



Vision 2030



National Research Centre on Camel

Bikaner

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Vision 2030



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Published

July - 2011

Printed By

R. G. Associates
Bikaner-334001
Mob.-9414603856

Contents

| | |
|-------------------------------------|-----|
| Foreword | v |
| Preface | vii |
| 1. Camel Production System Scenario | 1 |
| 2. Camel Research Scenario | 7 |
| 3. NRCC 2030 | 10 |
| 4. Harnessing Science | 12 |
| 5. Strategy and Framework | 19 |
| Epilogue | 21 |
| Annexure I: Strategic Frame Work | 22 |



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Foreword

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

The National Research Centre on Camel (NRCC) at Bikaner, established in July 5, 1984 has scaled different achievement milestones in the form of development of infrastructure facility for the conduct of basic, applied and strategic research; establishment of elite herds of the four Indian camel breeds; successful management of reproduction; nutrient requirements for camel for various physiological phases; evaluation of draught-ability of camel, and also its use for other utility works of electricity generation; development of camel milk products, their shelf life and therapeutic utility in human diseases; development of molecular diagnostic tools for camel diseases, etc. The Centre has become an international institution for the advanced research in different aspects of camel including camel nutrition, genetics, reproduction and management. The Centre also imparts trainings to the camel owners, field veterinarians and students on various aspects of camel husbandry.

It is expected that the analytical approach and forward looking concepts presented in the 'Vision 2030' document will, prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

Dated the 23rd June, 2011
New Delhi

(S. Ayyappan)

Preface

Camel belongs to the family Camelidae in the suborder Tylopoda (pad-footed); order Artiodactyla (even-toed ungulates). The family camelidae includes two genus- *Camelus* and *Lama*. The genus *Camelus* has two species viz. *Camelus dromedarius* (single humped or dromedary) having habitat in dry hot arid lands of Africa, Asia and Australia and *Camelus bactrianus* (Double humped or Bactrian) habitat in cold arid lands of Central palearctic ecozone. These two species are customarily called Old World Camels. The species belonging to genus *Lama* are *Lama vicugna* (Vicuna), *Lama guanaco* (Guanaco), *Lama glama* (Llama) and *Lama pacos* (Alpaca). These four species are termed as New World Camels having habitat in South America.

National Research Centre on Camel at Bikaner was established on July 5, 1984 based on the need of the region to conserve and preserve an important native germ plasm camel, an icon of adaptation in the deserts. The work started with establishment of world class research facility to undertake basic and applied researches in Camel. In order to address the research and development need for work on the camels a perspective plan Vision 2020 was drafted for the centre in 1997 and the areas of research included conservation and conduct of basic studies on camel to generate valuable information on this species. With the shift of scenario in agriculture and livestock farming a change was noticed in the use of camel power for the works of agriculture or its traditional use for draft also suffered due to rapid mechanization. And as a result a significant decline in camel population was witnessed in last one decade because the farmers found it uneconomical and burdensome to rear the camels. Hence it was felt necessary to re-look into the priorities identified earlier during 1997 and the perspective plan Vision 2025 was formulated in 2007 for the centre and new priorities and programmes were drafted to undertake the action plans involving research and extension. The proposed programme activity plans coincided with the XIth plan activities and implementation of focused activities led to identification of camel for other utility function such as milk production like the cattle and buffaloes.

With the biotechnological advancements new technologies and skills are now available which helped to identify new potentialities of camel as an animal of unique attributes which can benefit the human and animal health. Beside there are other aspects of camel's adaptation to biotic and abiotic stress situations which can be exploited for the benefit of other animals or even for human beings if used at molecular level. Therefore this document proposes programmes and activities in a mission mode to use this animal species for the benefit of mankind. The programmes proposed also envision undertaking activities related to value addition to camel milk and make efforts to highlight its nutraceutical value for the benefit of human being which will be an attempt forward to create consumer base that are conscious of health benefits. It is hoped this ultimately will lead to build confidence in the camel rearing communities about

usefulness of this animal species beside its limited value in agriculture, as a draft or animal of tourist attraction.

I would like to express my gratitude to Dr. S. Ayyappan, Hon'ble Secretary, DARE and DG, ICAR for his kind support and guidance in preparation of this document Vision 2030 for the centre. I am thankful to Dr. K.M.L. Pathak, DDG (AS), Dr. C.S. Prasad, ADG (AN&P), Dr. Gayaprasad, ADG (AH) and Dr. S.C. Gupta, ADG (AP&B) for their guidance and support. I express my sincere thanks to Chairman and members of QRT and RAC for their invaluable suggestions which helped to decide the activities. I appreciate the sincere efforts of my team of scientists, technical, administrative, and supporting staff in the preparation of Vision 2030 and hope that the document will serve the purpose of fulfilling the mandated aims set forth by the Centre and rightfully expected by the society.



N.V. Patil
Director

Camel Production System Scenario

The camel is an important component of Indian fragile desert ecosystem, a proven icon of adaptation with its unique bio-physiological characteristics has formidable ways of living in harsh situations of arid and semi-arid regions. 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 has many unique qualities to survive and serve under harsh climate and utilize low quality feed resources which other species cannot consume. In fact, the camels are the life line of rural population in remote villages in the present era also. Any development programme for livestock production system to which local people are well adapted has much greater chance to succeed and therefore camel improvement efforts have positive possibilities. There is no weakness in the camel as a domestic animal dedicated to serve the people but the mechanization of agricultural operations and the transport facilities have created a man-made weakness in it. The NRCC has taken up the initiatives to sustain the camel in the desert eco-system but the sustenance of camel is looking towards the policy makers and the mental make up of the modern population. Use of camel bio-energy can save foreign exchange on the petroleum products because the camels are renewable natural source of power and require indigenous renewable natural resources to survive and substantiate. However, motivation of the people and proper policies can lead to even better development of this species and hence that of the camel keepers of this country. The emphasis would be on developing perspective and strategic camel improvement policy and to undertake related research programmes to prove this animal as a multi-utility animal linking various good attributes of this animal for the benefit of human society, use and propagate camel milk and other products for extracting health and other benefits for human and animal health and involve various related scientific and promoting institutions of the region for future sustenance of camel.

Shift in Camel Population A Cause of Concern

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 countries. Somalia has the highest population of 7.00 million followed by Sudan 4.25 m, Ethiopia 2.40 m, Niger 1.65 m, Mauritania 1.49 million, Chad 1.39 m, Mali 1.15, Pakistan 0.95 and Kenya 0.94. India stands tenth in the world ranking with 0.51 million camels (FAOSTAT, 2011). The majority of world's camel population is of dromedary type except small population of Bactrian camels in central Asia.

India rank 7th in the world for camel population and in Indian camel population is mainly confined to the north-western part of the country. The states of Rajasthan (0.498 million), Haryana (0.128 million), Punjab (0.043 million) and Gujarat (0.058 million) inhabit almost 93.12% of Indian camel population. The other states where camel occurs in the substantial numbers are Uttar Pradesh (0.036 million) and Madhya Pradesh (0.015 million). Eleven arid districts of Rajasthan contribute 78.86% to the total Rajasthan camel population and 55.70% to the Indian camel population. The camel density during 1987 in India and the states of Rajasthan, Haryana, Gujarat, Punjab, Uttar Pradesh and Madhya Pradesh was 0.31, 2.10, 2.90, 0.30, 0.85, 0.12 and 0.03/km², respectively. The density in 11 arid districts of Rajasthan was 2.72/km². As per 17th livestock Census 2007 overall camel population in India during 2007 livestock census 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.

Conservation of Camel Genetic Resources

Based on utility- two main classes of dromedary - Single-humped camel (*Camelus dromedarius*) of Indian camels are distinguished as draught camel and riding camels. Eight distinct camel breeds/strains besides several other strains developed and named after local breeding tracts are available but these are syntheses of mostly one or more of the 4 main camel breeds viz. Bikaneri, Jaisalmeri, Kachchhi and Mewari. Comparatively small-sized hill camels available in Mewar belt- Mewari camels are popular for milk purpose. 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. Breed-wise census figures suggest that 2,69,787- Bikaneri, 1,77,151- Jaisalmeri, 29,921- Kachchhi, 733 Mewari and 563- double humped Camels are available of the total camel population of 5,16,828 and the rest belong to other nondescript or crossbred camels. Beside the states

of Rajasthan, Gujarat and Jammu & Kashmir, there is no activity of organized Camel breeding to provide genetically improved animals to the farmers hence it is feared that the precious germ plasm of local region might be lost in few years. Looking into the production potential and utility and also to maintain diversity there is an urgent need to undertake conservation efforts of all the regional breeds. The breeds like Kachchhi, Mewari and double humped camel need urgent attention and action for conservation.

In order to conserve the entire genetic diversity of the species, it is very much essential to initiate a network project to monitor the entire activities of the species in the respective breeding tracts on a regular basis. A comprehensive conservation approach would be through selection of breeding studs, sorting out of reproductive and health problems, ensuring proper nutrition and facilitating the marketing and related activities of the camel husbandry. The need is to initiate the network activities in Mewar region of Rajasthan, arid parts of Jaisalmer and Bikaner districts, in Kutch district of Gujarat and also at cold arid part of Jammu and Kashmir for double humped camels through NGOs and/or State Government set up. As stated animals are live gene banks, the characterisation of diverse genes through transcriptome analysis and other molecular techniques for documenting and further utilization of the genetic basis of uniqueness of the species is very much required.

Camel Production and Management

Field scenario

Camel husbandry system is in a state of flux as pastoralists are deviating from their traditional extensive management system to semi-intensive and intensive feeding systems like almost sedentary conditions. This rapidly changing scenario needs evaluation and there is urgent need to undertake multi-disciplinary studies for investigating effect of such changes on the camels and their owners. Camels are generally considered environment friendly and are not associated with environmental degradation. Use of camel bio-energy as a renewable natural resource for short distance transport, power generation and agriculture operations need be emphasized as an advantageous that will help in conservation of flora, fauna and soil fertility also. Development of camel-based livestock system will generate employment and help to improve income of the local rural population.

An understanding of traditional husbandry practices and rapid change in irrigation system and cropping pattern and continuous increase in agriculture area for fulfilling demand of human population is important before research priorities are established. Understanding socio-economic conditions of poor resourced dry land farmers is also important for deciding camel development activities. The emphasis therefore needs to be on developing perspective and strategic camel improvement policy and to develop research programmes related to camel milk and the products of utility and linking it to various institutions of the region for future sustenance of camel.

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.

Camel milk is unique in terms of having low fat (1.5-3%), low protein (2.5%) have longer shelf life, higher ratio of β -casein to κ -casein, absence of Lysozyme C and β -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 nutraceutical 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 and 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 an 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.

Camel meat also can have great future as it can be produced economically in the dry land but it is not popular in India. However to know the meat adulteration sometime reported in the country there is need to set molecular identification standards for the camel meat. A collaborative study in this regard can be planned with NRC on Meat.

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, durries, 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.

Marketing scenario

Marketing of camels is an important and good source of income for the farmers engaged in Camel rearing. Many livestock fairs being regularly held in Rajasthan and Gujarat support this trade of sale/ purchase in arid lands. The price realized through sale/purchase trend is fluctuating depending on fodder availability and prevailing

Camel Milk Products



Camel Milk Kulfi



Camel Milk Gulabjamun



Camel Milk Rasogolla



Flavored Camel Milk



Camel Milk Chocolate Burfi



Camel Milk Peda

drought conditions but middlemen involved in marketing also limit the profit availability to the camel-breeding communities. The average cost of adult healthy camel now ranges from Rs. 20,000 to Rs. 40,000 depending upon age, sex and health.

Evaluation studies on Integrated Rural Development Programme (IRDP) in Bikaner, Rajasthan indicated higher average income of the beneficiaries who were given loan for the purchase of camels and camel carts. And about 73.80% of the loans were distributed for the purchase of camel and camel carts. The credit flow was substantially higher in this sector and is predicted to increase in years. Comparative economic analysis of bullock and camel power use on farms in Haryana revealed that maintenance cost of a pair of bullocks on cultivated farm was higher than the cost of a camel but the 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. A survey on the use of camel draught power as source of livelihood and their contribution to augment income of family conducted by the Centre revealed that average net income to the camel cart owners ranged from Rs. 2,000 to Rs. 5,000/month/cart and the maintenance cost was estimated to range from Rs. 40 to Rs. 45/day (basis, 2003) depending upon fodder availability and its rates. A survey study with involvement of social scientist need be planned to know the profit or loss function of draft activity involving camels.

Camel and 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 bones are very popular with the tourists. Thus, improved camel development programmes are likely to open high export potential for the Indian camel breeders. At present, there is no defined government policy to regulate export of camels. 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 Research Scenario

Research on camel in India is mostly concentrated at National Research Centre on Camel (NRCC), Bikaner and State Agricultural Universities located in Rajasthan, Haryana, Gujarat, Punjab and Uttar Pradesh. Research in India is broad-based and it involves various aspects related to Health, Physiology, Reproduction, Anatomy, Nutrition, Surgery, Genetics and Breeding, Production Technology, Management, Production and Extension. With the inception of NRC on Camel, Bikaner research projects related to Physiology, Adaptability, Draughtability, Nutrient requirement, Feed evaluation, Reproduction, Breeding and Genetics, Artificial insemination, Disease aspects, Embryo transfer technology, Management and Camel products (milk, hair & manure), off-season breeding, and grazing behavior of camels are being organized. Sufficient and important data on these aspects have been generated and analyzed. Value added camel milk products have been developed, standardized and validated.

Nature has provided certain adaptations to this animal to survive and produce in harsh environments and on forages not palatable and indigestible by conventional livestock. The information on nutritional standards and requirements for various physiological functions need further in depth study to reduce feed cost especially when the camel is maintained on semi-intensive to intensive system of management. Camel husbandry and management aspects also need further research support. It is felt that productivity and effectiveness of management need to be improved if the camel is being promoted as the milch animal. Hump, oval and osmotically resistant RBCs, ability to withstand changes in body temperature, ability to thrive without water, thick coat reflecting sunlight, sturdy mouth, long eye lashes, long ear hairs, sealable nostrils, pacing both legs of same side at the same time, widened feet and ability to regulate water turnover through colon and kidneys are some of important adaptive features which are required to be studied to know adaptation mechanisms.

Some of the issues requiring long term studies over wide ethnic and geographical range includes, biotechnological aspects regarding camel genome, unique immunoglobulin, study of camel rumen microbiology, metagenomic study exploring unique pathways of rumen kinetics, AI, ETT, semen composition mystery, diagnosis of diseases, milk proteins, therapeutic values of camel milk, and similar technologies need to be strengthened.

The properties of camel milk make it an important health promoter, an animal product having nutraceutical values and it is expected that value added milk products can be formulated in future. Commercial dairies have also been setup 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 milch animal camel is advantageous because it can produce milk for a longer period, especially it provides milk during dry season.

Looking into their population and draught potential, one can recognize that it is not feasible to fulfill entire needs of transport and ploughing of land in modern economy

by this animal alone but certain areas and stakeholders still utilize this animal as work animal and therefore the implements which improve efficiency of animal and in general the work output need be designed and fabricated and proper testing of the same is required for promotion in the field. Regarding other functions, it is felt that camel remained unexplored for its milk production potential. Extension services to fulfill hopes and aspirations of people, solution of their problems within their own socio economic framework are required. It is relevant to develop programmes to help farmers efficiently utilize their animal and improve their quality of life by increasing income. It is proposed to determine production levels and constraints faced in real life situation, design experiments and methodologies for overcoming the constraints using local resources and testing solutions under actual operating conditions. Finally, it is envisaged to develop strong collaboration of institute, extension agencies and development workers for transfer of knowledge.

National Research Centre on Camel

The National Research Centre on Camel is the premier research centre on camel came into being on July 5th, 1984 as a project directorate on camel under the auspices of Indian Council of Agricultural Research which was later upgraded to the National Research Centre on Camel on September 20th, 1995. The centre is important 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. The Centre has also been identified as one of the important tourist place of Bikaner. The NRCC fascinates scientists, visitors, pastoralists, farmers and society at large.

The Centre has 689 ha of land in which administrative-cum-library, research laboratories, camel dispensary, camel corrals, farm office, camel museum, camel milk parlour, community centre, guest house and the residential complex have been developed. The Centre's camel herd consists of around 365 elite camels of four different genetic groups namely Bikaneri, Jaisalmeri, Kachchhi and Mewari. The Centre has undertaken field surveys for *in situ* characterisation, conservation and production enhancement of Jaisalmeri, Kachchhi and Mewari breeds of camel. Over the years modern well-equipped laboratories in different disciplines along with other infrastructure such as administrative block, Library, ARIS cell, camel museum and camel milk parlour have been developed. The Centre has generated substantial scientific data on various quantitative and molecular aspects of Indian camel. The important native breeds of camel Bikaneri, Jaisalmeri, Kachchhi and Mewari have been characterized and breed descriptors have been prepared. Emphasis has been given to make people aware about the quality of camel milk, milk products, value addition and its therapeutic importance.

The Centre is managed by the Director through scientific, technical, administrative and supporting staff. The total sanctioned posts are 75, out of which RMP (Director) is one and 20 posts are of scientists, 24 are of technical category, 12 are of administrative and 18 are of supporting staff.

The mandate of the Centre is

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

After achieving the initial goals of collection of base line data on various breeds, physiological, nutritional, health, reproduction and genetic aspects and development of basic infrastructure facilities including the modern laboratories, the Centre has advanced the research leading to the molecular characterisation of the breeds and development of molecular tools for exploring the genes of economic importance, disease diagnosis, development of growth and production databases, standardization of the technique of embryo transfer, sonographic monitoring of the reproductive organs in camel, hormonal standards specific to camel, artificial insemination, herbal formulations for the treatment of important camel diseases, nutritional requirements, characterisation of camel milk proteins and development of value added camel milk products. The Centre has also been recognized as an education and research hub by the Indian and foreign universities. To cater the requirements of the camel breeders of the country the selected studs are distributed to the camel breeders through the state governments for genetic improvement in the field. Health care and training for the preparation of camel milk products are the important constituents of the extension activities.

The National Research Centre on Camel, the premier research centre on camel dedicated to the cause of camel and camel keepers is aiming to revive the camel production system by re-establishing its traditional value and also find new role for the camels. The contribution of the Centre in conducting, collating and coordinating research on camel has received national and international recognition. The Centre has also been identified as one of the important tourist place of Bikaner. The NRCC fascinates scientists, visitors, pastoralists, farmers and society at large. The centre is striving to become leading institution of international repute which shall offer best output in terms of basic, applied and strategic researches on all aspects of Camel production, health and management which will cater the need of local as well as international stakeholders.

Vision

Improvement of traditional and economic utility of camel through scientific conservation, management, nutritional security, disease control and extension methods for various production and beneficial functions by exploiting its unique physiological and utilizing beneficial and adaptive capabilities through basic and applied researches, capacity building, extension of technologies for the benefit of camel rearing people.

Mission

Improve the Camel production system and livelihood conditions of people rearing camels in harsh arid and semi-arid regions

Focus

To fulfill vision and mission of NRCC- the priority would be given to the Camel farmers and the persons whose livelihood depends on the Camel production system. It is committed to undertake researches on exploring newer areas of the camel production to re-establish its utility value traditionally and enhance its status and profitability in the integrated farming system of arid and semiarid areas dominated by Camel production system. The key areas addressed would be

1. Development of human resource in camel production and health management and establish linkages with all the stakeholders of national and international stature.
2. Development of ideal package of management practices including nutritional interventions for optimizing camel productivity in the climate change conditions.
3. Exploiting unique Camel Immunology for human and animal benefit using biotechnology tools.
4. Exploration and expedition of insight of camel Diseases- Diagnosis, establishing molecular basis of host pathogen relationship and control.

5. Processing of Camel milk and value additions to enhance quality and utility. Development of functional foods by identifying active principles.
6. Improvement in camel reproduction efficiency using suitable assisted reproductive technologies, standardization of AI and ET protocol.
7. Exploring camel genome for improvement in growth and production potential. Establishment of genetic repositories for preservation and improvement purposes.
8. Assessment of draught ability of camel, energy budgeting and utilization in different spheres of transportation, farm operations and power generation.
9. Exploiting gene pool of camel for its adaptation ability to various biotic and abiotic stress factors prevalent in the local areas of inhabitations.
10. Knowledge of microbial and metabolic basis using metagenomic approach for the Camel's adaptability and maintaining production function on the feed and fodders of low nutritional quality.

NRCC would make efforts to reestablish the place of Camels in the arid and semiarid zone of the country by utilizing power of technological innovations for highlighting the virtues of Camel for the benefit of farming system prevalent in the region and also its utility to human and animals for supporting the health and production aspects. The efforts done would consist of undertaking basic and applied researches proving its adaptation worth for the harsh situations, its production value in terms of milk and other products of human and agriculture benefit, use of gene pool for its thermo stability during heat and cold situations, its novel immunity to combat biotic and abiotic stresses beside using latest technological advancements for conservation efforts, exploiting economic value characters and understanding nutritional and management requirements in the situations of harsh and unfavorable environment.

Although the technological and social challenges are many for bringing this kind of expected changes but the scientific advances are favorably offering new tools, methods, techniques and approaches which will help to achieve the objectives set for this mission and social attitudinal change by the society will also be attempted for acceptance of the advantages of new technological breakthroughs.

Conservation of Camel Genetic Resources

In order to address the problem of continued dwindling population of the camel (both Dromedary and Bactrian), it is essential that different camel genetic resources available in the country 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 Husbandary 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 power of biotechnological tools can be put to use to know unique abilities of camel and therefore can be used to undertake works like-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

The major constraints of camel rearing impinge on the socio-economic conditions of resource poor dry land farmers. 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 Total Mixed Ration 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, 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. Further research on therapeutic role of camel lactoferrin and other protective proteins is needed.

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 feed & 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.

Camel Milk 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.

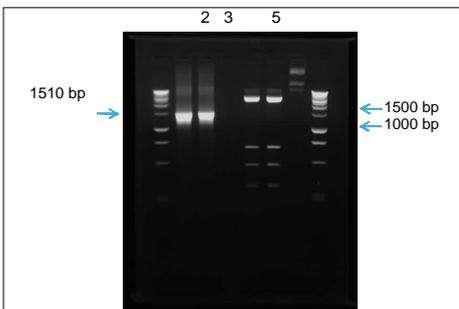
The extension programme should disseminate knowledge to the field so that the latest scientific knowledge can be utilized by the camel breeders for economic upkeep of their animals.



Double hump camel calf



Feed Plant



PCR amplification of Schlafen-like protein Gene of Camel poxvirus. Lane M - 1Kb DNA ladder; Lane 1 & 2 - positive amplicons; Lane 3 - Contagious Ecthyma positive scabs (negative control); Lane 4 & 5- Positive recombinants showing the release of gene of interest; Lane 6- Undigested recombinant plasmid.



Ultrasonograph of pregnant camel

Strategy and Framework

In order to accomplish the vision and the goals of National Research centre on camel a strategy involving activities enlisted in following 10 programmes would be adopted.

Prog. 1. Exploring camel genome for improvement in growth and production potential

Activities:

1. Identification of genes of interest by transcriptome analysis/ target capture and exome sequencing or equivalent technique(s).
2. Implementation of marker assisted selection for improvement in the traits of economic importance.
3. Strengthening databases and ex-situ conservation activity.
4. Initiating in- situ conservation activity in the breeding tract.
5. Developing a milch strain of Indian dromedary.

Prog. 2. Assessment of draught ability of camel, energy budgeting and utilization in different spheres of transportation, farm operations and power generation.

Activities

1. Assessment of camel energy during cart pulling & agricultural operations and Power generation
2. Physiological studies of racing camels, standardization of race - rest cycle.

Prog. 3. Utilization of camel endurance power to climatic changes to achieve optimal productivity

Activities

1. Physiological and performance adaptability of camel under hot arid environment.
2. Comparison of body condition scores (BCS) with various physiological parameters of camels under different physiological states.

Prog. 4. Improvement in camel reproduction efficiency using suitable assisted reproductive technologies

Activities

1. Improving the efficiency of artificial insemination in camel using existing and emerging technologies.
2. Use of suitable assisted reproductive technologies (ARTs) for reducing inter-calving period in camel.

Prog. 5. Processing of camel milk and value additions to enhance quality and utility

Activities

1. Proteomics of camel milk and products
2. Camel milk products development and by- products utilization
3. PFA standards for camel milk and products.

Prog. 6. Exploration and expedition of insight of camel diseases- Diagnosis, molecular basis of host pathogen relationship and control

Activities

1. Isolation, Identification and characterization of infections from camel- Bacterial, Viral, Fungal and Parasites-and related vectors - molecular, clinical-pathological and immuno-biochemical approach. Outbreaks of unknown origin.
2. Development of Molecular diagnostic techniques and molecular characterization for diseases of public health importance in camel.

Prog. 7. Camel immunology and biotechnology

Activities

1. Explorations of antibodies of camel for animal and human welfare diagnostics and therapeutics
2. Study of innate immunity TLR, Signal transduction pathways- apoptosis, cancer, inflammation complement etc.
3. Development of camel cell lines and biochemicals of camel origin.

Prog. 8. Biogeography of camel rumen and whole GI tract and optimization of camel production using nutritional interventions

Activities

1. Identification and Characterization of camel rumen and GI microbial diversity for optimizing rumen kinetics through biotechnological approaches by using metagenomics, metatranscriptomics and metaproteomics.
2. Developing measures to combat climate change by understanding methano/acetogenesis.
3. Development of economic feeding systems as CFB/TMRs using local feeds and fodders for various physiological functions.

Prog. 9. Development of ideal package of management practices for optimizing camel productivity in climate change conditions

Activities

1. Studies on camel husbandry practices in climate change scenario.
2. On farm testing of camel management practices and studies on camel behavior.

Prog 10. Development of human resource in camel production and health and establish linkages of national and international resources

Activities

1. Inter institutional linkages and coordination for research and extension.
2. Scientist/ Vets training AHDept /SAUs /NGOs camel health/ production.

Epilogue

The NRCC is well aware of the challenges faced by the Camel production system in the hot arid, semi-arid and cold-arid areas of the country regarding fall in population due to reduced dependency on camel draft and its traditional uses and increased threats in terms of poor resource availability and no or poor market and policy support for the farmers and landless labourers involved in camel rearing. The commitment of NRCC family towards establishing camel as multi-utility animal is sure to raise hopes of the traditional camel rearing community to support the programmes of reversal of falling population strength. We envision that the camel can fit into the milch animal category due to its milk production ability and the efforts to generate income through use of camel milk routinely will certainly help understand farmer the economic utility of this species. The continued hike in fuel prices and awareness of the people to use cleaner green energy will prompt people to use camels for the purposes of agriculture and related work in a relatively economic way. The researches planned strategically involving value addition to camel milk, production of functional foods and to explore the nutraceutically beneficial attributes of the camel milk and its products will expectedly create market opportunities for the Camel milk producers and generate income for the poor farmers.

Concerted sustained efforts are capable of transforming the NRCC to make camels productive in terms of its potential to serve the human society in terms of development of diagnostics and treatment aids for important diseases like tuberculosis or thyroid cancer or development of products such as anti-snake venom. The private partners as well the collaborative support of different institutes will make it happen for the ultimate benefit of all the stakeholders like camel rearing people, pharmaceutical and medicine industry and human with animals as end beneficiaries. It is also strived at developing national and international linkages so as to exploit the best adaptive attributes of this species at molecular and gene level so that the benefits of adaptation to heat and cold stresses and all abiotic stress situations of droughts, ability to utilize low quality feeds and fodders and resistance to biotic stress conditions can be exploited at molecular level for the benefit of other livestock and human beings as well. It will all be done in holistic way involving all partners of research and development.

Annexure I: Strategic Frame Work

| Goal | Approach | Performance measure |
|--|--|--|
| Exploring camel genome for improvement in growth and production potential | Identification of genes of interest by transcriptome analysis/ target capture and exome sequencing or equivalent technique(s). Implementation of marker assisted selection for improvement in the traits of economic importance. Strengthening databases and ex-situ conservation activity. Initiating in-situ conservation activity in the breeding tract. Developing a milch strain of Indian dromedary. | Number of genes of interest identified, selected and exploited for the improvement in the traits of economic importance. Initiation of <i>in-situ</i> conservation activity in the breeding tract(s). |
| Assessment of draught ability of camel, energy budgeting and utilization in different spheres of transportation, farm operations and power generation. | Assessment of camel energy during cart pulling & agricultural operations and Power generation Physiological studies of racing camels, standardization of race - rest cycle. | Improvement in draft ability of camel |
| Utilization of camel endurance power to climatic changes to achieve optimal productivity | Physiological and performance adaptability of camel under hot arid environment. Comparison of body condition scores (BCS) with various physiological parameters of camels under different physiological states. | Knowledge of factors responsible for adaptability and development of body condition score. |
| Improvement in camel reproduction efficiency using suitable assisted reproductive technologies | Improving the efficiency of artificial insemination in camel using existing and emerging technologies. Use of suitable assisted reproductive technologies (ARTs) for reducing inter-calving period in camel. | Reduction in inter-calving period and successful AI. |
| Processing of Camel milk and value additions to enhance quality and utility | Proteomics of camel milk and products. Camel milk products development and by- products utilization. PFA standards for camel milk and products. | Development of camel milk products having functional value and establish PFA standards. |
| Exploration and expedition of insight of camel Diseases- Diagnosis, Molecular Basis of host pathogen relationship and control | Isolation, Identification and characterization of infections from camel- Bacterial, Viral, Fungal and Parasites-and related vectors - molecular, clinical-pathological and immuno-biochemical approach. Outbreaks of unknown origin. Development of Molecular diagnostic techniques and molecular characterization for diseases of public health importance | Diagnosis and control of diseases |

| | | |
|--|---|--|
| Camel Immunology and Biotechnology | Explorations of antibodies of camel for animal and human welfare diagnostics and therapeutics. Study of innate immunity –TLR, Signal transduction pathways- apoptosis, cancer, inflammation complement etc. | Development of human and animal welfare diagnostics and therapeutics. |
| Biogeography of Camel Rumen and whole GI tract and optimization of camel production using nutritional interventions and Optimization of camel production using nutritional interventions | Identification and Characterization of camel rumen and GI microbial diversity through biotechnological approaches by metagenomics, metatranscriptomics and metaproteomics. Developing measures to combat climate change by understanding methano/acetogenesis. Development of economic feeding systems as CFB/TMRs using local feeds and fodders for various physiological functions. | Understanding rumen kinetics and optimization of rumen functions. Development of economic balanced feeding regime. |
| Development of ideal package of management practices for optimizing camel productivity in climate change conditions | Studies on camel husbandry practices in climate change scenario. On farm testing of camel management practices and studies on camel behavior. | Improvement in camel husbandry practices in climate change scenario. |
| Development of human resource in camel production and health and establish linkages of national and international resources | Inter-institutional linkages and coordination for research and extension. Scientist/ Vets training–AH Dept /SAUs / NGOs camel health/ production. | Number of trainings and linkages with national and international agencies. |

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