	3 (15.0)	10 (50.0)
≥7	6	4 (66.7)	0 (0)	4 (66.7)
Total	145	30 (20.7)	12 (8.3)	42 (29.0)

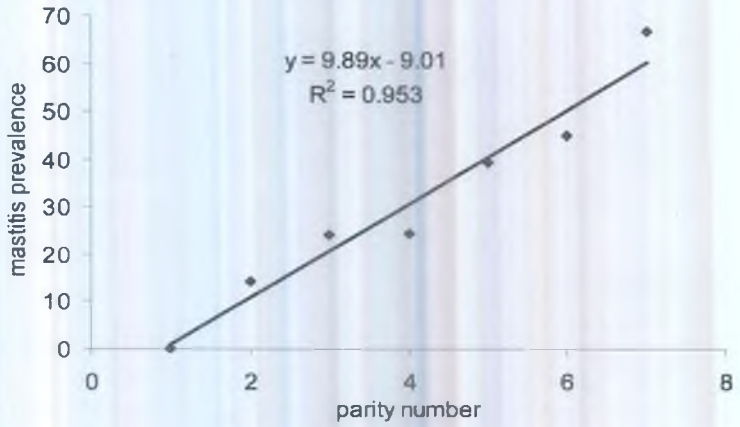

Figure 1. Linear relationship of overall mastitis prevalence with increasing parity number of lactating camels (n =145)

Discussion

On clinical grounds, 8.3% mastitis prevalence of this study is in agreement with the prevalence report of 12.5% by Bekele and Molla (2001) from Eastern Ethiopia. On the other hand, lower clinical mastitis of 2.1% was reported by Woubit *et al.* (2001) while Obied *et al.* (1996) reported relatively higher prevalence of 19.5%. The sub-clinical mastitis prevalence of 15.8% at quarter and 20.7% at animal levels is comparable to the reports of Almaw and Molla (2000) who reported 20.5% at quarter and 24.1% at camel levels using CMT. Bekele and Molla (2001) reported about a two folds prevalence (47.3%) of sub-clinical mastitis from eastern Ethiopia compared to the present study. High proportions of animals (42%) have no sound teats for milk production, suggesting considerable economic losses posed by mastitis. Similarly, Obeid *et al.* (1996) reported that only 5% of milking camels in eastern Sudan had sound and healthy udders.

In traditional husbandry practice of the study area, anti-suckling device, fibers from plants or strip of cloth are tied to the teat to prevent the calf from sucking the dam similar to reports of others (Agab and Abbas, 1999; Abdurahman, 2006). Moreover, the udder is a predilection site for tick infestation which causes udder skin and teat lesions, facilitates bacterial entry and leaves behind permanent tissue damage. This may gradually damage the teats and udder, favoring bacterial infections and subsequently results in mastitis and udder lesions. As a result, significantly higher proportions of camels with udder lesion and tick infestation were mastitis positive. In a study by Almaw and Molla (2000), 72% of the udder were infested by ticks and the incidence of mastitis was higher in heavily infested (30%) than non-infested (9%) udder. Similarly, Bekele and Molla (2001) have also observed an association of mastitis prevalence with tick infestations and udder lesions. Thus, tick control using acaricide treatment may reduce mastitis and udder health problems in camels. Abdurahman (2006) has suggested the benefit of removing ticks even when the animal is not lactating by gentle rotations and firm downward motions without damaging the udder skin.

Age and parity number affected mastitis prevalence. There was an increasing trend of mastitis prevalence with increasing parity number and age. Due to insufficient treatment efficacy, a possibility of carry over from the first parity to the next may occur and this increases the prevalence of mastitis in multiparous animals (Abdurahman, 2006). Furthermore, physiological defense mechanism of the udder or the milk reduces with advancing age, so that minor pathogens and opportunistic organisms get access to the glandular tissue and cause inflammation of mammary gland.

Other udder health problems of the studied camels were lesions, traumatic wounds and udder deformities. It has been demonstrated that udder lesions due to ticks, thorny bushes and cauterizations of the udder skin, and poor udder hygiene are the major hindrance to overcome the udder health issues of camels (Almaw and Molla, 2000; Woubit *et al.*, 2001; Abdurahman, 2006). These conditions may be responsible directly to mastitis by causing injury and predisposing the udder to bacteria invasion.

Additionally, injuries and laceration wounds were found to be further infested by fly larvae leading to sever complications. Similarly, abnormal udder conformations were also common among the studied camels. Conformational problems including small nipple, large bulbous nipple and divergences from the vertical axis were reported in Camelidae (Tibary and Anouassi, 2000). These abnormalities may be the result of chronic mastitis or blockage of teat canals or excessive udder lesion.

The bacteria isolated from camel milk samples; *Staphylococcus* species, *Streptococcus agalactae, E. coli* and *Bacillus* species are known mastitis causing organisms in cow and goats (Radostits *et al.,* 2000). Staphylococcus species were major isolate comprising 49.1% while the second most was *Bacillus* species (20.0%). Even though the proportion varies, mastitis pathogens isolated in the study were also reported by other researchers (Almaw and Molla, 2000; Bekele and Molla, 2001; Woubit *et al.,* 2001). As camels have not been a subject of research, the epidemiology and pathogenesis of these mastitis pathogens remains unclear (Abdurahman, 2006). On the one hand, the disease is not usually treated in traditionally managed camels, hence takes a natural course to chronicity (Obeid *et al.,* 1996). On the other hand, the traditional treatments attempted by herders are usually ineffective (Ramadan *et al.,* 1987). These conditions may lead to chronic, often fibristic sequel resulting in permanent loss of milk production and early culling of the animals. It is incontestable fact that camels are kept in remote, infrastructure poor areas for subsistent production, and prevalence of other major diseases concerns the herders and scientist much more. Thus, early problem recognition and taking intervention measures to reduce the losses due to mastitis is questionable.

Camel mastitis reduces milk production, indeed, affecting food security and survival of the pastoral households where camels are the major source of food. Although, there is dearth of information about the economic loss due to mastitis, it is not an obscured issue to imagine the potential losses associated with mastitis and blocked teat canals. The present study showed that 17.9% and 10.9% of the quarters were affected by mastitis and blocked teat canals, respectively. Taking only clinical mastitis and blocked teats into account, 42.1% of the camels had no sound teats for milk production. Other effects such as pain stress posed on the dam condition, calf growth performance and consequent impact on camel productivity and population growth are not known, but can be speculated. In conclusion, the study showed that udder health problem is very common and a major problem of the investigated camels. Thus, mastitis is a major problem in the studied camels and deserves further attention due to its potential impact on milk production and hence on food security.

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Diagnostic Decision and Technological Support for Clinical Examination of Camels in the Field

Melaku Tefera
College of Veterinary Medcine
Haramaya University, PO Box 144, Haramaya, Ethiopia
melaku22@yahoo.com

Introduction

The periphery encircling Ethiopia consist generally lowland plains, elevation below 1500 m above sea level and mean annual rainfall below 500 mm (Tefera and Fesha, 2001). The climate in the lowlands is arid and, owing to the unreliable rainfall, the ecosystem in these environments never achieves equilibrium between grazing capacity and fixed number of settled livestock. Thus, traditional pastoralism constitutes the only efficient means of exploiting the dryland resources (Payne, 1990). In the drylads where biomass is meager, resource utilization should be optimized through appropriate livestock production system (Njeuru, 1996). Multiple herd species has ecological, and socio-economic adaptive value, risk spreading and conservation of resources. Camels cause less environmental harm compared to other livestock specie (Schwartz and Doli, 1992). As climate change drastically altering the global landscape, camels raising could become an alternative livelihood next to none. In comparison to other livestock, camel production would appear minor, if viewed in isolation from the environment because camels can produce milk under very harsh conditions when and where other livestock species cease producing (Yagil, 1985).

Improving animal health care could be a positive alternative intervention in pastoral development. Camel health is a major determinant for improving the productivity and capacity to pastoral subsistence production Whereas, the position of camels vis-à-vis productivity and disease is not greatly different from that of other farm animals (Tefera and Feseha, 2001), research on the camel conducted during the past two decades has had very little, if any, impact on the practical routine improvement of camel health (Schwartz and Doli, 1992). Camels are usually owned by nomads, who move from place to place in search of food and water in harsh and remote areas where diagnostic facilities are very scarce. In such pastoral areas, there is a shortage of qualified veterinarians and any animal health service tends to be delivered by so-called Para-Vets or Community Animal Health Workers (Brown and Andriessen, 1998). Unlike pet, dairy, feedlot and racing animals, for which there is an ever-increasing emphasis and reliance on the extensive use of clinical pathology and biophysical tests (Radostitis et al., 1994), diagnosis in the camel is, as a rule, clinical. It is difficult to examine and treat a camel without knowing its behavior, anatomy, and physiology. Hence, these aspects of the camel should be studied in relation to health and disease (Higgins, 1985).

Due to their size, strength, mobility, and aggressiveness, camels are potentially dangerous and are able to inflict fatal injuries. Damages from bites and kicks are common (Tahizib, 1984). Some camel owners are reluctant to restrain their camel and so put a novice practitioner at considerable hazard. There are no improved equipment and facilities to restrain the camel. The health status of a camel or herd of camels is not easy to assess. The camel is tolerant of pain and pronounced signs are hardly seen. Much work remains to be done in the area of clinical diagnosis.

Clinical examinations of the camel have the same objectives and principles as in other domestic animals. However, the species differences necessitate some specific examination techniques (Tefera 2004). The objective of this study was to describe restraint technique used by *Afars* and assess the efficacy of newly designed restraint equipment and crush, define the optimal methods of clinical examination and the sources of common errors that require special consideration in the camel, and to generate a diagnostic decision support system based on empirical signs that would facilitate rapid diagnosis in the field.

Materials and Methods

Study area

The study was carried out in the Afar region of Ethiopia. This pastoral area is classified as lowland, and varies in altitude from 116 m below sea level in the Afar triangle to 1500 m above sea level at Aba-Ala. The mean annual rainfall is 500 mm at Aba-Ala, and is bimodal in pattern. The mean annual morning ambient temperature is 25 °C, while the afternoon temperature is 40 °C and night temperature may be as low as 7 °C. The soils are generally sandy and silty. The vegetation consists primarily of trees and bushes with a few annual grasses but no perennial grasses.

Experimental animals

Thirty-three camels, apparently healthy ranging in age between 1 and 7 years was studied. The animals had access to water every 3 days. The camels belong to Afar salt caravan system as shown on plate 1. The camels were traveling up and down between Mekelle town and Dalol twice a month covering 200 km with altitudes ranging 2000 m to negative 100 m.

Restraining technique

The restraining techniques used by the Afar and Somali were defined and new restraining equipment namely camel holder, a muzzle and a crush were designed and applied to facilitate handling during examination as shown on Figure 1 and Figure 2 respectively.

Physiological triads

Data were recorded in the morning at 0800 and in the afternoon at 1400 hours. The body temperature was taken with a rectal thermometer. The frequency of respiration was determined by inspection of the respiratory movements and auscultation of the trachea, and was expressed as breaths/minute. The heart rate was determined by auscultation of the cardiac area or from the pulse rate determined by palpation of tibial, middle coccygeal and femoral arteries and was expressed as beats/minute. Rumen motility was counted by placing a fist on the left flank and by auscultation for 5 minutes. The mucous membranes of the eye, mouth, vagina, and rectum were examined by inspection. The superficial lymph nodes were located by inspection and palpation of the body surface. Rectal palpation was made on camels in sternal recumbency. The organs in the pelvic cavity were palpated.

Laboratory Examination

Hematology and urine analysis for RBC fragility test and urine concentration were determined. Blood was obtained from the jugular vein using Heparinized vacutainer (Becton Dikinson). PCV was determined using microhematocrit. Hemoglobin was determined using Sahli hemoglobinometer. Differential count was made by counting 200 WBC on thin film slides and stained with Giemsa. Resistance of RBC to hypotonic saline was made following the procedure of Schalm (1974). Urine specific gravity was determined using a refractometer method.

Results

Two technologies for restraining camels, in standing and in sternal recumbency are shown in Figures 1 and 2, respectively. Most of the camels were well trained to obey the verbal and tactile commands of their herders. The camel should be approached using friendly words and by gentle patting. The first thing in restraining camels was to control the head and neck; without doing this it is impossible to restrain the animal. Usually, a twitch was applied on the mandible behind the canine teeth. In order to facilitate this, a restraining implement (Camel holder) was designed to facilitate the passage of a loop on the lower jaw (Figure 1). The camel holder was effective in controlling the head movement and also serves as a twitch and helps to lead the camel. Once the head was controlled, a muzzle was applied as shown in Figure 1. The muzzle was effective to control bites and gurgling during restraining. The construction of the camel crush and steps to restrain the camel in ventral recumbence are shown in Figure 2. Once the camel was restrained in recumbency, it could be tied to the rings on the crush. The use of a blindfold may be useful for calming the animal. When releasing from the restraint, the hind legs were untied first and the mouth twitch was removed last.

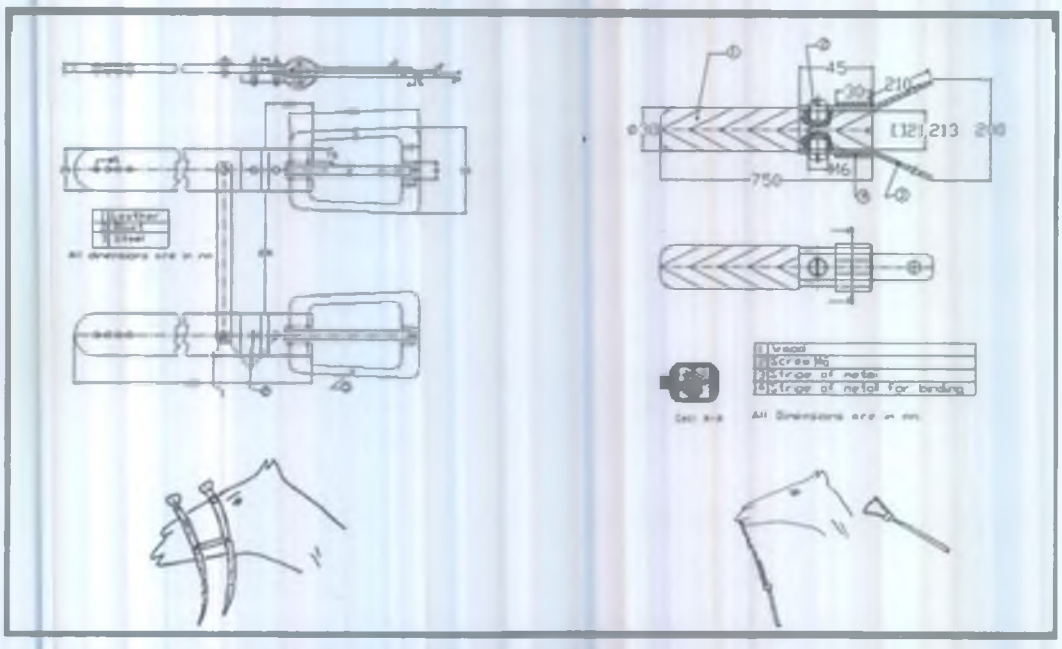

Figure 1. Schematic design of camel muzzle and camel holder

The rectal temperature varied between the morning and the afternoon (Table 1). As the normal respiration of the camel is thoraco-abdominal, the rates could be taken from a distance, when the camel is in the herd, by observing the flank movement, or in a restrained animal by auscultation of the thorax wall or trachea. There was no increase in respiratory rate with the rise in environmental temperature. The posterior tibial artery, the middle coccygeal artery, and, in young camels, the femoral artery, could be palpated, but it was difficult to detect the pulse. However, it was easy to take the heart rate directly by auscultation, just medial and proximal to the point of the armpit. There was no significant difference in heart rate between the morning and afternoon.

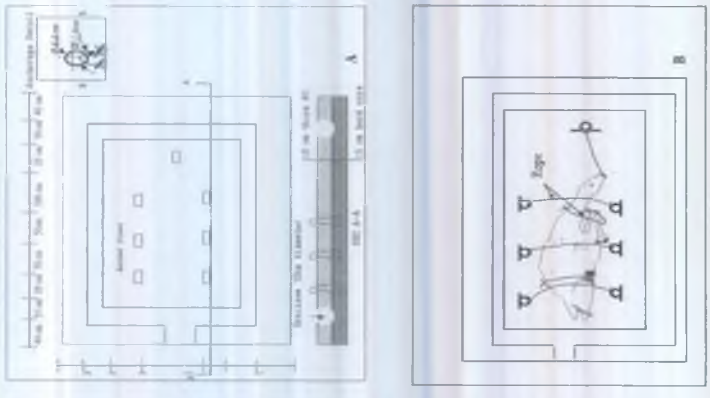

Figure 2. Steps of restraining the camel in sternal recumbency in camel crush.

The mean number of ruminal contractions (contractions / five minute) was 3±1.2; the best site for assessing this being the left flank. Eight external lymph nodes could be palpated. These were the parotid, maxillary, and prescapular, inferior cervical, thoracic, pectoral, cubital, illial, and popliteal. They were large and could be seen on simple inspection. It was found that the urinary bladder and female genital organs were palpable, but not the left kidney. The results of the hemogramm are shown on table 3. The PCV fluctuated very high and RBC resistance to hypotonic saline was very high. The urine specific gravity (USG) varied from 1.000 – 1.050 showing diluted and concentrated urine.

Table 1. Physiological triads of normal camels

Day time Number of Animals	Morning (8H-10 H) 17	Afternoon (13H-15H) 16
Rectal temperature °C		
Mean	36.5	38.9
Range	35.7-37.4	37.5-38.9
Respiratory rate /minute		
Mean	11	11
Range	9-16	9-16
Heart Rate		
Mean	45	45
Range	35-50	40-50

Table 2. Results of hemogramme of camels

Parameter	Mean	Range
Total RBC	7,000,000	5,200,000 - 8,940,000
Total WBC	14000	12000 - 16000
Haemoglobing/dl	12	9 - 16
PCV%	36	27 - 48
RBC fragility		
Maximum	0.44 - 0.36	
Minimum	0.28 – 0.22	
Differential count %		
Neutrophil	60	48 – 65
Eosinphil	2.5	1 – 4
Basophil	0.5	0 – 1
Monocytees	7	5 – 10
Lymphocytes	30	24 - 37

Discussion

The camel has always been considered as a patient, docile animal. However, even in trained camels, patience often turns to obstinacy during the rutting season if a male animal is isolated from the herd or handled by a strange person. Contrary to the observation by Yagil (1985), the camels are able to recognize their attendant's voice and have a good sense of smell, so there was a good bond between the herder and the animal. The veterinarian in camel practice is rightly judged by the herder by the way he

approaches and handles the patient. If the clinician has the correct approach, the herders will soon develop confidence in him. Never approach a camel from the rear.
The camel is restrained in a number of ways that vary in simplicity from twitches and hobbles to immobilizing harnesses. Preference should be given to simple mechanical means of holding the lip, neck, or limbs. Restraining in recumbency is helpful for physical examination, taking blood samples, to giving injections, oral treatment, and for minor surgical interventions, including open castration using local anesthesia, while the restraint in standing position will keep the camel from moving far and fast. In young camels, physical examination is usually carried out in the standing position because they have not been trained to kneel down. In adult camels, due to their long body, examination in recumbency is preferred. As both young and adult camels, become disturbed when approached or restrained, the clinician should wait a few minutes until the animal becomes quiet. Males are usually easier to restrain than females, as they are accustomed to hard work and carrying baggage. There is no method of restraint that is equally effective in every case, because individual animals react to the restraints in different ways (Fowler, 1978). Therefore, one should always have at hand several means in order to achieve the desired effect. Many mechanical instruments and methods of restraint can cause injury if used incorrectly or clumsily (Leahy and Barrow, 1953). It is preferable to avoid casting the camel in lateral recumbency, unless this procedure is obligatory. Otherwise if restrained in lateral recumbency, there could be bloating and staggering that may result in leg injury. It is also not good to hobble the fore and hind limbs together as this may cause the camel to fall down and may lead to fracture.

The camel is a gregarious animal and shows a great disinclination to leave others, and if isolated for examination, it became nervous. Therefore, whenever possible, it is better to examine a camel while it is within the herd. Lengthy separation of camel from the herd or seeking shade while the herd is browsing is indicative of severe illness.
The mean rectal temperature of the camels recorded in this study showed a variation of 3.2 °C between the morning and afternoon. A variation of 8°C was reported by Faye (1997). The camel is a homoeothermic animal, but, there is a circadian cycle in the body temperature of dromedaries, which permits their body temperature to fall to 35 °C overnight and increase to over 40°C during the day (Schmidt-Nielsen, 1997). This cycling of body temperature permits much of the heat load of the day to be dissipated by non-evaporative mechanisms such as radiation, conduction and convection during the cool hours of the night, so that they don't lose water in thermoregulation (Hill and Wyse, 1989). Thus, it is difficult to establish a critical temperature for fever, the judgment depending on considering the ambient temperature and a complete clinical examination. The fluctuation in body temperature is less in camels watered daily (Schmidt-Nielsen, 1997). Camels also tend to remain lying down in the same spot from early in the morning when the ground is still cold as part of their behavioral thermoregulatory mechanism (Gauthier-Pilters, 1979, cited by Mukasa-Mugerwa, 1981). This has to be differentiated from a pathological sign of reluctance to move.
When drinking water is restricted in the dry season, the camel attempts to conserve body water and to diminish the heat load as far as possible. This is partially accomplished by a drastic decline in metabolism, which diminishes oxygen

consumption and also the respiratory rate (Yagil, 1985). Camels are obligate nasal breathers and mouth breathing indicates a respiratory disorder. Auscultation over the thorax wall or trachea are not effective means for taking respiratory frequency due to overlapping by the dominant bleating sound produced by the camel when restrained. The respiratory rate in these camels did not showed a significant variation between the morning and the afternoon. However, if a camel suffers from hyperthermia, the rise in body temperature causes an increase in thyroid activity, which in turn, increases the respiratory and pulse rates leading to additional respiratory water losses (Yagil, 1985). Such a, rise in respiratory and pulse rates need to be differentiated from pathological increases.

Determination of heart rate by auscultation also has the disadvantage of the disturbing bleat of the camel during examination but detection of the pulse is difficult. One reason for this could be the thick skin of the camel. An intermittent and irregular pulse is not uncommon in camels and is not always a sign of illness (Schwartz and Doli, 1992). Hence, it is preferable to take the heart rate rather than the pulse rate. Although the pulse rate and the heart rate are usually the same, a difference between the two may occur when some of the ventricular contractions are weak, as in cardiac insufficiency, or when they follow one another too quickly, as in extra systole, because insufficient blood is propelled into the circulation to cause a detectable pulse (pulse deficit) (Rosenberger, 1977).

Swelling, *calor,* or increased sensitivity to pain in the lymph node is a sign of sickness and the effect on the lymph nodes may be local or generalized, depending on the type of infection. Although we were able to palpate only 8 superficial lymph nodes, Schwartz and Doli (1992) and Faye (1997), were able to palpate 10. The infra thoracic and the pectoral lymph nodes were not palpated. This might be due to the camel's breed difference. It is easy to palpate the lymph nodes of cattle. Unlike the lymph nodes of cattle, the lymph nodes of the camel are large and they are visible to the naked eye by inspection; this is not a sign of disease. Sometimes swelling of the lymph nodes occurs without any disease. In the process of healing enlarged lymph nodes regress in size, but not to their original size and they are not painful (Schwartz and Doli, 1992).
Pallene, redne, congested, or yellow discolorations of the mucous membrane of the eye are indicative of illness. The mucous membranes of the mouth, rectum, and vagina are unsuitable for examination, as stomatitis is common, due to feeding on thorny plants while inspection of the rectum or vagina requires additional restraint of the camel.
Ruminal motility in camels is different from that of true ruminants; the number of ruminal contractions per five minute being 2-3, while that of cattle is more like 1 every 4 minute (Dukes, 1979). Rumination and eructation differ greatly from those in the reticulo-rumen of cattle (Yagil, 1985). Motility of the rumen and reticulum starts with a single rapid contraction in the reticulum, immediately followed by a contraction of the caudoventral region and glandular sacks of the rumen. The caudodorsal portion then contracts, followed by contraction of the cranial sac. There is a slight pause before the start of the next contraction. The duration of each cycle in a resting animal is 4.5 min. There are 2-3 audible sounds/cycle (Schwartz and Doli, 1992). Ruminal motility is best appreciated by auscultation of the flank rather than application of fist. However,

there is considerable disturbance due to bleating when nomadic camels are handled for examination. Transrectal palpation may be useful for appreciation of pregnancy and palpation of the female genital tract. However, as in horses, the rectum of the camel is quite tight and fragile. Small hands are an advantage and lubrication should be used.

Often, the only visible sign of illness is poor body condition, which may be indicative of severe illness, but it may also be the result of dehydration, which is quickly reversed when the animal drinks its fill of 100 to 200 liters of water (Yagil, 1985; Schwartz and Doli, 1992). A history of 6 months without drinking water is not necessarily an exaggeration by the owner, because the camel is also able to satisfy its water requirement by feeding on forage plants that may contain up to 80% water (Yagil, 1985). There is little evidence that can be gained from the examination of the environment as the camel pastoralists frequently move from place to place. Hence, diagnosis depends much on the information obtained from the herders and this requires good communication skills and respect for their opinions and values. Hematology result showed that the camel has peculiar characteristics. The RBC has higher resistance to hypotonic saline and it has the ability to concentrate its urine. The urine of camel can reach from 1000 mosmol to 3000 mosmol (Shwartz and Doli, 1992) In most cases; the urine specific gravity varies in a relatively predictable way with the osmolality, with the specific gravity rising by 0.001 for every 35 to 40 mosmol/kg increase in osmolality. Thus, a urine osmolality of 280 mosmol/kg (which is isoosmotic to plasma) is usually associated with a specific gravity of 1.008 or 1.009. This shows that there is high variability on constituency depending on degree of dehydration. This reminds any clinical pathology using blood sample and urine sample should indicate or describe the frequent drinking water. Otherwise, levels could fluctuate and may be source of errors for determining substances in these samples. Although breeders have a good knowledge of ethnoveterinary medicine, they usually fail to appreciate the existence of sub-clinical diseases such as gastrointestinal parasites (Payne, 1990).

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Knowing the Unknown Camel Disease:
The case of Afar and Karayu Pastoral Communities

Tezera G. Tiruneh, Abdi A.Hussien, Tafesse M. Metaferia, Wendessen G.Wolde and Daniel T.Gelan
Pastoralist Forum Ethiopia (PFE

Introduction

Pastoralism is a method of agricultural exploitation based upon extensive herding where movements of herds and men are the major components of the system. The human population of pastoral areas is estimated to be between 12-15% of the country of which 93% are pastoral/agro pastoral and the remaining 7% depend on other agricultural activities such as hunting, petty trade, and mining. Pastoral areas in Ethiopia are located in the Northeastern, Eastern, Southern-Eastern, Southern, and Southwestern part of the country (MOFED, 2002). The regions are characterized by frequent calamities (conflict and drought), food insecurity, and lack of adequate social services and institutions (MOFED, 2006). Historically, the pastoralist areas have been sidelined in the development process: policies and programs have overlooked pastoralists' way of life and living conditions, and until recently, they have experienced decades of socio-political exclusion. Due to these factors, pastoralists have remained the poorest of the poor and become more vulnerable to the growing process of impoverishment.

According to Central Statistical Agency National Agricultural Survey (CSA, 2006/07), there are more than 43 million cattle, 43 million Shoats, and little more than 0.6 million camels. Out of these, it is estimated that more than a quarter % of the total cattle, more than 55 % of shoat, and more than 73 % of camel population are found in pastoral areas of the country. In areas where pastoral communities are rearing and using camel for improved livelihood, the camel has been threatened since 1997 due to the "unknown" camel disease. Some stakeholders including local and international non-governmental organizations (NGOs) and Networks affiliated with pastoralism have felt the importance of raising the issue of addressing problems of the "unknown" camel disease that is afflicting serious damage on camel, which is the source of livelihood for the pastoral communities residing in swathe of drylands. Therefore, the present paper aims at understanding the extent to which the "unknown" camel disease had affected the livelihood of the Afar and Kereyu pastoral communities and the perceptions of different actors on the disease and efforts made to curb the problem.

The study was conducted end of 2008 and covered selected pastoral communities in the Afar (Gawane Woreda) and Oromia Regional State[1] (Fentale Woreda) representing the Afar and Kereyu pastoral communities, respectively. The primary data collection was made from two representative kebeles from each Woredas. Based on geographical proximity; level of prevalence of the disease; and representativeness of the pastoral communities, the Baida and Barkle Da'ar kebeles from Gewane Woreda and Haro Kersa and Golja Kebeles from Fantale Woreda were purposefully sampled. The data collection methods include: field observation, key informant interviews (KIs), focused group discussion (FGD), and case study, particularly on the pastoral family members affected by the "unknown" camel disease. In addition, major government policy documents such as SDPRP and PASDEP, research and development reports and various periodic reports have been reviewed.

Results and discussions

Overview of the "unknown" camel disease

In Ethiopia, during 1995-1996 and in Kenya and Sudan at the start of 2000, the virus PPR (small ruminant virus), was identified as being the potential cause of the death of hundreds of camels. In Sudan, an outbreak of a previously unknown disease occurred in 2004 in Kasala state followed by isolation of the PPR virus. The clinical and epidemiological observations combined with the laboratory results (serology tests, viral detection), would suggest that this virus plays a role in the emergence of an enzootic disease among camel populations in the Horn of Africa. Other pathogens have been isolated but their presence could be because the animals' immuno-defence systems are depressed because of the presence of this virus.

In 2005, in a workshop held in Uganda, it was reported that the mysterious disease kills mainly fat and healthy animals in the herd. The following are the scanty signs and symptoms given by the affected camel owners. It was noted that these are only examples of isolated single cases, which could also be due to other camel diseases:

- The animal becomes restless and makes unnecessary noise looking for its calf and dies within 24 hours;
- Bent necks;
- One case noted discharge of blood from the mouth as the animal was collapsing;
- Some farmers mentioned heart abnormalities i.e.. haemorrhage from the heart;
- Miscarriage followed by death;
- Before animal collapses and die the legs become too weak to support the weight;
- There were more deaths reported in herds previously grazed on high ground than those grazed on dry grass at lower-lands; and
- The carcass (meat) from the animal tastes quite normal for human consumption

[1]The administrative hierarchy of the Federal Democratic Republic of Ethiopia starts from Kebele, which is the smallest administrative unit followed by Woreda (equivalent to District), followed by Zone and then Regional State. Currently, Ethiopia is composed of nine regional governments and two city governments.

At the end of 2007, it has been reported in international newspapers that more than 2000 camels have died in less than five months in Saudi Arabia. Various theories have been forwarded to explain the numerous deaths. For several years, the Sahel and the Horn of Africa have also seen similar numbers of deaths. In 1995-1996, CIRAD worked on a fatal epizootic disease affecting camels in Ethiopia. According to François Roger, Head of CIRAD's research unit (UPR) Epidemiology and ecology of animal diseases, "Additional research is required in order to determine the causes of this disease and to identify whether or not the PPR virus has a role to play, such as continued virology diagnoses, epidemiological studies to measure the respective roles of the virus, other pathogenic agents and environmental risk factors". In this way, we could contribute to understanding the causes of the emergence of this disease and its socio-economic impact." Moreover, as Bernard Faye, head of the animal resources department at CIRAD, explained: "For years, we have been witnessing new pathologies in camels. There is nothing to suggest that the causes of these diseases are identical because the symptoms are not always the same."

Head of Diagnostic Research Laboratory (DRL), Dr. Endris suggested or envisaged that the cause this disease could be either viral, bacterial, or recent environmental change or deficient of certain minerals from nutrients. In addition, eefforts are being made by various international organizations (Department of Vet Services of FAO; ILRI, VSF-B, etc) and samples has been take and tested at national and international levels for the last 7 years. Despite all these efforts, it has not been established whether it is a viral or bacterial disease. The deaths are probably due to a multitude of factors, which have a detrimental effect on the immune system, including some viruses, which could increase the severity of infections or parasitic infestations in animals.

Damage caused by unknown camel disease

The number of camels afflicted/diseased amount to 75,709 heads (Table 1). Of the total affected camel about 37% were treated. Camels died due to diseases and from other causes accouted to 48 and 20% of the inflicted camels, respectively. Therefore, the asset loss due to lack of proper and timely services was high and might have adversely affected the livelihoods of the pastoral communities.

Table 1. Number of camels afflicted, treated, and died from the disease and other caues

Particular	Afflicted	Treated	Died from disease	Died from other causes
Ethiopia	75,709	28,174	36,635	15,218
Afar	18,611		435	240
Oromia	24,588	3,014	15,951	2,083
Somali	17,972		6,212	121

Source: CSA (2006)

A father of ten children, who is Kebele chairperson, when asked about the "unknown" camel disease, said that this disease has resulted in loss of many camels, and showed the team along with other villagers' fresh carcass of died camels. When asked about the reaction of those families who lost their camels due to this "unknown" camel disease, most community members prefer to conceal information even from their neighbours for their safety, as neighbours and/or community members would be mistreated in a way by segregating the contacts of their animals with others either at water points or grazing/browsing areas. In addition, there have been cases when some herds wrongly envisaged as carriers of the "unknown" camel disease and held at gunpoint for hours until other camel herds driven away to "safe" areas.

A veterinarian from Gewane Woreda shared his experience that a family that lost 5-6 herds of camel has been isolated from the community at gunpoint for the fear that the disease would spread to their herd. He was forced to intervene personally into the case explaining the possible means of increasing incidence of the "unknown" camel diseases. Head of the Animal Health of the Regional Bureau of Pastoral and Rural Development similarly explained his personal account. He iterated the shocking incident occurred four years ago in Amibera area, where large numbers of livestock were grazing in cotton field. The next day over 400 camels perished in single morning that made the people to panic and leave the area immediately.

Considering individual's account, the threat focuses on the most productive and those within the reproductive age of camels. This fact has been strongly confirmed by few studies undertaken. Even with the many years experience in raising camels, most pastoralists could not detect signs and symptoms because of its sudden nature. The disease mostly affects expectant camels over seven months pregnancy and those about to deliver, mature and castrated steers, newly born camels and heifer of 3 to 4 years of age. Pastoralist communities do not sell female camel unless to relatives or family members. In this case, female camels are among the most vulnerable groups. This factor hence; contribute to the negative consequences of the "unknown" camel disease on the pastoralist system, as camel specifically female camels is one of the economic and productive assets of the pastoral communities that generates incomes to families.

Pastoral representatives have said that camel is the "second son". They also noted that a camel is equivalent to 44 Sheep and goats that each on average, is worth Birr 160-300. Besides, camel guarantees pastoral families by supplying milk as it provides daily 3-5 liter of milk for 10 months. It is also guarantor for social security, as it is used to settle blood compensation and wedding. Whereas, a representative of Gewane Woreda Pastoral Development Office reflected on the importance of camel to pastoral communities by iterating Afar saying, "Camel never embarrass you, it can be milked any time for family members and unexpected guests." With regard to the nature of the disease, another representative reported that the disease is respiratory and started in 1987/8 spreading from the North Ethiopia - Mille - Gewane - Kereyu. The other key informant (KI) said that the disease had started in the late 1997 from Ethio-Eriterian border spread to Afar region due to drought migration of camels from the north. Symptoms have been suggested by some stakeholders. These include: sudden shivering

followed by immediate death, camels died being milked, physical weakness, diarrhoea, beating the belly with ground, DDT odour coming out of the mouth, restlessness, swelling of front leg, discharge from nose, and eye sore, With no sign of sickness camels collapsed in the market area while being bargained and others while milking.

Box 1 - Case study in Gawane Baida kebele

Gitta Mohamed Amadi is the resident of Baida kebele in Gawane woreda. He stated that when the disease was seen ten years ago, it was not sudden death disease, but was a respiratory problem of camels. Symptoms included sleeping in the pen and found dead in the morning. He said the same disease came back after four years, up on post mortem heart blood clots was observed. If survived from the disease discharge from mouth for a long time, high fever, and considerable loss of appetite was observed. He said camels were drenched with water solution containing pepper and chilly in addition to oxy tetracycline that gave temporary relief.

When this happened, he said his camels were not at the incident area, but his uncle from a camel herd of fifty lost fourteen because of sudden death in a week time. Only one was male and six of them perished in single night. Reflecting to such type of disaster within limited period has forced the community members to conduct three days of communal prayer led by community's spiritual leaders. The disease occurred towards the long dry season. Loss of fourteen camels worth Birr 3,400 (approximately USD340) each. He said the disease came from the north Djibouti, appeared in Dalifage at the time the camels were browsing in a large cotton farm residue. God knows the causes, but we were all shocked by the mass death of camels, which was the first of its kind in camel history. He said that he thinks it came through the wind; one cannot see it but feels it. Seeing how horrendous the disease was killing camels, we stopped drinking all its milk right away and left the area immediately.

Finally, he recommended that camel should be give proper attention. Camels live in very remote areas need to have health technicians with commitment to move with them all the time and camel study center which provides proper drugs and advice must be established. For advocacy strategy, he said, "the value of a camel is more than ten quintals of *teff* on the one hand and there is a major shift to camels than donkeys for drought endurance in the context of highlanders nowadays on the other.

Box 4 - Case study in Fantale woreda - Haro Kersa kebele

Haji Chilo Jiri is a resident of Haro Kersa kebele and has 55 camels. He said he had lost three camels and was happy, as he was not much affected as compared to most others who lost all or half of their herds. He said the disease first came from Afar. The disease occurred in dry season but animals were in good condition in that particular year. According to his memory, it was some 3 or 4 years ago. Three ferenjis (westerner/white people) and doctors who came from abroad have taken some samples but no one brought back any feed back towards the nature of the disease. He concluded that it is not a disease but a curse from God.

The causes of the "unknown" camel disease are not clearly identified by experts. The perceptions of the pastoral communities range between Gods curse to environmental changes. Currently, considering what pastoral communities face in terms of rearing animals due to lack of grazing and access to water for animal consumption, as well as steadily improving market opportunities; the extent of loss of camels at family level would have significant negative consequences. This has been realised during the focussed group discussions undertaken. It has been asserted by the community representatives that loss of camel due to the "unknown" camel disease have resulted in increased migration and demand for food aid mainly for those marginalised pastoral families.

Box 5 - Case study in Fentale woreda Golja kebele

In an interview with Haji Qasur Jilu Bulga who is 70 years old, has many children and grandchildren and spent most of his life in the area, he said Kereyou know about the ten common camel diseases which are easily identifiable and recognized without much complication. He said that 45 years ago he had seen a new camel disease that occurred in Kereyou area. This disease is locally known "Furija" literary discharge from nose. It killed camels in large numbers not suddenly but after several days. According to the Haji, in 1996/97 25 camels most of them were pregnant and lactating died out of 160 camels from his immediate extended family members.

Up until now, he remembers the death of his camel was by a disease that came from Afar. When the animal is dying, the victim makes no move. The causes he categorized into two; air pollution by Ferenjis or God's curse for people who do not pay zeka. In a related incident, he said an old respected man seen a vision that men and camel suffering from calamity. After seen a prayer was held all animals were in the highland during the dry season. Eventually men survived but camels suffered.

When asked about the movement of camel, he said Kereyou's has contacts with Afar and Itu, while Itu has contacts with Issa and Hawiya. Issa in turn has contacts with Babile, which has direct contact with Fig/Jigjiga camels. These herds have contacts with Emi that has contact with Bale and Afdher to Borena and Liban then it goes through Kenya. As a recommendation the elder said camels do not have government, if they do they would get immediate intervention. For example, he said two common cattle diseases were eradicated from the country by the government, we use cattle's drug for camel. Camel is the only animal that can survive with changing environment; it should be given proper vaccination and medication.

Through time, the role of camel in the rural economy of the country has increased remarkably. Hence, demand for camel in the highlands has increased. Accordingly, camel is currently used as means of transportation for grain, crop residues, agricultural inputs, and outputs from and to the markets. Besides, camel is used as means of transporting water in rural lowlands and highlands. Accordingly, the threat of this "unknown" camel disease adversely affects not only the pastoral communities in terms of cash income but also the highlanders in terms of production and productivity as well as in cash income to those families owning camels in the crop producing highlands. Two senior government staffs have confirmed how severely the disease affected the society, encompassing economic, social, and psychological effect on the pastoral communities and families. Realising the consequences of the adverse effects of the "unknown" camel disease calls for detailed research works and its results envisaged to address the problems that ultimately erode the livelihoods of the pastoral communities.

This issue has been voiced by the representatives of the pastoral communities as well as technical experts at all levels.

Gawane Woreda individuals have proposed an initiative to designate a "**camel's day**," which will be celebrated every year, among the activities, poem competition would be held on the merits of camel in the context of their livelihoods. Here is a clip of the poem of one pastoralist recited which goes as: "The mother of my children, milk provider of my off springs, numerous of mine, it is you who nourishes them in dry and harsh season, are you abandoning them in such a sudden manner, Standing on its carcass, I am asking God for better replacement".

Development actors' interventions to manage the camel disease

Realising the existing challenges associated with the "unknown" camel disease, pastoral community members exercised rituals by slaughtering animals, prayed in mosques led by the spiritual leaders such that Allah repent. This is usually practiced whenever the causes of the issues and /or problems seem beyond the capacity of the direct and indirect beneficiaries and government authorities as well as international bodies. The pastoral communities agree that the "unknown" camel disease appeared four years back spreading from North to South of Afar. The pastoral community members attempted to know the causes through post mortem examination. Accordingly, water has been seen in the chest of the camels and liver was swollen and borne-water.

Some have used antibiotic before the camel got sick as preventative measure, which brought a temporary relief. An individual reported that thirteen camels out of fifty camel herds, which belong to his father, died due to this disease. He also estimated the total camel loss in 1997/98 was 20-30% in Fantale woreda. On the other hand, in order to avoid animal contact, community members have separated those camels thought to be affected. The government experts had taken many samples from camels, but the communities have not heard about the laboratory results. This disease is so pressing that in each cabinet meeting the issue was repeatedly raised with no proper answer. Some experts expressed their concern of people's limited camel awareness, and concerted effort of the central government. Some of these suggestions include, among others, incorporating into the higher educational institutions' academic curricula. The comparison between the credit hours of camel and pig given at higher institutions in the country and their respective provisions among the society livelihood was made.

A veterinary professional raised concern on the lack of interest on camel among the animal health institutions and was surprised by the lack of many literatures on camel in the country let alone vaccination medicine. This and the lack of laboratory results on the disease despite the samples being send to Germany, USA, India and other national laboratories brought anger and frustration among the pastoralists in the area. DRL started to prescribe oxide tetracycline for temporary relief. The main symptoms observed on the animal include unpleasant discharge, miscarriage, and respiratory problems. Earlier, DRL attempted to vaccinate and no progress was observed. Vaccination of camels was tried in Unab and Barahle Woredas. In addition, the sub sector experienced ineffective and disorganized studies on camel disease among many institutions, without proper feedback.

Melka Werer Agricultural Research Center under Ethiopian Institute of Agricultural Research (EIAR) has two years project to specifically study on this strange or "unknown" camel disease. Part of their base line activities is a paper produced by Mekele University; Sebata Agriculture/lab Centre is going to be an important stakeholder in terms of analysis and diagnostic lab procedures. Their key approach is taking routine sample collection even if at the time of healthy camel seasons. They are targeting six Woredas in Afar regional state. These Woredas are Amibera and Gawane woreda in zone 3, Ewa and teru woreda in zone 4, and Mille and Chifra woredas in zone 1.

The information collected from major sources indicates the extent of the problem of camel disease and the impact on the livelihoods of the pastoral communities that is left in the open air. Some of the pastoralist communities and experts have attempted to compare the responsiveness of major stakeholders, if the issue has been of highlanders or of teff or sheep and related commodities. Moreover, limited capacities of the research centres even located in pastoral areas of the country do not enjoy decentralised decision making, as their resources are centralised, are under equipped and poorly funded to take prompted actions in addressing the problems of the pastoral communities. These ideas and issues have been entertained through suggestions and recommendations of the pastoral communities' representatives, individuals, and other stakeholders. Accordingly, it seems appropriate that relevant authorities and networks focus on the lobbying and advocacy works such that those issues that positively affect the livelihoods of the pastoral communities of the country improve in order to attain the set objectives of PASDEP and MDGs at least in the short term.

Tackling the problem

The conceptual as well as practical frameworks to tackle such problem, which is challenging the livelihoods of the pastoral communities, need to take into account the diverse aspects and weakness of the relevant bodies and stakeholders incorporated in this assessment. Some of the suggestions and recommendations are as follows:

- Federal and Regional Authorities should finance research works on camel and provide appropriate vaccination and medicine on time;
- Camel should be give proper attention; camels live in very remote area and health technicians with commitment to move with all the time and establishment of camel study center which provides proper drugs and advice need to be in place;
- In the designing framework for lobbying and advocacy strategy, "the value of a camel which is more than ten quintals of teff on the one hand and there is a major shift to camels than donkeys for drought endurance in the context of highlanders nowadays on the other hand should be understood; and
- Many institutions, universities, UN, FAO, research institutions and NGOs are very much concerned and involved in the study of this strange disease. In order to avoid the overlapping of resources and efforts, a conference of sharing and coordination should be arranged to all concerned institutions.

Conclusions and Recommendations

Some Afar pastoralists called the disease the camel exterminator, while Somalis named it "Habad" meaning "the bullet." The causes of this disease are still obscure from scientists, veterinary professionals, and pastoralists. The possible hypothesis put forward include

- The cause is viral or bacterial disease that over time changed its strain;
- The intensified use of Pesticides on farmlands remained on grazing/browsing plants that in turn affect camels; and
- A new disease that comes because of global warming and environmental changes that poisons the air.

Recommendations

- Pastoralists inspired, led and managed advocacy on camels through "camel's day" celebration;
- Coordination of different stakeholders' efforts by organizing annual camels' conference to create synergy;
- Curriculum improvement at higher education institutions that addresses camel learning;
- Funding camel oriented research activities; and
- Collect, document and disseminate pastoralists' indigenous knowledge on camels and its disease.

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Camel Disease Prevalence and Management in Somali Regional State of Ethiopia

Muhumed Ali Faara
Somali Pastoral and Agro-pastoral Research Institute, Jig jiga

Introduction

The Somali Regional State together with Afar and Borana lowlands is known for its large number of camel population. Most of the pastoralists and some agro- pastoralists of the Somali Regional State depend on camel for their meat and milk requirement, particularly during the severe dry periods. Camels are also sources of income for many household from the sale of live animals and milk. Moreover, camels are considered as a corner stone of the social organization in the region (Bekele, 2002).

Over the past few decades, camels have begun to regain recognition for their food producing potential in arid and semi- arid areas. Their vital role in supporting human population in some of the poorest and frequently drought stricken areas of the world, such as the horn of Africa, has now been widely acknowledged (Hjort af Omas, 1988). The devastating drought in 1984-1985 demonstrated that camel ownership could give pastoralists a competitive edge and an excellent chance for survival in similar crises, where the entire herd of cattle, sheep, and goats succumbed to the arid condition, camel populations survived relatively unscathed. Consequently, some pastoral groups with deep rooted traditions of cattle herding such as the Samburu in northern Kenya, started to acquire camels (Sperling, 1987), a fact which has come to the attention of development agencies and international organizations.

Although camels are resistant to dry conditions, they are not free from constraints that reduce their survival and productivity. These constraints can vary from one place to another depending on environmental, climatic, and social factors. Disease has been indicated as one of the major problems of camel production in the camel rearing regions of Ethiopia (Teshome et al. 2003; Cattley, 1999; Tefera and Gebreah, 2001). However; information on diseases and other camel production constraints are limited to certain villages and districts due to inaccessibility, poor infrastructure, the lack of attention and mobility of the pastoralists. The eastern districts of the Somali Regional State that borders with Somalia are examples of such areas where information on camel production is scanty. Therefore, the objective of this study was to generate information on camel production constraints in the four eastern districts of the Somali Regional State with particular emphasis on diseases prevalence and management.

Methodology

Study areas

The study was conducted between February to September 2005 in four eastern district of the Somali Regional State, namely, Bokh, Gasham, Galadi and Harshin. Rainfall of the area is generally between 250 – 450 mm annually and temperature ranges 25-35 °C. The soil is sandy in Gashamo, Bokh and Galadi districts, while in Harshin district it is in between sandy and black soil. The vegetation in all districts includes different types of Acacia species, different shrubs, and grasses. The areas are mainly flat land with few scattered small mountains and hills. Livestock species in the area are camels, goats, sheep and cattle, and it appears that the number of grazers is decreasing in the area.

Sampling

The selected districts were selected purposefully as information on the prevalence and management of camel diseases were lacking because of poor infrastructure and inaccessibility. In each district, four locations were selected purposefully based on the distribution of camels (Table 1.). From each district, 36 household heads (HHs) were selected randomly giving 144 HHs in the four districts. Data were collected from respondents by interviewing them using a semi-structured questionnaire developed and tested before the start of the actual survey.

Table 1. Sampled locations in the surveyed districts

District	Location 1	Location 2	Location 3	Location 4
Bohk	Dumco	Jilacle	Mirafadle	Wanaagsan
Galadi	Dhudub	Dhrwaayaale	Hanamwaylood	Qorof
Gashamo	Ali Jaamac	Dayrfadal	Dhagaxyacad	Xalxalis
Harshin	Afuflay	Dhancade	Lata taagan	Saylalay

Data analysis

Data were analyzed using descriptive statistics by SPSS statistical package for windows.

Results

Profiles of respondents

The profiles of the respondents household heads is presented in Table 2. Most of the respondents were men. About 19% of the respondents had an average family size of less than or equal to five while the remaining had a family size of more than five people per household. Although the majority of respondents are pastoralists, agro-pastoral respondents were also included in the surveyed areas. About 79.2 % of the respondents were not educated while 19.4 % and 1.4 % had adult and elementary school education, respectively. The majority of the respondents had small to medium camel herd size but only a few had large herd size. Economically, most of the respondents were poor to medium rich though there were few rich ones.

Table 2. Profile of respondents of the study districts

Profile	Indicators	Frequency	Percentage
Sex	Males	132	91.7
	Females	12	8.3
Family size	≤5	27	18.8
	>5	117	81.2
Occupation	Pastoral	139	96.5
	Agro- pastoral	5	3.5
Level of education	Illiterate	114	79.2
	Adult education	28	19.4
	Elementary school education	2	1.4
Herd size	Small	60	41.7
	Medium	82	56.9
	Large	2	1.4
Economic status	Poor	67	46.5
	Medium	75	52.1
	Rich	2	1.4

Animal holdings by respondents

Camel owners also keep other livestock together with their camels (Table 3). All pastoralists and agro-pastoralists in the study districts keep goats and sheep, although the average number of goats per household is greater than that of the sheep. More than half of respondents (54.2%) and a few of them (18.1 %) keep an average number of 22 cattle and 2 donkeys per household, respectively. Pultry holding is also common in the study districts.

Table 3. Number of livestock per household (2005)

	Cattle	Sheep	Goats	Donkeys	Poultry
Minimum	4	20.0	15	1	15
Maximum	70	129.0	160	6	30
Mean	21.7	59.5	72.8	2.0	22.5
SEM	2.83	1.77	2.57	0.09	7.5
percent of respondents	18.1	100.0	100.0	54.2	1.4

SEM = standard error of the mean

The average number of camels kept by the pastoralists and agro-pastoralists per household decreased from 63 in 2001 to 30 in 2005 (Table 4), possibly due to the different diseases that occurred in the area in the years 1995-2005. The deseases that might have resulted to decreases in camel population over the years include camel's respiratory diseases syndrome, camel posterior paralysis, per acute camel killer disease, and new type of camel pox killing calves. The lack of appropriate vaccine and vaccine dosage for the prevention of camel diseases in the country might have also aggravated the incidence camel mortality and resulted to lowered camel population. For instance, anthrax vaccine has been produced in the country with ease vaccination for cattle, sheep, and goats. However, no dosage is prepared in the production laboratory of Debre Zeit for camels. The reduction in camel population over the four years period is an indication for the emergence of new camel production problems in the surveyed areas.

Table 4. Numbers of camels per household

	Year 2001	Year 2005
Minimum	15	2
Maximum	203	120
Mean	63	30
SEM	2.36	1.42

SEM = standard error of the mean

Diseases

Helminthiasis was perceived by most respondents as the major disease of camels followed by tick born disease, anthrax, and pneumonia (Table 5). Qanji is a disease perceived by respondents as a mild form of anthrax, trypanosomiasis, manage mites; posterior paralysis and werrying neck were also believed to be important diseases in affecting camels. Other diseases of less importance listed by respondents were sabat, nasal boties, pasterullosis, and foot swelling.

According to the respondents' perception, the prevalence of disease varies from one district to another. For example, anthrax is believed to be less important in Gashamo district than in the other three districts whereas

trypanosomiasis is more problematic diseases in Galadi district than in the other districts. The numbers of diseases believed to affect camels are higher in Gashamo and Harshin than in Bohk and Galadi districts. Not almost all respondents (98.6 %) believed in the existence of contagious diseases between camels and other livestock.

Table 5. Percentage of respondents on diseases of camels

Disease	Disrict				Total
	Bohk	Gashamo	Galadi	Harshin	
Helminthiasis	22.2	20.1	22.9	23.6	88.8
Tick born	22.9	16.7	18.1	22.2	79.8
Anthrax	25	9	24.3	17.4	75.7
Pneumonia	22.9	22.9	2.1	23.0	70.9
Qanji	19.4	5.6	20.8	0	45.8
Trypanosomiasis	2.1	13.2	22.2	4.9	42.4
Mange mites	0.7	13.2	6.9	17.4	38.2
Posterior paralysis	14.6	10.4	1.4	5.6	32
Werrying neck	0.0	9.7	5.6	11.8	27.1
Camel pox	0.7	8.3	2.1	4.2	15.3
Sabat / ragaad	0	13.9	0	0	13.9
Nasal	0	1.4	0	5.6	7.0
Diarrhea	0	0	0	1.4	1.4
Pasterullosis	0	0.7	0	0.7	1.4
Foot Swelling	0	0.7	0	0	0.7

The pastoralists and agro-pastoralists stressed on two diseases that are similar, but differ in their symptoms. These diseases are anthrax and qanji. The respondents believed that qanji is the mild form of anthrax. Around 50.0 and 81.3% of the respondents observed qanji and anthrax on their camels, respectively. About 44.4 % of the respondents observed an outbreak of qanji in 2005 while about 41.7% observed an outbreak in 2003. On the other hand, 63.2 %, 13.2% and 20.1% the respondents observed an outbreak of anthrax in 2005, 2004 and 2003, respectively.

The camel owners have their own criteria to differentiate anthrax from qanji by their symptoms see (Table 6). Sudden death, high mortality rate, coughing, swelling lymph nodes, and zoonosis seemed to be the major differentiating criteria between anthrax and qanji. However, there is a need to collect blood samples from camels infected with both diseases in order to isolate the exact causative agents of these two similar and confusing diseases.

Most of the respondents (79.2 %) perceived that qanji affects old aged camels, while a few (1.39 %) believed both young and adults are affected by the diseases. Most of the respondents (58.5%) observed camels dying from qanji with an average death of 2 camels per household during outbreak. However, the majority of the respondents (60.0%) believed that recovery from Qanji infection is high.

Table 6. Symptoms of anthrax and qanji as perceived by respondents

Symptoms of Anthrax	Percent of respondents	Symptoms of Qanji	Percent of respondents
Sudden death	43.0	No sudden death	41.0
High mortality	46.9	Low mortality	47.6
Low morbidity	38.3	High morbidity	36.8
Affects man	43.7	Does not affect man	41.0
Affects other animals	2.1	Not affects other animals	47.9
Dark blood when slaughtered	2.8	No dark blood when slaughtered	2.1
Affects all ages	12.5	Does not affects calves	16.7
No swelling lymph nodes	46	Swelling lymph nodes	67
High body temperature	2.1	High body temperature	2.1
Shivering	1.4	Shivering.	4.2

Time of diseases outbreak

Types of diseases that are believed to be prevalent during the dry and wet seasons are presented in Table 7 and Table 8, respectively. The major diseases that are common in the four districts during the dry season are helminthiasis, antharax, Mange mite, Werrying neck, and Pneumonia. Unlike the dry season, large number of the respondents (85 %) observed incidence of tick born diseases (TBD) in the wet or rainy season. Qanji, trypanosomiasis, mastitis, wounds, and diarrhea were also reported as predominant wet season diseases. Mastitis and wounds are more common in Bohk district as compared to the other three districts. Generally, wet season diseases are believed to be prevalent in Bohk and Galadi more than in Gashamo and Harshin districts.

Table 7. Diseases outbreak during the dry season as perceived by the respondents

Disease	Bohk	Gashamo	Galadi	Harshin	Total
Helminthiasis	24.3	23.6	24.3	23.6	95.8
Anthrax	25.0	9.0	25.0	18.1	77.1
Mange mite	18.1	16.7	12.5	18.18	66.4
Werrying neck	17.4	15.3	22.9	10.4	66.0
Pneumonia	22.9	20.1	2.8	14.3	61.1
Posterior paralysis	5.6	0.7	1.4	0.0	7.6
Tick born disease	2.8	0.7	0.0	0.7	4.2
Nasal bodies	0.0	0.0	1.4	2.1	3.5
Diarrhea	0.7	0.0	0.0	0.0	0.7

Diseases predisposing factors

Respondents pointed out the different factors that predispose camels to disease are shortage of feed, shortage of water, long distance travel, or migration to new areas, drought conditions, and high temperatures in their order of importance (Figure 1).

Almost all respondents migrate to new areas during shortage of feed and water. The majority of the respondents (60.4%) travel longer than 100 km in search of feed and water during periods of drought while most others (38.2%) travel 60-100 km for the same purpose. All respondents believe that cisterns Berkas are the main water sources that predispose their camels to helminth infection during summer times

Table 8. Diseases outbreak during the wet season as perceived by the respondents

Diseases	Bohk	Gashamo	Galadi	Harshin	Total
Tick born diseases	20.1	21.5	20.8	22.2	84.7
Qanji	22.9	9.0	22.2	0.0	54.2
Trypanosomiasis	3.5	16.7	22.9	4.9	47.9
Mastitis	18.8	2.1	8.3	0.7	29.9
Wounds	18.8	2.1	5.6	0.0	26.4
Diarrhea	8.3	6.3	4.9	1.4	20.8
Retained placenta	9.0	2.1	0.0	0.7	11.8
Mange mites	0.7	0.7	4.9	0.0	6.3
Werrying neck	0.7	2.1	0.7	0.0	3.5
Posterior paralysis	2.1	0.0	0.0	0.0	2.1
Pneumonia	0.7	0.0	0.7	0.0	1.4
Pastrullosis	0.0	0.0	0.0	0.7	0.7
Helminthiasis	0.7	0.0	0.0	0.0	0.7

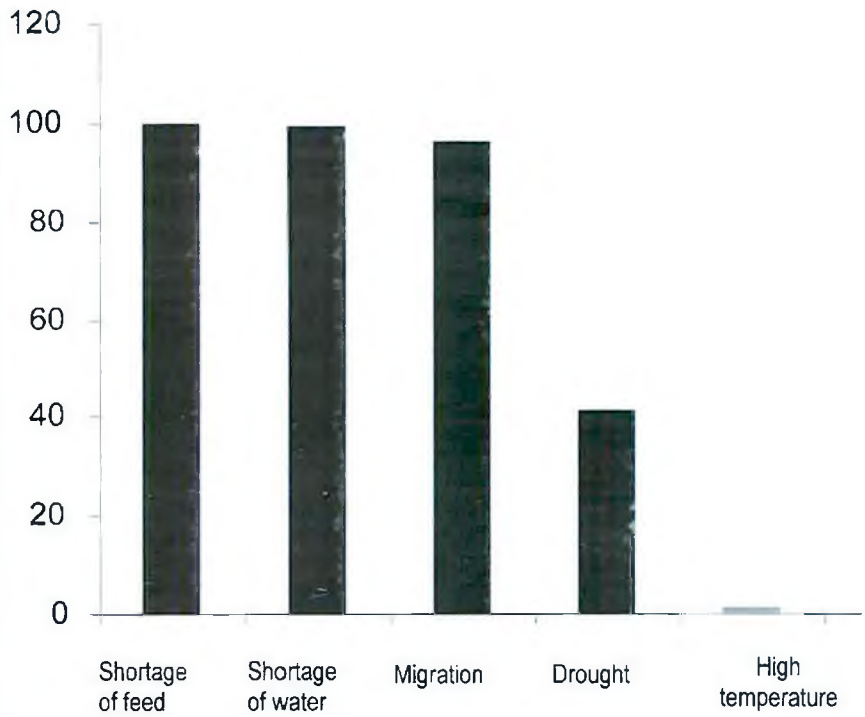

Figure 1. Factors that predispose camels to diseases as perceived by the respondents

Disease Management

Vaccination

Respondents were asked how they manage camel diseases. Most of the pastoralists and agro- pastoralists (75.0%) noted that their camels got vaccination against some diseases at least once a year, while about 23.0% of the respondents replied that their camels do not get vaccination. For those who get the vaccination, camels are usually vaccinated against anthrax followed by pasterullosis (Figure 2). Although camels are vaccinated against these two diseases annually in the early rainy season, there is however, no dosage for camels and as such, cattle dosage is used for vaccinating camels.

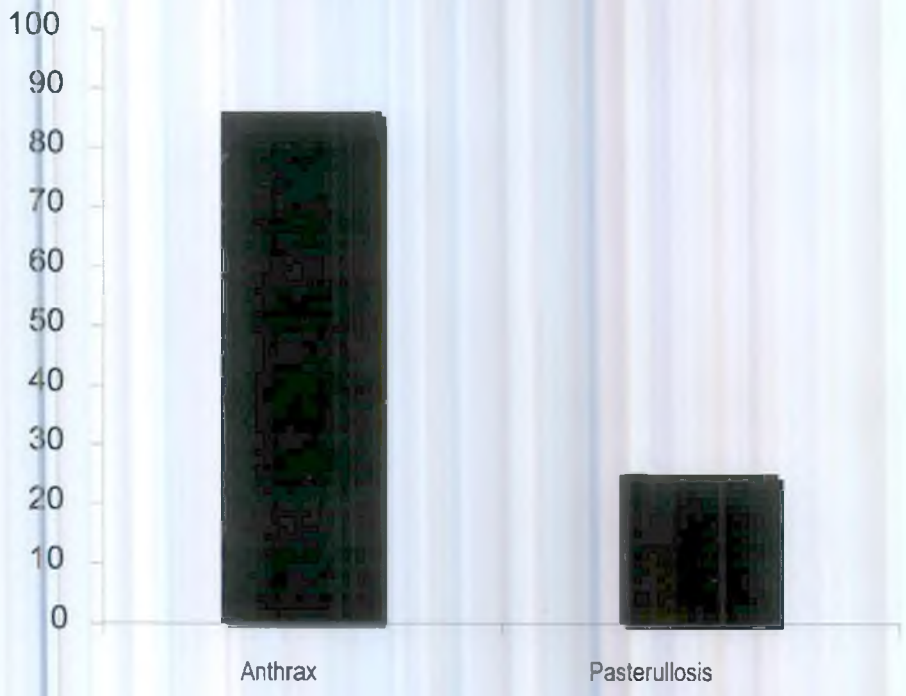

Figure 2. Percentage of that practice vaccination of their camels for anthrax and pasterullosis

Clinical treatment

Most of the households (97.9%) indicated that their camels receive clinical treatments during disease outbreak. The respondents listed a range of diseases that their camels are treated for (Table 9). More than half of the respondents indicated that camels are clinically treated for helminthiasis, anthrax, pneumonia, and tick-borne diseases. These treatments are given by camel owners and paravets. However, most respondents (97.2%) believed that the clinical treatments received by camels are not satisfactory.

Table 9. Percentage of respondents who replied that their camels are treated for a certain disease

Diseases	Bohk	Gashamo	Galadi	Harshin	Total
Helminthiasis	25.0	23.6	21.6	24.3	94.4
Anthrax	25.0	7.6	21.5	16.0	701
Pneumonia	26.0	20.1	2.8	16.7	64.6
Tick born disease	20.1	11.8	2.1	20.1	54.2
Trypanosomiasis	2.1	13.9	20.1	4.9	41.0
Mange mites	4.9	13.2	6.3	14.6	38.9
Qanji	19.4	5.6	11.8	0.0	36.8
Werrying neck	3.5	9.7	4.2	8.3	25.7
Loxowgaal	o.o	0.0	0.0	4.2	4.2
Diarrhea	2.8	0.0	0.7	0.0	3.5
Pasterullosis	0.0	0.0	0.0	0.7	0.7

Traditional treatments

Many of the respondents (92.4%) asserted that they had traditional treatments for their camels against some common diseases (Figure 3). Camel herders treat their camels for mastitis, wounds, diarrhea, retained placenta, mange mites and werrying neck diseases or nervous disorder. The wound treated traditionally could be due to open castration in male camel, predatory wounds and the like. Effectiveness is a major criterion in any disease treatments practice. Most camel owners (80.6%) rated their traditional treatment as effective, while 12.5% and 6.9% of the respondents rated the traditional treatment practice as very effective and not effective, respectively (Figure 4).

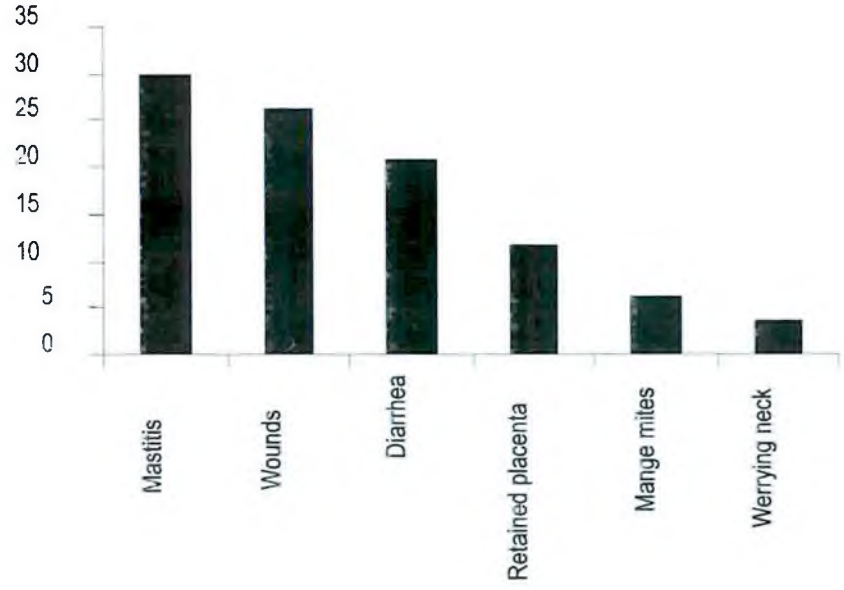

Figure 3. Percentage of respondents who treat camels traditionally for certain diseases

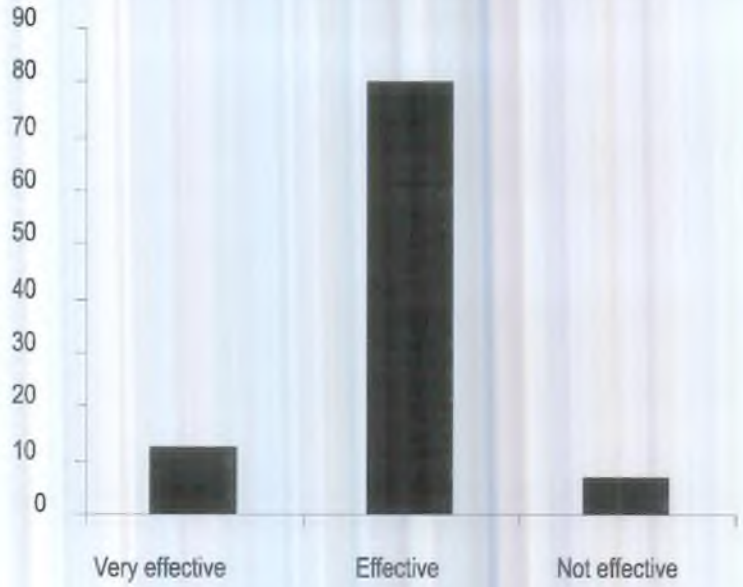

Figure 4. Perception of respondents towards the effectiveness of traditional treatment of camel diseases

Constraints in camel production and diseases management

The pastoralists and agro- pastoralists listed a number of constraints that are believed to impact camel production in the area (Figure 5). Veterinary services appeared to be the major constraint for camel production in the study area. As such, lacks of veterinary drugs followed by poor quality of the drugs are indicated to be the top ranked constraints for camel production in the area. Other camel production constraints as perceived by the respondents in their order of importance include predators, feed scarcity, irregular vaccination, recurrent drought, lack of clean water, absence of well established livestock market and lack of sufficient vaccine.

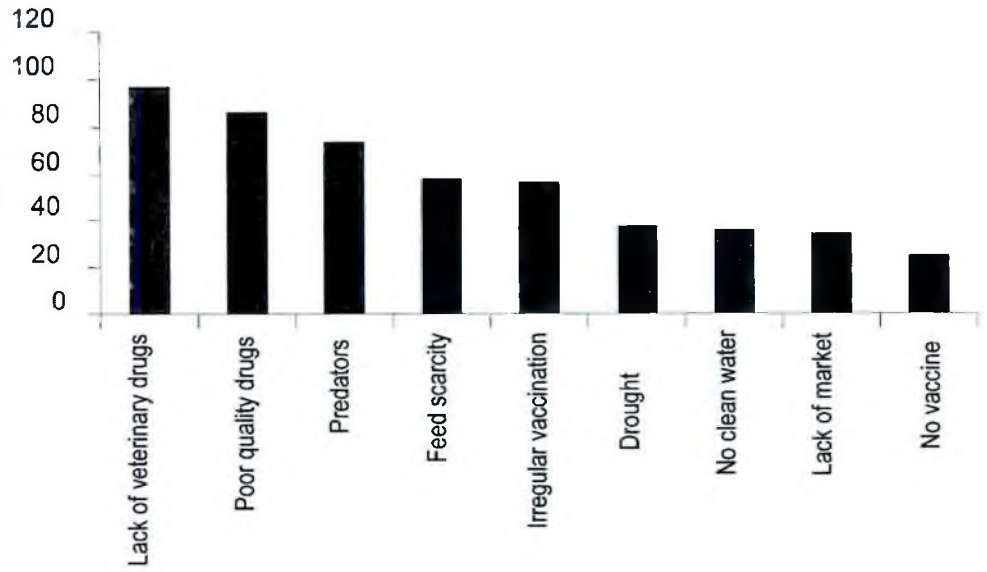

Figure 5. Constraints in camel production as perceived by the respondents

Solution for camel production constraints

The pastoralists and agro- pastoralists were asked to rank their immediate needs for improving camel productivity in their areas. Accordingly, supply of quality drugs, control of predators, training of veterinarians, improving range conditions and regular vaccination programs were ranked by the respondents as the most important steps that should be taken in order to improve the productivity of camels (Figure 6). Other potential recommendations forwarded by the respondents to tackle the prevailing camel production constraints and bring about improvements in camel production include improving the prevailing veterinary services, improving the livestock market infrastructure, and availing clean water for camels in the area.

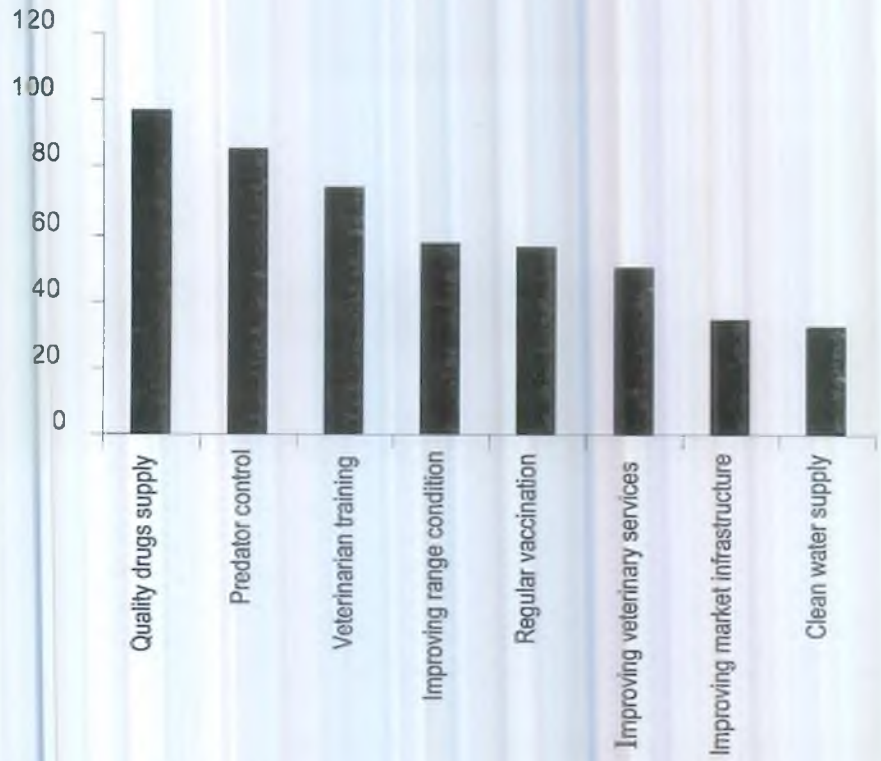

Figure 6. Possible solutions to improve camel production as perceived by the respondents

Discussion

Livestock is the main food and income source for respondents in the study area. The household family size of more than 5 people of respondents in the study area is indicative of the risk of food insecurity up on losing animals to disease or drought. However, almost all pastoralists and agro- pastoralists in the study area keep other livestock, particularly goats and sheep together with camels, which is a good strategy to reduce the risk of food insecurity and income shortage when a given species is severely affected by the incidence of diseases or drought.

The majority of the camel owners have medium camel herd size, which has decreased almost by half in a period of five years. Among others, different camel diseases and deteriorating range conditions are mentioned as major factors for the decline in camel numbers. Most of the camel diseases listed by the pastoralists and agro-pastoralists in this study agreed with previous studies conducted in the other districts of the Somali Regional State (Teshome et al., 2003; Cately, 1999) and neighboring countries (Ocaido et al., 2005). Helminthiais, tick born diseases, anthrax and pneumonia were the major camel diseases in the study districts. Qanji, trypanosomiais, mange mites,

and posterior paralysis were the second group of camel diseases listed by the respondents. However, importance of the different diseases varies among the surveyed districts suggesting the need to consider regional differences in disease management. For instance, anthrax and pneumonia are less important in Gashamo and Galadi districts, respectively as compared to other districts. Similarly, qanji was not reported in Harshin but both qanji and trypanosomiasis are the most common diseases in Galadi district. More number of diseases was reported from Gashamo and Harshin compared to the other two studied districts.

The pastoralists and agro- pastoralists observed the highest disease outbreak to occur during the dry season. This may be related to a decrease in the resistance of camels to different diseases due to shortage of feed and water. Respondents are also aware that shortage of feed and water, long distance travel migration to new areas and sustained drought conditions, which are common features of the dry season, to be the major disease predisposing factors in camels. As such helminthiasis, anthrax, mange mites, werrying neck, and pneumonia are common during the dry season. On the other hand, tick born diseases, qanji, and Trypanosomiais are believed to be more prevalent during the wet season. Mastitis, wounds, and diarrhea are also reported by 21-30 % of the respondents as diseases common in the rainy season as compared to the dry season.

Most camels in the study districts are vaccinated against anthrax and to some extent against pasterullosis and dewormed against helminthiaisis. However, most respondents indicated that vaccination of camels was irregular and inaccessible to most of the camel herders. Although pastoralists and agro-pastoralists get a limited veterinary service to their camels, they indicated that the service is unsatisfactory. This could be due to absence of enough veterinarians, lack of infrastructure, remoteness, and high mobility during dry periods. Most camel owners treat their camels traditionally diseases such as mange mites, werrying neck, retained placenta, mastitis and external wounds effectively. This is common in many pastoral areas (Cately, 1999), and this indigenous practice needs to be recognized and supported by community animal health workers and researchers.

The major bottleneck of proper diseases management pointed out by the respondents have to be tackled by community animal health workers, researchers, development workers, regional governmental and non-governmental organizations that are working in the pastoral and agro- pastoral areas of the region. Poor quality of veterinary drugs in the study districts could have been a result of wide spread black market in the border with Somalia, which demands strict measures by the government bodies. There is also a need to teach the pastoralists about the negative effects of poor quality drugs and conditions must be created to deliver genuine drugs. Concerned bodies in consultation with the pastoralists should solve the problem of predators. Improving range conditions through proper range management, area closure, and certain degree of afforestation is imperative in order to increase feed supply to camels and other livestock in the study districts.

Conclusion

This study provided valuable information on camel production constraints in the eastern districts of the Somali Regional State. High prevalence of diseases, shortage of feed and water, frequent drought conditions and attack by predators are the major camel production constraints in the four surveyed districts. Lack of veterinary services, poor quality of veterinary drugs and irregular or lack of vaccination programs are found to be serious problems in camel disease management in the studies area. Camel diseases are more common in the dry than in the rainy season and hence diseases management practices should focus reducing predisposing factors during the dry season.

Recommendation

The information generated from this survey gave insight about the major camel production constraints in the four eastern districts of the Somali Regional State. The following recommendations are drawn to improve camel productivity in the study area.

- Improving range condition and utilization so as to reduce feed scarcity which is the main disease predisposing factor in camels;
- Water harvesting during the rainy season in order to reduce water shortage during dry season and to shorten the distance traveled in search of water;
- Widening veterinary services and provision of quality veterinary drugs for the most common diseases such as helminthiais, anthrax, mange mites, werrying neck and pneumonia that are dominant in the dry season and tick born diseases, qanji and trypanosomiasis in the wet season;
- Vaccination of camels against the common diseases like anthrax and pasterullosis; and
- Supporting traditional camel disease treatments practices and encouraging research in this line.

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Assessment of the Supply and Demand of Camel Milk

The Case of Pastoral Community of Kereyu

Daniel T.Gelan[1], Wendessen G.Wolde[2], and Tezera G. Tiruneh[3]
[3]*Pastoralist Forum Ethiopia*

Introduction

In the past, Fentale district is known to be exclusively pastoral community but in the recent past, the pastoralists have started involving crops production as well. However, Pastoralism is the dominant livelihood in Fentale. The Karrayu area has been hit by recurrent droughts over the past several decades. The other main hazards affecting the Karrayu livelihood zone are livestock disease and conflicts with neighbours. In Fentale, there are three main seasons; Ganna (June to August) the long rainy season, Bira (September to November) short dry Season, Bona (December to February) long dry season and Arfasa (March to May) the short rainy season are the four seasons in the Karrayu livelihood zone. The livestock sales peak from May to September when the camels are in good body condition.

The main livestock species reared in the district are cattle, camels, goats, and sheep. Camels produce more milk for longer period than any other livestock species under difficult conditions. The most remarkable features of camels are the ability to continue lactation during periods of severe draught. Milk yields ranges from 3 to 10 litres in a lactation period of 12 to 18 months are common. Camel milk is one of the main components of the community's basic diet. In the context of rapid urbanization in around the district and surrounding, camel milk is increasingly commercializing. Indications from recent studies of market-oriented camel dairying in peri-urban areas emphasise to its increasing implications in the household income of pastoralists. The demand for camel milk in big towns such as Addis Ababa and Adama is rapidly building up, largely driven by the increasing population of Somali community and recognition of medicinal value of camel milk to some extent. It has been reported that there is an increasing popularity and interest in camel production among the pastoralists in Fentale.

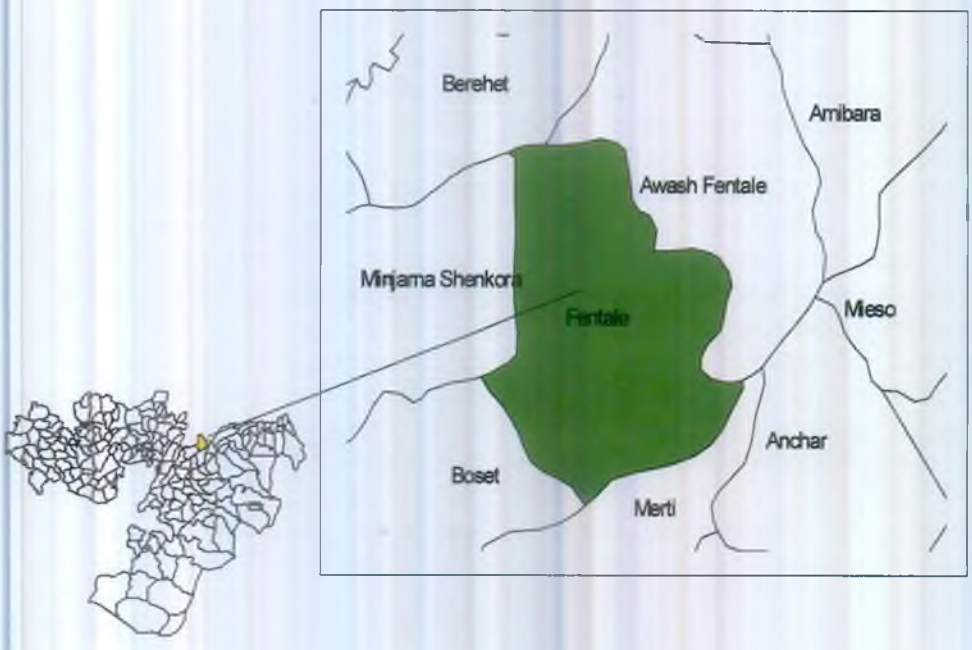
In this connection, this study provides an overview of the camel milk sub-sector in Karrayu by exploring the production and supply of camel milk, and an assessment of the current and potential demand for camel milk to show the extent to which there exists a demand-supply gap. On the supply side, a key issue explored in the study was the existence of production clusters within which leveraged interventions can be targeted, while on the demand-side, the various segments of the market and prospects for growth within each are some of the key areas of focus.

Methodology

The Study Area

The study was conducted in Fentale Woreda of East Shoa zone of Oromia regional state. Fentale Woreda is found in East Showa administrative zone of Oromiya Region. The capital of the Woreda is found at 193 km form Addis Ababa. The district consists of 18 Peasant Associations (PA). Fentale district bordering with: Awash Fentale of Afar Region from north and northeast, Merti district of Oromiya from south, Boset from southwest, and Minjar shenkora of Amhara from west and Berehet from north. The topography of the district is more of plains but there are hills and mountains such as mountain Fentale that is 2007 meters above sea level. The total area of the district is about 1,200 Km^2. The population settlement is very sparse. As per district administrative office, the total population of the district in the year 2006 was estimated to be 58,902 of which 53% are male and 47% are female. The district has great potential for extensive agricultural farming. Large-scale commercial farming such as Metehara sugar factory exists in the district. Fruits are also largely produced by private sectors. The average altitude of the district is about 980 meters above sea level. The climate is hot for most parts of the year. The maximum temperature reaches 41 ^0C in the period of June- to August.

Location of Fentale Woreda In Oromiya Regional State of Ethiopia



Camel Population and Production System

Camel Population

The total population of camel in of the district is estimated to be is 450,000. However, all the camels don't belong to the Karrayu community rather some of them are those owned by neighbouring pastoralists from Meso, Abomsa, and Boset as all the group share the woreda for camel raring. According to the information from Fentale district Pastoral and Agriculture Office, by the year 2007 the camel population of the district is estimated to reach about 61,425. However, the data from the study indicated that the official figure on camel population is underestimated. This is partly due to lack of updating the figures on regular basis and the community are afraid to tell the exact number of livestock population due to cultural reason and fear of higher tax. It has also been found that the number of camel in the district is increasing from year to year as camel is the most adaptive to changing situation in Fentale district and fetching higher price in the market as the result of increasing demand of life camel.

Attempt has been made to determine camel distribution by wealth categories; it was found that number of camel owned by different wealth group was 1 camel for very poor, 4 for poor, 17 for middle and 40 for better. This indicates the huge gap in terms of the number of camel ownership between the wealth groups. According to the key informants, in Banti kebele five households have more than 200 camels. It has been also estimated that more than 90% of total camel population are female out of which estimated 33% were found to be lactating. This indicated that pastorals prefer female camels producing milk. They usually sell male camel quickly as it is difficult to keep many male camels together in the stock.

Table 2 .Camel Population by Wealth Group

Wealth category	No. of households	Average households camel ownership	Total number of camel heads
Very poor	1,803	1	1,803
Poor	2,555	4	10,219
Middle	2,029	17	34,489
Better off	1,127	40	45,084
Total	7,514		91,596

Livestock species composition

It was reported that the species composition is favoring camel as unlike the others therefore the population of camel is increasing. Based on the estimate in sample Kebeles the following table was made. Based on the discussion it has been found that there is a shift in purpose and priorities of species. The purpose of camel has increased and replacing the purpose the cattle holds in the society.

Table 3 Livestock species changes

Livestock	Estimate of the Proportion before 40 years	Current proportion	Future trend	Reasons
Cattle	80	33	Reducing	Reduction in feed resources,
Camel	10	53	Increasing	Market value/ management/ drought resistance/ distance movement, consideration as asset
Sheep	4	10	Increasing	Simple management /breeding characteristic /market value
Goat	5	4		Breeding characteristic

Table 4. The Past and Current Priorities in Species

Species	Before 40 years		Current	
	Purpose of keeping	Rank	Purpose of keeping	Rank
Cattle	Milk, meat butter and skin (domestic use) dory, social value (death)	1	Is replaced by camel , its economic importance is highly variable based on the climatic condition	3
Goats and sheep	Cash , immediate use	2	Cash ,immediate consumption in the family	2
Camel	Transportation, keeping for difficult time only, less market value	3	Increasing economic value, transportation value, increase in use of high land, milk production drought resistance	1

Camel Production and Management

Camel production is the basis of the economy for the majorities of pastoral communities in Fentalle district the existing camel production system in the district is that often identified as transhumance system. Transhumance system featured by strategic seasonal movement of pastoralists along with their animal in search of pasture along with water source for human and livestock enable to cope up the effect of relatively longer dry period and returns back to their original place during the onset of rainy season. Camels are an essential part of the pastoral daily life of Karrayu community. They are important source of food in the form of milk. Camels are important sources of cash for pastoralists.

Quantity of Milk Produced

In estimating camel milk production, the following variables were taken: the camel population data from district Pastoral and Agriculture Office, which is 61,425, was taken as bases of estimation. According to the result of various Focus Group Discussions (FDG) conducted with producers during the field work of this study, the

number of Female camel is 90 % of the total camel heads. Thus, the number of female camel was taken as 55,282. The same source indicate that 33% of female camel are lactating and thus the number of lactating camels was taken as 18,243. Similar, as per the result of FGDs, the average daily milk from a lactating camel was 4.5 litters. Therefore, the total volume of milk produced on daily bases in Fentale district is estimated as 82,094 litters. The total camel milk produced per year is 2.9 million liter. .

Productivity and Seasonal Variability of Milk Production

Milk production and productivity is affected by the seasons of the year. There is more milk produced with high productivity during Gena rain from July to mid-September or wet season and short rainy season called (the Belg rain), locally called Arfasa, which occurs from March and April, and productivity is fluctuated over season and years. Key informants and participants of FGDs indicated that during the rainy or wet season the productivity of camel is highest and reached up to 7 litters per day per camel. During extreme drought months, it drops up to 2 litters per day per camel on average. Surprisingly, camel can be milked five times a day. The lactation length for camel usually is 12 months according the key informants.

As per the FGD with camel milk producers, the total amount of camel milk produced on daily bases will be used for three major purposes. Some part of the milk will be normally feed to the calves. Some portion is used to feed the family and given to the community members who do not have lactating camel or lack camel at all. Very few (50 out of 9874 camel producing households) supply to some part of their annual milk produce to the market.

According the estimation of this study the total amount of camel milk produced per day is 82,094 litters. If we assume that 50% of the milk is consumed of given to communities lacking camel milk, 41047 litter of milk can be supplied to the market. However currently only 4% of the surplus milk is supplied to the market and 96% is wasted.

Milk Quality

Milk production and handling practices influenced the level of contamination and quality of milk. Almost all camel producers milk their camel using traditional methods. Most of them do not milk animals on treatment, do not wash hands before milking, do not cover the milk, and have no potable (boiled) water for washing hands and utensils. However, currently camel milk marketing cooperative which established by the community is operational in the area and this cooperative supplies clean water and traditional smoking woods for selected households which got the chance to supply their milk to the cooperative with the purpose of improving the quality of the milk. Each supplier is using its own small milk pot/container to bring the milk to the collection center. The suppliers reported that they found difficulty to clean the milk pot/container through hand wash except rinsing with water and smoking.

Constraints and Opportunities of Camel Milk Production

Camel Milk Marketing in Fentale District

According the information of key informants, camel milk marketing is recent practice to the Karrayu community. It was started in 1998 when buyer from Somalia community in Addis Ababa had come to Fentale and convinced some households to sell their milk.

Since 1990s, the price was only one Birr for pastoralist and 12 Birr at Addis Ababa market. Only less than 100 litter use to be supplied. The price does not favor the pastoralists because of the intermediaries. Motivated by this fact some enlighten pastoralists established a milk collecting and marketing cooperative in 2002 EC to overcome this problem with the help of the district cooperative promotion. Trades were forced to negotiate price. The contract has been entered to supply the milk to the traders. The demand for milk is cold season is lower than while the demand is higher in the hot season and special demand during Muslim fasting.

Market actors

There are four major actors in the camel milk market value chain. The first are producers who bring their camel milk on the roadside collection centers twice a day. The second are cooperatives who collect the milk and supply to traders in Addis Ababa and Adama markets. The third are Trader in Addis Ababa and Adama. In addition, the fourth are consumers in Addis Ababa and Adama cities.

Analysis of supply side

Currently 320 households supply camel milk to the cooperatives on daily bases. Producers supply their milk to 7 milk collection centers. Each producer supply 5 liter per day on average. The total amount of milk supplied on daily bases is 1620 litters. Producers sell their milk to the two cooperative in seven collection centers. They sell one liter of milk for 7 Birr to the cooperatives. The producers supply the camel milk to the collection center using small milk pots having the capacity of 3 to 5 liter. .

Buyers from the Producers

Two cooperatives collect the milk from the producers and supply to Addis Ababa and Adama markets. The cooperatives buy the milk from producers for 7 Birr per liter and sell to the traders for 9 Birr per liter. The two cooperatives are not cooperating to the benefit of their community. One is working to monopolize the whole market and they made price cut to the level of zero profit with the purpose of chasing out the other from the business. Some intermediaries play the game for getting high profit margin through monopolizing the market.

Cooperatives - Buyers Support to Producers

The milk collection and marketing cooperative provides clean water and traditional smoking woods for selected households, which got the chance to supply their milk to the cooperative with the purpose of improving the quality of the milk. The cooperatives

collect the milk using milk pos with 25 liter holding capacity. Adulteration of the milk is the major problem especially during the hot season. During this season, the milk will be spoiled unless taken to the market early in the morning. This is due to lack of cold chain and improved container to collect and transport the milk to the terminal market. The cooperative made quality control through smelling, test, visual observation.

Analysis of Demand Side

Major Camel Milk Terminal Markets

Addis Ababa and Adama market are the two camel milk markets in the area. The only sources of camel milk to this market are from Karrayu and surrounding areas. On average, a total of 1420 liter of milk enters to the Addis Ababa market and 200 liter to Adama market per day from Karrayu areas.

Frequency and Means of transportation to terminal market

There is a permanent Minibus, which transports milk from Karrayu to Addis Ababa and Adama market on daily basis. According to the focus group discussion with milk freighters association and information obtained from the transporters, up to 1620 liters of milk is supplied to both Addis Ababa and Adama Market. The amount of milk supplied to the market for dry and wet season remains same although there is high milk production during wet season. The surplus production during both seasons will not supply to market because of limited consumers in both Addis and Adama markets.

Retailers and Retail Price in Addis Ababa and Adama Market

In Addis Ababa Market, there are three wholesalers, one at Bole Michael, one at Saries and the other around 24. The wholesaler sell to retailer for 16 -18 birr per liter. The retailer sells to the consumer 20 - 25 birr per liter. The major consumers in Addis Ababa market are Somali refugees, Ethiopian Somali and Afar communities living in Addis Ababa and some other Muslim communities.

Challenges and Opportunities in Camel Milk Marketing

Challenges

The major challenges observed in camel milk marketing are:

- Easy spoilage of milk due to long distance walk of pastoralists to the market;
- Lack of improved milk collecting and transporting facilities;
- Inadequate market;
- Lack of improved technology to increase shelf life of the milk;
- Lack of skill to improve quality;

- Lack of milk processing plant, Absence of private pasteurized or UHT milk processing plant in the area;
- Poor quality control systems at milk collecting centers;
- Short shelf life of fresh milk; and
- Needless competition between cooperatives

Opportunities

The major opportunities that need to be exploited for upgrading of milk value chain in Fentale pastoral areas are the following:

- High social capital;
- Good long term milk consumption habit in the area;
- Introduction of information communication technology for instance mobile phone;
- Interventions of Pastoral Community Development Project (PCDP) to improve market infrastructure;
- Pastoral area received great attention from the Government; and
- Many NGOs working in supporting the marketing

Recommendations

Based on the discussion made on challenges and opportunity of milk and milk products and the findings of the discussion made with the pastoral community and other stake holders , the following intervention points are identified –that would potentially done by all the stakeholders

Improving market

- Develop milk market development strategies for Fentale pastoral communities;
- Show the profitability of the milk business in Fentale to the big private companies to invest on UHT/pasteurizing milk processing industry and to establish chilling centers at different potential milk production sites;
- Support pastoralists to organize themselves into milk marketing groups and cooperatives with a voice;
- Facilitating effective and efficient market information net work that can be accessible by all actors fairly benefit the actors along the milk market channel;
- Expanding market in Addis Ababa market through assessing interested wholesaler in other places where Somali refugees are residing;
- Looking for export market to Djibouti and Saudi Arabia, and in country market for pasteurized milk; and
- Conducting detail value chain analysis

Improve milk quality

- Train producers on the issue of milk quality management through incorporating in the existing extension services and different interventions done by different development organizations;

- Support mechanisms for setting of appropriate quality standards in milk and milk products their enforcement – both by actors;
- Facilitate development of simple and easy to use testing equipment for milk quality with acquisition of appropriate milk handling containers among producers and other actors along the value chain with awareness campaigns to stimulate demand for quality milk among consumers in the process of ensuring quality;
- Establish quality payment systems at the processing level; and
- Facilitate credit to the pastoralist groups to purchase aluminum container to avoid plastic pot.

Improve animal health

- Undertake strategic vaccination programs for economically important diseases;
- Strengthening the capacity to undertake diagnostic, epidemiological surveillance and reporting by upgrading laboratory;
- Supporting efforts to limit the spread of these diseases through controlled livestock movements;
- Strengthen the current efforts done by the government and development organizations to improve animal health in pastoralist;
- Promote private sector and the development organization to provide the service at affordable prices;
- Control distribution of veterinary products;
- Train youth pastoralists to identify the type of disease and the treatment needed;
- Train women pastoralist on the cause of mastitis;
- Demonstration and sensitization on cheaper methods of tick control; and
- Support to establish community based animal health workers

Promote private sector to engage in milk sub sector

- Conduct different consultative meetings with the zone administration and other actors the need of the private sector on milk processing and the need of special packages of incentives;
- Work with the government to design packages of incentives to the private sectors;
- Promote the business opportunities of milk business in Fentale pastoral areas;
- Lobby and link with the investors that are knowledgeable to the area and others;
- Organize workshop for investors to promote the milk investment opportunities; and
- Support for the increased availability of milk business development service providers able to advise pastoral producers groups not only on husbandry issues but also on business practices and market access.

General Discussion

The general discussion was held on Saturday, 29 October 2011, starting from 11: 00 am after the participants returned from visiting camel herds around Fafem. The chairperson of the conference organizing committee, Ato Seyoum Bediye, opened the session by introducing an outline of a program for the general discussion as follows: Accordingly, the Chairman of the session Ato Abdi invited a representative from Oromia Pastoral Council, Ato Nura, to make five minutes speech about the conference.

Pastoral Elder from Oromia Region

The representative, Ato Nura, indicated that given the fact that camels have been given little attention and neglected, the International Camel Conference held in Jijiga is timely and very important, and he thanked the organizing committee for arranging the conference. Then he posed the following questions:

- Why camels have been given little attention and marginalized despite their very important
- contributions?
- What are the medicinal values of camel milk and camel meat?
- Is there any effort towards development of vaccine for camels?
- In the five years development and transformation plan, the Government talks about settlement. Is the settlement for people or for animals?

Pastoral Elder from Somali Region

The representative thanked the conference organizing committee and indicated that he agrees with Ato Nura about the uses of camels. He mentioned that for the Somali, camels are the most important animals since time immemorial. Camels have three major uses including:

- provide milk;
- provide meat; and
- used for transportation of people and goods.

Generally, the conference is timely and important.

Pastoral Elder from Afar Region

He appreciated the attention given to camels by organizing this conference. Thus, he thanked the conference organizing committee. He indicated his especial appreciation to Prof. R. Yagil for his in-depth knowledge on camels. He further pointed out that there is a very urgent need of research on camel diseases and to development of appropriate drugs/vaccines for camels. He stressed the need for organized camel market in the future.

International Scientists

Dr. Bernard Faye, France

He appreciated the organization of the International Camel Conference in Ethiopia. He indicated that Ethiopia is among the top 15 countries in terms of publications on camels. He further mentioned that the local scientific community should link with International scientific community such as by attending the upcoming ISOCARD conference.

Dr. N.V. Patil from India

He said he is impressed by the way; the committee organized the camel conference. He pointed out that camels are marginalized because they were domesticated later than other domestic animals and they can easily adapt to harsh environments. He mentioned that scientists, pastoralists and all stakeholders should work together to solve the problems associated with camels; there should have an appropriate forum to address issues related to camels; there needs to be a development effort towards camel milk value chain; and he indicated the need for involvement of women in camel dairy.

Prof. R. Yagil from Israel

He reminded the conference participants saying that since the conference is about enhancing sustainable livelihood of pastoralists through camel research and development, we need to have an idea about sustainable development of camels. For industrialization of the camel sector, we have to start from the pastoralists not from the industry. He said he is willing to help in this regard and asked the participants to contact the University of Ben-Gurion, Israel for future collaborative work. He indicated that pastoralists need good education and change will come through education. He stressed about the need for an effective extension service. He further indicated the need for research to develop functional and health foods from camel milk and camel milk products and camel meat and meat products, and on wool and bone products from camels. He also highlighted that pastoralists should not be exploited. He closed his speech by saying "I have a dream that the camel industry will change one day in the future."

Prof. Osman Mahgoub from Oman

He started his speech by indicating that pastoralists should not be excluded from all aspects including research, extension, development, etc. There should be mutual interaction between pastoralists and the Government and all stakeholders. He indicated the need for pastoralists to be open when telling camel numbers and any other data to researchers. He also stressed the need for training and collaboration between different countries. He also pointed out that it is not possible to put effort on every aspect of camels. Thus, we need to prioritize the development interventions to be undertaken. The scientific community should do both basic and applied research in consultation with the pastoral communities. Finally, he welcomed everybody to attend the upcoming ISOCARD conference that is going to be held in Oman in 2012.

Prof. Ashraf Sobhy Mohamad Saber from Egypt

He said that in Egypt they developed a technology to preserve camel meat by applying garlic and some spices. The meat treated in this way can keep for six months. He said he is willing to help pastoralists in this regard.

Dr. Atif E. Abdel Gadi from Sudan

He indicated that Sudan wants to work together with Ethiopia, Kenya, Somalia, and Eastern African countries on different aspects of camel research.

Dr. Kisa Juma Ngeiywa from Kenya

He started his speech by mentioning that he is very happy about the organizing committee for their successful organization of the conference. He stressed the need for regional cooperation. He further pointed out that disease is one of the most important constraint to camel production and thus needs to be given due attention. He also mentioned the problem associated with *Prosopis juliflora* encroachment in Afar Region. Finally, he welcomed every body to attend a camel conference organized by Kenyan Camel Forum in the future.

Miss Alicia Sully from USA

She mentioned that the conference has been wonderful and indicated that the participants can contact her about documentary films and videos about camels through email in the future.

Local Participants

A Representative from the Parliament

Government representative replied to the question raised by Ato Nura about settlement of pastoralists. He indicated that the Government plan is to establish infrastructure that will benefit pastoralists in pastoral areas with the consent and willingness of the pastoralists. The Government is not planning forced settlement.

A Representative from the Federal Ministry of Agriculture

Dr. Edmalem Shitaye representing the Federal Ministry of Agriculture thanked all participants from abroad for attending the conference on the behalf of MoA. He stressed the need for working in concert/holistic manner to solve the problem of the pastoralists.

A Representative from FAO

The FAO representative mentioned that FAO considers camels as animals of the future in pastoral and agro-pastoral areas of Ethiopia especially in line with climate change. He indicated that FAO supports development works related to camels.

A Representative from Pastoralist Forum Ethiopia

Ato Tezera Getahun representing PFE and ESAP indicated that camels need recognition. He thanked SORPARI for organizing this important conference. He mentioned that PFE would work together in the future towards improvement of the camel sector. After the speeches of the different representatives, a Somali elder played a poet praising camels.

Ato Mohamed Sherif, Director General of SORPARI, after thanking all participants on behalf of SORPARI posed a question as on the continuation of such a conference. He suggested establishment of International Camel Forum or International Camel Journal.

At the end of deliberation of the International Conference on Camel Research and Development: Enhancing Sustainable Livelihood of Ethiopian Pastoralists, the following recommendations have been forwarded and endorsed.

- Organize the same conference and theme for the horn of Africa;
- Produce proceedings and share with stakeholders;
- Optimize participation in the national, regional and global meetings regarding camel research and development;
- Undertake census of camel population assisted by modern tools and techniques;
- More integration need to come to realize research and development efforts on camel;
- More need to be done in terms of camel health due to absence of vaccine developed for camel so far;
- Synthesize global experience and work out how camel herders in Ethiopia can benefit from the existing technology and knowledge ;
- Organize Camel Association of Ethiopia; and
- Camel as globally unifying animal, we need to put hands together in advancing research and development on camel

Participants

1.	Abbas Abdullahi	Haramaya University
2.	Abdi Mohammed	SoRPARI
3.	Abdi Abdullahi	Pastoralist (Somali)
4.	Abdi Bile	SOCDA
5.	Abdi Hassen	SoRPARI
6.	Abdi Mohamoud	Pastoralist (Somali)
7.	Abdi Omer	ESTV
8.	Abdi Salad	SRS President Office
9.	Abdi Tayib	Karamar Regional Hospital
10.	Abdifatah Ali	SoRPARI
11.	Abdifatah Mohammed	SoRPARI
12.	Abdigebar Mohammud Ahmed	Haramaya University
13.	Abdikadir Hasan Muhamed	SoRPARI
14.	Abdikadir Mahamud	Pastoralist (Somali)
15.	Abdikarim Ahmed Rayd	Pastoralist (Somali)
16.	Abdikarim Guled Bulhan	Pastoralist (Somali)
17.	Abdikarim sudi	Warder District
18.	Abdikhadar Haybe	SoRPARI
19.	Abdilahi Gas	SoRPARI
20.	Abdirahman Mohamed	SoRPARI
21.	Abdirazak Abdulahi	SoRPARI
22.	Abdirisik Ahmed	SoRPARI
23.	Abdirizak Ahmed	SoRPARI
24.	Abdiwahab Sh. Yusuf	Pastoralist (Somali)
25.	Abdo Teshite	ERTA
26.	Abdukadir Maha	Pastoralist (Somali)
27.	Abdulahi Adam Ahmed	Pastoralist (Somali)
28.	Abdulahi Hussen (Dr.)	Mercy crops
29.	Abdulahi Mohamed	SoRPARI
30.	Abdulahi Mohammed	SoRPARI
31.	Abdulkadir Ahmed	SoRPARI
32.	Abdullahi Adan Ahmed	Pastoralist (Somali)
33.	Abdurehman Eid	Jigjiga University
34.	Abebaw Shimels (Dr.)	SoRPARI
35.	Abebe Kirub	Ethiopia Institute of Agricultural Research
36.	Adan Moahamoud Ahmed	Pastoralist (Somali)
37.	Adinew Feleke	ETV
38.	Ahmed Haji	Pastoralist (Somali)
39.	Ahmed Haji Omer	Pastoralist (Somali)

40.	Ahmed Moalin Osman	SoRPARI
41.	Ahmed Nur Sh Mohammed	SoRPARI
42.	Ahmed Shel	SoRPARI
43.	Ahmed Siyad Harur	SRS
44.	Ahmed Teyib	SoRPARI
45.	Ahmed Yusuf Ismail	Pastoralist (Somali)
46.	Aklilu Zewde	Ministry of Agriculture
47.	Aleme Asrese	Haramaya University
48.	Alicia Sully	USA
49.	Amin Yusuf	SoRPARI
50.	Assefa Tewodros	PCDP
51.	Atif Elamin (Dr.)	University of Khartoum
52.	Badri Mohamed	SoRPARI
53.	Badri Yusuf	SoRPARI
54.	Bare Abdurehman	SoRPARI
55.	Bash1r Hassen Igal	SoRPARI
56.	Bashe Abdi	Cakaara news
57.	Bereket Moila (Dr.)	Jigjiga University
58.	Bernand Faye (Dr.)	FAO
59.	Cheko Mohammed	Afar
60.	Dahir Omar	Pastoralist (Somali)
61.	Daniel Seyoum	SoRPARI
62.	Daniel Temesgen (Dr.)	Pastoralist Forum Ethiopia
63.	Derese Teshome	EIAR
64.	Edmealem Shitaye (Dr.)	Ministry of Agriculture
65.	Elyas Abate	
66.	Eyasu Seifu (Dr.)	Haramaya University
67.	Faysal Burale	PLDO
68.	Faysal Mohammed	SoRPARI
69.	Fekadu Beyene (Dr.)	Haramya University
70.	Fekadu Demsie	National Veterinary Institute
71.	Fufa Abunna (Dr.)	Hawassa University
72.	Garaad Mahammd Dole	Community Elder
73.	Gelagay Ayelet	National Veterinary Institute
74.	Getachaw Gebru (Dr.)	MARIL
75.	Getachew Animut (Dr.)	Haramaya University
76.	Getinet Kasahun (Dr.)	Haramaya University
77.	Getnet Assefa (Dr.)	Ethiopia Institute of Agricultural Research
78.	Girma Sima	SoRPARI
79.	H/E Ato Ahmed Dek	V/President and Head BoFED
80.	H/E Ato Hussein Geda	House of People's Representatives
81.	H/E Derfata Diigaba	House of People's Representatives

82.	Haii Mohammed Ibraahin	Pastoralist (Somali)
83.	Haji Mohamoud	SC-UK
84.	Haji Muhumed Dahir	Pastoralist (Somali)
85.	Hamse Sh Abdi	SoRPARI
86.	Hassen Abdisalam	SRS Culture and Tourism Bureau
87.	Hassen Abdurehman	SoRPARI
88.	Hassen Mohammed	Pastoralist (Afar)
89.	Haybe Yusuf Hassen	Pastoralist (Somali)
90.	Hayi Mohamed	Pastoralist (Somali)
91.	Helen Asfaw	SoRPARI
92.	Hibo Ahmed Umer	SoRPARI
93.	Hussein Geda	Oromiya
94.	Hussen Mohamoud	Afar
95.	Ibrahim Jibril	SoRPARI
96.	Ibrahim Mohamed	Somali Region House of People's Representatives
97.	Idil Mohamoud	SoRPARI
98.	Iid Siyaad Maxamed	Pastoralist (Somali)
99.	Istifanos Irda	Pastoralist (Oromia)
100.	Jemal Kalinleh Aden	Pastoralist (Somali)
101.	Kasahun Lamboba	Haramaya University
102.	Kayse Yusuf Hassen	Degehabur District
103.	Kibrom G/hiwot	SoRPARI
104.	Kissa Juma (Dr)	Kenya
105.	Mahamed Badel	SoRPARI
106.	Mahdi Egie (DR.)	SoRPARI
107.	Mahdi Musa	SoRPARI
108.	Mahmoud Hassen	APARI
109.	Melaku Tefera	Haramaya university
110.	Mengestu w/hanna	Haramaya University
111.	Mengistu Urge	Haramaya University
112.	Mitiku Eshetu	Haramaya University
113.	Mohamad Abdi Noor	SOCDA
114.	Mohamed Hussein	SoRPARI
115.	Mohamed Osman Mahamud	Pastoralist (Somali)
116.	Mohamed Yusuf	SoRPARI
117.	Mohammed Abdullahi	SoRPARI
118.	Mohammed Abyia	Oromia
119.	Mohammed Adan Ahmed	SRS
120.	Mohammed Ahmed	Karamara Regional Hospital
121.	Mohammed Alyi (Dr.)	Oromiya Livestock Agency
122.	Mohammed Burale	SoRPARI
123.	Mohammed Hassen	SoRPARI

124. Mohammed Ibrahim (Dr.)	LCRDB
125. Mohammed Ismaan Giley	Pastoralist (Somali)
126. Mohammed Osman	Pastoralist (Somali)
127. Mohammed Samatar	SoRPARI
128. Mohammed Sharif	SoRPARI
129. Mohammed Yusuf Kurtu(Dr.)	Haramaya University
130. Mohammed Yusuf	SoRPARI
131. Mohamoud Hassen	Afar
132. Mohamoud Kaman Yusuf	Pastoralist (Somali)
133. Mohamoud Osman	APARI
134. Muhidin Jemal	SoRPARI
135. Muhumed Ali Farah(Dr.)	SoRPARI
136. Muhyadin Mohammed	LCRDB
137. Mukhtar Mohammed	Pastoralist (Somali)
138. Mukhtar Muhumed	SoRPARI
139. Muna Mohammoud	SoRPARI
140. Murha Abekeri	Pastoralist (Afar)
141. Musa Kari	Pastoralist (Afar)
142. Mussa Mohammed (Dr.)	PCDP
143. Mustafa Abdi Hassen	Pastoralist (Somali)
144. Mustafe Mohammed	SoRPARI
145. Najah Aydil Essie	Somali Region House of People's Representatives
146. Nuur Dida	Pastoralist (Oromiya)
147. Prof. Ashraf S.Saber	Menoufiya University, Egypt
148. Prof. Belay Kassha	Harmaya University
149. Prof. Osman Mahgoub	Sultan Qaboos University, Oman
150. Prof. Reuven yagil	Israel
151. Prof.N.V. Patil (Prof.)	National Research Center on Camel, Bikara, India
152. Seid Alemu	ERTA
153. Seid Mohammed	Jigjiga University
154. Seid Mohammed	Semera University
155. Semunigus Yamane	EIAR
156. Sewnet chekol	Federal
157. Seyoum Bediye	EIAR
158. Seyoum Mekonen (Dr.)	SoRPARI
159. Shako Mohammed	Afar
160. Shanko Delelegne	Mo FA
161. Shek Mohammed	Pastoralist (Afar)
162. Shugri Haji Ali	Pastoralist (Somali)
163. Sirak Alemayehu	APARI
164. Sisay Telahun (Dr.)	SoRPARI
165. Siyad Omer	SoRPARI

166. Solomon Yaynshet	Mo FA
167. Sultan Ahmed	Pastoralist (Somali)
168. Taffesa Mesfin (Dr.)	Pastoralist Forum Ethiopia
169. Tahir Omer	Pastoralist (Somali)
170. Takele Dejene	SoRPARI
171. Tamrat Mokonon	Pastoralist Forum Ethiopia
172. Tarekegn Tolla	FAO
173. Tariku Mokonnen	
174. Teklemariam Berhe	Haramaya University
175. Tezera Getahun	Pastoralist Forum Ethiopian
176. Ugaas Mohamed Ahmed	Community elder
177. Wendessen Gulelat	Pastoralist Forum Ethiopia
178. Yosef Legese (Dr.)	Jigjiga University
179. Yoseph Mekasha (Dr.)	Haramaya University
180. Yusuf Abubaker	Haramaya University
181. Yusuf Bashir Jama	Warder District