भाकृअनुप
ICAR

Vision 2030

National Research Centre on Equines
and
Veterinary Type Culture Centre

Hisar - 125 001, Haryana

www.nrce.gov.in

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National Research Centre on Equines
and
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Sirsa Road, Hisar - 125 001, INDIA

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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 endeavor, 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.

Significance of equines to mankind is well documented through the ages of civilization. Horse served the mankind in different capacities viz. draught & transport especially in hilly and difficult terrain, agricultural operations, equestrian events etc. India possesses 1.57 million equines as per livestock census, 2003. Majority population of equidae comprises horses, ponies, donkeys, mules that provide livelihood to the rural societies living in arid, semi-arid/hilly regions. The National Research Centre on Equines (NRCE), Hisar has been playing a crucial role as a technical leader in the development of equine sector by initiating efficient R&D for equine health and production, developing value added products and processes, consultancy, policy and planning, enhancing awareness among stakeholders about equine husbandry practices and bio-security etc. The NRCE has prepared the strategic framework to cope up with the emerging situation in equine sector in India preparedness to combat emerging and re-emerging diseases of equines, development of national equine biological resource bank, and development of state-of-the-art research facilities for technological innovations.

It is expected that the analytical approach and forward looking concepts presented in the 'Vision-2030' documents 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 24th June, 2011
New Delhi

(S. Ayyappan)
Secretary, Department of Agricultural Research & Education (DARE)
and Director General, Indian Council of Agricultural Research (ICAR)
Krishi Bhavan, Dr Rajendra Prasad Road,
New Delhi 110 114

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Part I

National Research Centre on Equines
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Preamble

National Research Centre on Equines (NRCE) was established on 26 November 1985 at Hisar (Haryana) under the aegis of the Indian Council of Agricultural Research. The mandate of the Centre is to undertake research on health, production and management in equines; development of diagnostics/biologicals for major equine diseases; diagnosis, surveillance and monitoring of equine diseases; and providing diagnostic, advisory and consultancy services to equine owners and other stakeholders. Since its inception, NRCE has strived hard for bringing in improvements in health and production of equines in India. In a short span, NRCE has been recognized as a premier research Centre in the area of equine health and production. A sub-campus at Bikaner established in 1989 is contributing significantly for upliftment of the landless and marginal farmers by helping in conservation and improvement of the germplasm of indigenous equine breeds, besides disseminating the technologies for the efficient and economically feasible equine production. We feel a sense of satisfaction and grandeur in realizing our existence for 25 glorious years in the service of equine owners and stakeholders in the areas of equine diagnosis, prophylaxis and production technologies, which have made a difference in the arena of equine husbandry of our country.

We rededicate ourselves to the dream of Mahatma Gandhi *"the dream of all-inclusive sustainable development"* to serve our stakeholders, the richest-of-the-rich and poorest-of-the-poor equine keepers. We are already into the task of improving the existing diagnostics, vaccines and control measures for equine diseases and development of newer and cheaper biological for disease prevention and control.

The Centre is maintaining the international standards of disease testing and certification and contributes to the adoption of SPS agreements as far as equine health is concerned. The Centre is working continuously towards the control and subsequently eradication of different diseases, which threaten the equine husbandry in the country. Eradication of diseases like equine infectious anaemia and equine influenza and

getting country declared free of AHS in the past sets example for the future. In this endeavor, the Centre is continuously working towards containment of diseases which re-emerged amongst indigenous equines in India viz., glanders, and equine influenza. Pathogens do not respect boundaries, nor do they respect social strata. In the year 2008-09, equine influenza hit the equines of poor animal keepers as well as horses kept by well-off people of the society. We, at NRCE, feel proud in sharing the success to control this disease, thus bringing succor to equine owners. Further, NRCE has already geared up to be in preparedness in the event should an emergency arise in future in the form of emergence of any exotic disease in the country.

The disease surveillance and monitoring programs received renewed thrust so as to keep an eye on the emerging health status of equines. For the sustenance of our equine genetic resources, we also endeavoured to evaluate different indigenous breeds of equines in India. Therefore, phenotypic characteristics of Bhutia, Spiti and Zanskari equids were recorded and analyzed, which was followed by genetic characterization of these horse breeds. Currently, NRCE is carrying out work on phenotypic and genetic characterization of indigenous donkey population in order to establish donkey breeds in the country. The NRCE also makes it a point to deliver equine husbandry information, management practices and technologies to the farmers at their door-steps.

With due emphasis on capacity building including HRD in frontier areas of technology, strategic researches, national/international linkages, extension activities with feedback mechanism, inter-institutional linkages and multi-disciplinary approach would lead to the development of suitable technologies and package of practices for their transfer to the ultimate beneficiaries.

❑

Equine Scenario

The horse have been a symbol of bravery and power since ancient time and this taboo is still in existence in our society. In India, the Aryan started domestication of horses and since then many wars were won by cavalry of this species. In spite of downward trend of equine population from 1966 to 2003/2007 in India (Fig. 1), our export/import of live horses has increased remarkably (Fig.2 A, B). The present scenario with respect to equines in the economy and social structure varies in various parts of the world. In contrast to the affluent Western societies which prefer domination of horses for sports and recreation, it is the livelihood of the landless, small and marginal farmers in India. As per 2007 livestock census the total population of equids in India is 1.18 million which comprises of horses (52%), donkey (37%), and mule (11%) (Fig.3). Approximately, 98% equine

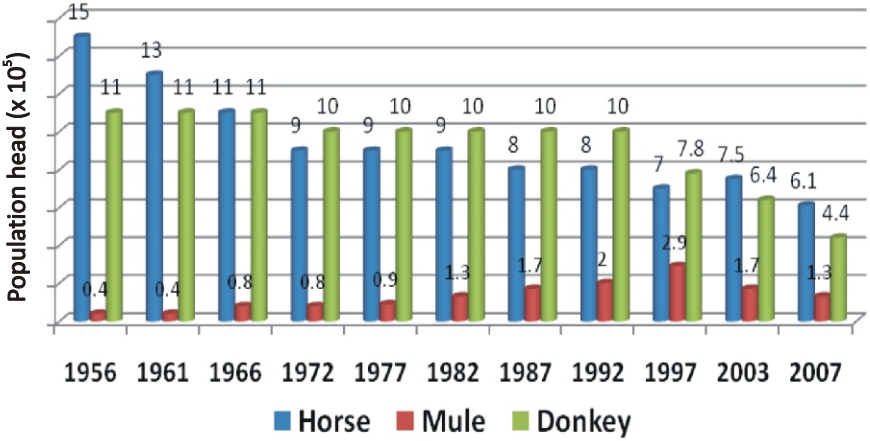


Fig. 1: Equine population trends

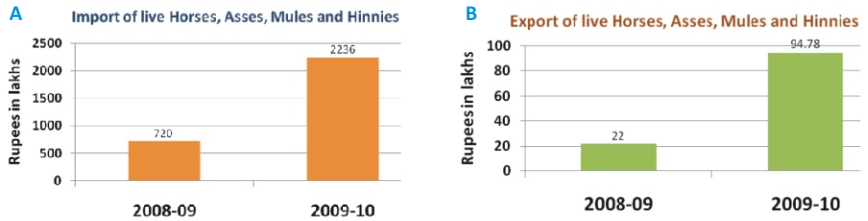


Fig. 2: Live horse, ass, mule and hinny export import trends

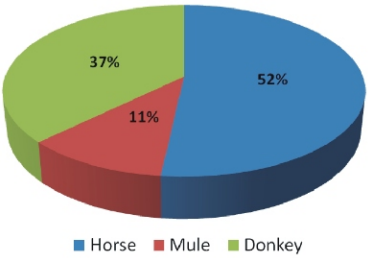


Fig 3: Indian Equine Population Demography

populations in India substantiate income of poor equine farmers. The remaining about 2% of the equine population owned by elite sections of society, is used for races, sports, military and paramilitary purposes.

Breeding tracts of Indian Horse Breeds

Government of India identifies six breeds of Indian horses as Marwari, Kathiawari, Manipuri, Spiti, Bhutia and Zanskari (Fig. 4). The breeding tract of Marwari horse is the Marwar region in Rajasthan. The Kathiawari horse is the original saddle horse of the Kathiawar province in the state of Gujarat in India. The Marwari and Kathiawari horses are famous for their beauty and vigor. The Manipuri horses are bred in the north - eastern state of Manipur and are being acclaimed as original polo pony. The Spiti horses are found in the Kaja subdivision of the Lahaul and Spiti district and the Yanthang area of the Kinnaur district of Himachal Pradesh. They are capable of thriving in cold climates and can survive even in adverse climatic conditions. Zanskari horses are bred at the high altitude in Zanskar region of Ladakh in eastern Jammu and Kashmir State of India. Spiti and Zanskari ponies are able to undertake long journeys at high altitude. Bhutia animals have their home-tracts in foothills of Himalayas namely Sikkim, Darjeeling, Arunachal Pradesh in India and Bhutan.

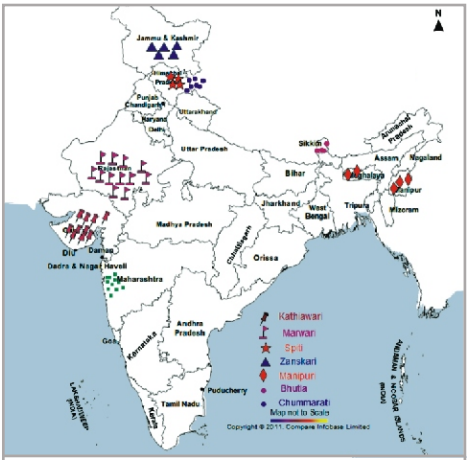


Fig. 4: Breeding tracts of horses/ponies

Issues for Indian Equine Sector:

Since equine population is decreasing continuously, conservation of elite animals of each breed is one of the main issues that needs to be addressed on priority on the basis of lacunae in our equine production, reproduction and managemental policies.

National Equine Breeding Policy

- There is an urgent need to have a clear-cut "National Equine Breeding Policy" for conservation and upliftment of each breed as indiscriminate breeding has already led to loss of true-to-breed equines of all the six established breeds of horse (Marwari, Kathiawari, Manipuri, Spiti, Zanskari and Bhutia).
- Registration of indigenous equines in a National Equine Society under the Department of Animal Husbandry, Dairying and Fisheries, GOI along with development of a Stud book, is the need of the time.

Conservation strategies for all the endangered equine species

- At National level, we have to decide and finalize a minimum equine strength of true-to-breed animals for declaring a breed as an endangered one. As per International standard, most of our pony breeds (Manipuri, Zanskari, Spiti and Bhutia) come under the category of endangered breed as true-to-breed animals of each breed are less than 10,000. Almost similar is the case of Marwari and Kathiawari horses.
- Since future requirement of our indigenous equine power is not known, efforts needs to be made to conserve all the indigenous equine breeds on priority either at State level or through ICAR (NBAGR/ NRCE)
- These indigenous breeds have acquired unique traits as per their geographical localization. Registration of these breeds under Geographical Indicators needs to be done so as to protect our germplasm at International level as well as preventing their unauthorized use. This would be a direct aid in the conservation of the animals and also to boost the exports.

Nutritional requirements

Though equines are in use in different parts of the country by different sections of the society but their complete nutritional requirements are generally ignored due to ignorance and lack of resources.

- Basic information on specific feed and fodder requirement of all types of working and non-working equids, foals, broodmare, yearling, stallions etc. needs to be generated.

- Area-specific Package-of-Practices for feed and fodder requirement along with minerals need to be chalked out on priority in collaboration with State departments.
- For disaster management, good quality feed and fodder in the form of pellets/ blocks also need to be developed for each area for betterment of equine production and productivity. This is also important for economic equine husbandry development.

Enhancement of opportunities for Equine utilization

Decreased equine population is also directly related with decreased demand of this animal power due to fast mechanization in transport, agriculture, warfare system etc. However, these equines are still a source of livelihood for the poorest-of-the-poor including potter-men, washer-men, nomadic etc. Interest of common people in rearing these animals needs to be enhanced by creating export opportunities for sturdy and precious equine germplasm.

Active involvement of State governments

- Equines have remained neglected at almost all the fronts during the last five decades at both State and Centre's level. Till date, most of the State Animal Husbandry Departments have no special fund for development of the equines. For betterment and conservation of these animals, all the State Departments must have sufficient funds either from their state or Centre.
- Secondly every state must have a fleet of trained equine practitioners to meet the day-to-day demands of equine owners.
- The research agencies are developing many technologies which are not reaching to the end-users on account of poor demand and low socio-economic status of the equine owners. Thus, active involvement of the departments of State Governments is required to adopt and implement technologies like semen freezing technology and AI technique for superior quality mule production and propagation and *in situ* conservation of true-to-breed horses.

Package of practices

Area specific packages of practice need to be developed on at least the following aspects.

- Feed and fodder requirement of equids of all the categories.

- Animal utilization capacity to prevent misuse, over utilization/ overloading, proper harnesses, stress management etc.
- Health and production management.
- Animal welfare.

The gap between the availability and transfer of technologies highlights the need for concerted efforts for the development of more practicable technologies and their transfer to ultimate beneficiaries and users through participatory approaches.

To understand the location-specific needs and problems associated with equine husbandry in different parts of the country, inputs and feedback is required to be gathered from stake holders.

Achieving freedom from dreaded equine diseases through development of modern diagnostics, vaccines, and therapeutics.

Studies on utilization of by-products of equine origin, namely milk, dung, urine and hair to enhance income of the owners are required.

Income generation through market intelligence activities.

NARS : National Research Centre on Equines

The National Research Centre on Equines (NRCE) is one of the component of National Agricultural Research System (NARS). The foundation of NRCE was laid on 26th November 1985 at Hisar (Haryana) under the aegis of the Indian Council of Agricultural Research with a belief that equines play an important role in society and in everyday lives of landless and marginal farmers. NRCE has been striving hard since then by performing activities that have come to fruition in improvement of equine health and production in India. The institution grew stronger in 1989 when a sub-campus was established at Bikaner thereby expanding the scope and depth of it's services. In a short span, NRCE has gained recognition as a premier research centre in the area of equine health and production.

The research activities continue to bridge the gap between basic biology and clinical applications thereby providing cutting edge translational research for improving the health and welfare of the equine population in the country. In addition to ongoing research in the areas of equine virology, bacteriology, parasitology, immunology, pathology, medicine, biochemistry, biotechnology, genetics and breeding, reproduction, physiology and nutrition, the institution is disseminating information at national and international level to equine owners through publications and news articles.

The centre has contributed significantly for upliftment of the landless and marginal farmers by helping conservation of the indigenous equine germplasm of breeds and improvement of productivity. Recently Veterinary Type Culture Centre (VTCC) has also been established in the year 2005 at NRCE for collection and storage of microbes of animal origin. NRCE looks forward to the future with great enthusiasm to extend benefits to equine population in the country.

Vision

Generation of demand driven technologies for equine health and production management and capacity building for competitive power utilization in agriculture operations to serve the underprivileged under changed environmental and socioeconomic scenario.

Mission

- Achieving freedom from dreaded equine diseases through development of modern diagnostics and vaccines.
- Technology transfer for superior mule and true-to-breed indigenous horse production in their home tracts using A.I. and embryo transfer technology with an aim to establish embryo bank of Marwari and Kathiawari horses to enhance export.
- Enhancing performance of working equids especially in arid, semi-arid and mountainous regions.
- Income generation through market intelligence activities.

Mandate

- To undertake research on health and production management in equines;
- To develop diagnostics/ biologicals for major equine diseases;
- To act as a National Referral Facility for diagnosis, surveillance and monitoring of equine diseases;
- To provide diagnostic, advisory and consultancy services.

Objectives

- Generation of demand-driven technologies for equine health & production management.
- Capacity building for competitive equine power utilization in agricultural operations to serve the under privileged under changing environment & socio-economic scenario.

Major Achievements

A. Equine Health

Diagnostics for equine diseases

The centre has been recognized as national referral centre for diagnosis of important equine infectious diseases by Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture (Government of India). The centre has developed and refined diagnostics against various equine diseases including immunodiagnostics and molecular diagnostics:

- **Equine herpes virus-1 (EHV-1):** A highly sensitive and specific neutralizing monoclonal antibody-based diagnostic kit namely Equiherpes B-ELISA was developed by the centre for diagnosis of EHV-1 antibodies.

- **Equine herpes virus-4 (EHV-4):** A type-specific ELISA using EHV-1/4 recombinant glycoprotein G has been developed for differentiation of EHV-1 and EHV-4 infections. A multiplex PCR targeting glycoprotein G has also been developed for differentiation of EHV-1 and EHV-4 and is routinely used in the laboratory.
- **Equine Rotavirus:** A sandwich ELISA was developed employing a monoclonal antibody raised against VP6 of rotavirus, for detection of equine rotavirus (ERV) from stool samples.
- **Equine influenza virus (EIV):** EIV is routinely diagnosed by haemagglutination inhibition assay. RT-PCR for equine influenza diagnosis and typing has also been developed. Furthermore, real-time RT-PCR based assay targeting M gene has also been developed for diagnosis of EIV.
- ***Theileria equi*:** For serodiagnosis of *T. equi*, a recombinant antigen based-ELISA has been developed using a truncated gene segment of a merozoite surface protein, EMA-2. The centre also developed PCR and nested-PCR for diagnosis of this protozoon.
- **Trypanosomosis:** An indirect ELISA has been standardized using whole cell lysate antigen and purified antigens of *Trypanosoma evansi*. RoTat 1.2 gene-specific PCR has also been standardized for sensitive detection of surra.
- **Japanese encephalitis virus (JEV):** Serum neutralization test (SNT) and haemagglutination inhibition (HI) has been standardized for diagnosis of JE. Monoclonal antibodies against JEV have also been raised and are under trial for development of Mab-based capture ELISA.
- **Equine infectious anemia:** Coggins test for EIA is routinely being used at the Centre. A recombinant protein from a synthetic gene of 26kDa expressed in *E. coli* was evaluated for use in AGID/indirect ELISA in a pilot study for sero-diagnosis of EIA.
- **Equine viral arteritis:** Virus neutralization routinely used for serodiagnosis of EVA.
- ***In vitro* culture of *Trypanosoma evansi*:** The centre succeeded in *in-vitro* cultivation of bloodstream forms of *T. evansi* in artificial media by using specially formulated cell culture medium.

Vaccines and Immuno-biologicals developed by NRCE

- **EHV-1 vaccine :** An equine herpes virus-1 (EHV-1) killed vaccine namely "EquiherpAbort" incorporating indigenous strain (Hisar-90-7) of EHV-1 has been developed by the centre.
- **Equine influenza vaccine:** The Centre has developed equine influenza vaccine using indigenous isolate (A/equi-2/Ludhiana/87), in view of the re-emergence of EI in India. The vaccine has been updated in 2010 incorporating epidemiologically relevant isolate {A/eq/Katra-Jammu.06/08 (H3N8)} responsible for equine influenza outbreaks during 2008-09.
- ***Salmonella* Abortus equi:** Improved bacterin and outer membrane protein-based vaccines have been developed for *Salmonella* Abortus equi.

Monoclonal antibodies

Monoclonal antibodies have been developed for diagnosis and characterization of equine herpes virus-1, equine rotavirus, equine influenza and Japanese encephalitis.

Surveillance and monitoring of equine diseases in India

NRCE is involved in nation-wide monitoring and sero-surveillance of important equine infectious diseases, with a view to manage, control and eradicate diseases. Important achievements of the centre in disease surveillance are:

- Information generated by NRCE about the status of AHS in the country helped in declaring India free of African horse sickness in 2006 by Office International des Epizooties (OIE).
- Outbreaks of glanders in equine during 2006-07 and 2010 were detected and control measures were taken to prevent its further spread.
- NRCE diagnosed equine influenza (EI) in India in 2008 from Jammu region (July 2008) that subsequently affected equines in 13 different states. The biosecurity measures were implemented in collaboration with various State Animal Husbandry Departments. No new cases of EI have been reported from India since May 2009.
- NRCE has continuously been screening equines for equine infectious anemia from 1998. One mule has been found seropositive during 2009-10.

Molecular characterization of equine pathogens

- Equine influenza virus (EIV): HA genes of EIV isolates from 2008 outbreak (A/eq/Jammu-Katra/08, A/eq/Mysore/08 and A/eq/Ahmedabad/09) were cloned and sequenced. Phylogenetic analysis revealed clustering of Indian and Chinese isolates in a separate cluster designated as Asian clade for M gene.
- Equine rotavirus (ERV): Sequencing of VP7 gene of ERV isolates indicated circulation of G10, G3 and G6 serotypes in India. Sequencing of outer surface proteins (VP4 and VP7) of equine rotaviruses for their genotyping and molecular epidemiology was done.
- Japanese encephalitis virus (JEV): Sequence analysis of E-gene of JEV isolated from an equine indicates genotype 3 was responsible for causing the disease in equine and that the equine JEV isolate clustered with Vellore group of JE isolates responsible for JEV in humans in India.

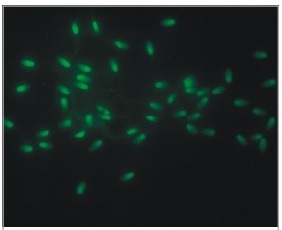
Biological Resource Bank

NRCE has a strong biological resource base having numerous pathogens, recombinant clones, reference sera, equine sera, monoclonal antibody secreting hybridomas, etc.

B. Equine Production

Basic biochemical, physiological and haematological indices

- Different biochemical, physiological and haematological indices were evaluated to establish baseline data for different indigenous equine breeds of either sex and different age groups for their further use in disease diagnosis and prognosis.
- Different biochemical indices were evaluated during stress due to routine use of drug(s), vaccine and other natural stress conditions-clinical evaluation of ivermectin, effect of fenbendazole, effect of vaccination, short term feed deprivation stress, long term feed deprivation stress, heat stress, water deprivation stress, diurnal changes in physiological indices



DNA intactness of Zanskari spermatozoa stained with propidium iodide

Equine work efficiency load carrying capacity of donkeys

Load carrying capacity of donkeys for their optimum utilization was

evaluated using a pack load equivalent to 40, 50 and 66% of their body weight under work rest work cycle and continuous work for various duration of work.

Establishment of Nucleus Herds

- **Exotic Donkeys:** Twenty Jennies and six jacks of European breed (Poitu) were imported from France through ODA, UK in 1990, for the improvement of indigenous donkeys and production of superior mules.
- **Marwari Horses:** In an effort to conserve true to breed equids, the Centre has also established a nucleus herd of Marwari horse at Equine Production Centre, Bikaner.
- **Zanskari Ponies:** NRCE has initiated an *in vivo* conservation programme in the form of developing an Equine Sanctuary at EPC, Bikaner. Under this, 12 Zanskari ponies (eight mares & four stallions) were bought from Zanskar valley, Kargil, Ladakh, Jammu & Kashmir, in November, 2009.
- **Indigenous donkeys:** The Centre has initiated the establishment of nucleus herd of large white donkeys found in India.

Cryopreservation of Marwari stallion semen

AI using frozen semen was adopted for the first time at EPC Bikaner. Semen was collected, cryopreserved and used for AI in farm and field Marwari mares. Technique of semen cryopreservation was standardized and sufficient number of semen doses are with NRCE. An easy technique of semen cryopreservation was developed for lab and farmers door.

Evaluation of indigenous donkey and ponies for their optimum production

- Physiological and hormonal indices in new born pony and donkey foals at different growth intervals. The basic information generated can be useful for better management of the young foals. Folliculogenesis studies in both donkey and pony mares were carried out during breeding (mid Feb. to October) and non-breeding season to assess the kinetics of ovulation, length of estrous cycle as well as to determine the part of the year up to which ovulation takes place for their utilization for breeding purpose. Folliculogenesis and progesterone profile in cyclic, pregnant and irregular cyclic indigenous donkeys and pony mares were recorded.

Hormone and pregnancy diagnosis in mares

- Pregnant mare serum gonadotropin (PMSG) or equine chorionic gonadotropin (eCG): PMSG was purified and characterized from

pregnant mare serum. Immunoassay was developed for pregnancy diagnosis using PMSG as the indicator hormone, which was subsequently, developed in the form of a kit for both early confirmation of conception in mares as well as for assessing the viability of fetus after 30 to 80 days of gestation.

- Pregnancy diagnosis in equines by ultrasonography: One of the most promising technology for pregnancy diagnosis. An ultrasound can detect pregnancy earlier than rectal palpation. NRCE used ultrasonography for conducting studies like folliculogenesis, endometritis, stage of the pregnancy, fetal well being.

Characterization of equine breeds

- Phenotypic characterization of Indigenous breeds: All the six indigenous breeds of equines namely Marwari, Kathiawari, Spiti, Zanskari, Bhutia and Manipuri, have been characterized phenotypically on the basis of their biometric indices and coat colour.
- Genotypic characterization of Indian equine breeds
- Heterozygosity analysis with different polymorphic microsats indicated the presence of high genetic diversity within and between different breeds.
- The Neighbor joining algorithm was used for the construction of both the topology as well as phylogenetic tree. The Thoroughbred horses expectedly clustered separately in topology as well as phylogenetic tree. Other Indian breeds clustered into two distinctive classes. One cluster grouped Kathiawari and Marwari horses while the other cluster had Manipuri, Spiti, Zanskari and Bhutia ponies. It can be inferred from the study that the geographically distant breeds are also genetically distant.
- Recent bottleneck in the population i.e. within past few dozen generations was examined by a graphical method analyzing distortion of allele frequency distribution which plots groups of alleles from a sample of many polymorphic loci into each of the ten frequency classes. All the seven breeds showed normal “L” shaped curve reflecting no bottleneck in the recent past.

C. Patents

- Patent has been granted by the Patent Office, Government of India entitled "A method for preparation of a diagnostic kit useful for forecasting Equine Herpes Virus-1 disease".

- A patent has been filed for "COFEB-Kit for diagnosis of *Babesia equi* infection in equines".
- A patent has been filed for "A method for preparing complement fixation test based (COFEB) kit for the diagnosis of *Babesia equi* infection in equines".
- The centre has filed a patent for "A kit for detection of pregnancy in equines and assay thereof".
- A joint patent with DRDE, Gwalior has been filed for "A recombinant protein for diagnosis of glanders".

D. Kits developed

HERP kit & Equiherpes B-ELISA kit (For EHV-1 diagnosis), recombinant protein based ELISA kit for the diagnosis of *Theileria equi*, and Pregmare kit for pregnancy diagnosis has been developed by the centre.

Pregmare - A pregnancy diagnostic kit

B-ELISA kit for EHV-I diagnosis

E. Services

NRCE provides following services to the farmers and equine breeders:

- Disease diagnostic services for various infectious and non-infectious equine diseases.
- Artificial insemination for production of superior quality Marwari horses, mules and donkeys.
- Supply of quality jacks and jennies to various states, breeding societies and farmers.
- Health certification for movement of equines within and outside the country.
- Imparting trainings on equine management, production and health.
- Organization of health camps, awareness programmes and farmers meets etc.

NRCE-2030

With the establishment of NRCE, a positive impact on the equine health & production improvement has been visualized by the timely efforts made for control of equine influenza out breaks (1987 and 2008), eradication of equine infectious anaemia, African Horse Sickness disease-free status to the country, development of vaccines against equine influenza, equine herpes virus-1. The Centre has also developed many diagnostics specific for equine bacterial (*Rhodococcus equi*, *Salmonella* Abortus equi) viral (equine influenza, equine rotavirus, equine herpes virus, Japanese virus), protozoan (*Theileria equi, Trypanosoma evansi*) and also for early pregnancy diagnosis in horse mares. NRCE has shown steady growth by establishing several high-end laboratory facilities, trained scientific manpower and other farm infrastructure facilities. Some of the technologies generated by the centre are ready for transfer for commercial purposes.

The previous experiences, problems and constraints analysis revealed that sustainable development of equines can be achieved by integrated multi-disciplinary approach, targeted by sound research programmes involving stakeholders. We should develop strong national and international linkages for sustainable development of equine husbandry in the country.

Vision

Sustainable development of equine heath & production through scientific innovations and public-private interventions.

Mission

Development of national state-of-the art research facilities, developing package of practices, and capacity building in the area of equine health and production for development of novel technologies in a sustainable manner for strategic overall growth of equine husbandry in the country and empowering the stakeholders

Focus

- Strengthening of research in equine health on those diseases where NRCE has already succeeded, particularly on (i) refinement of

diagnostic tests, assays, kits, reagents; (ii) vaccines and reagents to meet out the international requirements for diagnosis, prevention and control of infectious diseases of equines; (iii) understanding pathogen evolution, emergence/re-emergence; (iv) emergency preparedness in terms of early diagnosis of disease and strategies for containment the disease. Emphasis will be given to clinical proteomics in disease diagnosis and pathogen characterization and nanonized molecule(s)-targeted drug/vaccine delivery.

- Use of bioinformatics and modern biotechnology tools in designing vaccines, drugs and stem-cell therapy approach for control of important equine diseases.
- A national policy on disease control, prevention and management is required to be developed by NRCE in respect of endemic, re-emerging and exotic equine diseases and this should be in compliance with OIE norms.
- To conduct epidemiological investigations especially in widely distributed working equine populations with a statistically based population sampling survey framework so as to formulate disease forecast and control measures.
- Establishment of equine sanctuary and *in-situ* conservation of indigenous breeds of horses and donkeys by way of perfecting ETT technology.
- To devise indigenous breed conservation approaches and initiate immediate action plans with the respective state governments /NGO/ SAUs and, agencies/department approved by Government of India.
- To initiate research work on equine welfare issues *viz*. harness design, improving weight carrying capacity, shelter management etc.
- Database and validation of ITKs in equine production
- Genetic improvement of mules, donkeys and ponies used for draught purposes.
- Promotion of research for enhancing nutritional quality of indigenous feed/fodder for formulation of ration for equids.
- Training of personnel including veterinarians and livestock assistants, educating equine breeders and farmers on training/adopting scientific equine practices for overall improvement of equine health and productivity.

- Perfection and propagation of artificial insemination techniques in horse and pony production using frozen semen of true-to-breed indigenous stallions for the consortium of threatening breeds in India.
- Explorative research for value addition of equine products and by-products namely blood/serum, dung, urine, milk, placenta and hair.
- Extension activities through information technology and institute development programmes for the upgradation of the indigenous breeds of equids in the different parts of the country in collaboration with the State Animal Husbandry Departments.
- Converting biowaste arising out of equine husbandry to wealth for employment generation, augmenting income of the stakeholders including rural equine owners, ensuring animal/human health, and environmental sustainability.

Harnessing Science

India has a unique amalgamation of geographically distinct, draught-hardy distinct indigenous breeds of horses along with local donkey population which are well adapted under varied agro-climatic conditions. Equines have been closely related with our society since ages. Horse had been used in warfare in addition to their use in domestic and recreation activities. Ponies, mules and donkeys are still a source of livelihood for their poor owners at many places in India. Since the equine population is decreasing rapidly due to their decreased utility and indiscriminate breeding practices, NRCE would strive to harness power of science in increasing its population through biotechnological tools, and make efforts to search additional means for utilization of equines in order to augment the revenue generation by its owners. Programmes for improved health and managemental conditions, optimization of equine production through better housing, nutrition, breeding and management, by tackling field oriented equine problems, transferring the research output directly to equine owners, enhancing opportunities for better economic gains from equine power, etc. will be taken up by the institute for the betterment of society.

Optimization of equine production

Recent decreasing trends in equine population are alarming which emphasizes to harness various streams of science. Bioinformatics if applied to the current information on population genetic resources can improve the breeding strategies that ultimately will result in stabilizing the population level of pure bred animals. In addition, decrease in equine population is directly or indirectly related with poor breeding efficiency of adult mares. Harnessing of hormonal tools in terms of better and rapid diagnostic facility for identification of non-pregnant, infertile and problematic mares and management of foal and pregnant mare's health will have real impact on equine population along with clear-cut equine breeding policy. Genetic markers for identification of infertility can also be traced in horse genome through biotechnological tools that may provide the better insight to deal with infertile mares. Good quality frozen semen made available at farmer's door for artificial insemination will improve the production of purebred animals and controlling the population of nondescript breeds.

Potential of animal power utilization

Modern agricultural tools and mechanization of transport system has reduced the animal utilization but horse, donkey and mules are still one of the common animal power used by poorest-of-the-poor for earning their livelihood. Potential of this power needs to be harnessed through…..

- Creating awareness and facilities for use of equines in transportation and agriculture.
- Use of scientific tools for developing better saddles, cart, shoe, bagghi, bit, harness etc.
- Draughtability evaluations of working equids.

Donkey being used in ploughing operation

- New scientific ideas for involving equines in day-to-day activities (for example: in tourism through state Govt., encouragement for production of true-to-breed animals through fair/mela, health camps, competitions, possible export potential of indigenous equids, development of equine museum for generating awareness among common masses etc.).
- Development of equine based agricultural implements for ploughing, winnowing, sowing, inter-culture, chaffing, water lifting etc.

Biotechnological interventions

Biotechnology and its advancements have gain tremendous utility in past decade for developing basic valuable information for animals through complete genome analysis. With the study on equine genomics involving next generation sequencing, many doors are open for its ultimate use in multiple disease diagnosis through evaluation of genes directly related to horse diseases, performance indicators, endurance capability (athletico-genomics), immunity of equines against different diseases which may lead to betterment of the species. Parentage testing for horse registration, breed signature, identification of true-to-breed animals to increase their population and animal export may serve as another landmark. Other advancements in biotechnology such as reproductive biotechnology, stem cell therapeutics, transgenic animals, gene farming/mining, functional genomics, proteomics, phenomics etc. are of utmost importance for benefit of animal and human society.

Use of softwares/chips/nanotech devices etc. to maintain, analyze & interpret biological data will facilitate sustainable use of available genetic resources. Research based on these frontier areas and techniques would be integrated in the ongoing and future projects for improving research efficiency, better targeting of technologies and also identifying production and marketing environments.

Vaccines and diagnostic for better health

In this endeavor, availability of low cost vaccine, easy and cheap diagnostics services and immunological tools for better and quick diagnosis, ready to use penside diagnostic involving latest biotechnological tools need to harnessed on priority, trans-border movement of equines is taking place for trade and sports activities. Centre will develop capabilities for molecular and serological diagnosis of the exotic diseases, for emergency preparedness of the country to face various threats. Important bacterial, viral, parasitic pathogens of equines will be characterized for their genomic, proteomic and host pathogen interaction. The information will be utilized for development and updation of diagnostics, vaccines and control strategies.

Equine disease surveillance and monitoring

The surveillance of equine diseases has been undertaken by the Centre during last two plans. A baseline data of equine diseases in different states of the country has been generated. However, more exhaustive data on temporal and geographic basis on equine diseases need to be generated to develop disease mapping, forecast and development of timely control strategies using remote sensing and GIS data by involving vector biology of important equine diseases and precise emphasis on infectogenomics, pathogenomics and clinical proteomics.

Utilization of byproducts and value addition

Scope need to be identified in the area of secondary and value added products of equines. Management of equine dung, milk, serum, bones, hair etc. with value addition would be done for increasing revenue/agri-marketing etc.

Technology transfer systems

Enhanced participation of stakeholders and increased awareness among equine owners and farmers would be given high priority for the breeding, utilization and upliftment of the equine species leading towards

accomplishment of the goal of at least maintaining equine population and its use. The effective and efficient interaction with Animal Husbandry Department of various States and equine industry comprising of equine breeders/owners, Turf Clubs, Riding Clubs, Army, Border Security Force, Equestrian Federation of India and Indian Polo Association have been the hall-marks of the Centre's programmes and activitis.

The gaps between the availability and transfer of technologies highlight the need for concerted efforts for the development of more practicable and refined technologies and their transfer to ultimate beneficiaries, end-users and NGOs' through participatory approaches. Two types of packages of practices, one suitable for under privileged equines used as beasts of burden and the other for elite horses which are used for competitions, sports, defence and security purposes, are required to be developed through appropriate technology generation.

Inter-institutional linkages

Linkages among the government agencies, research organizations, traders and end-users within the country and abroad are of utmost importance in achieving the target of increasing export potential in respect of indigenous equines. The linkages must be developed with the OIE accredited international laboratories to meet the health requirements, international trade forums to initiate the process of export and other agencies, which the industry deem fit for the purpose.

For effective technology transfer, co-ordination and linkages between research and developmental agencies need to be strengthened besides infrastructural and financial support from the Central and State Governments for promoting modern technologies. Emphasis would be given to multi-disciplinary inter-institutional supplementary research in close collaboration with agencies involved in developmental and technology transfer. The Centre would follow a holistic approach in mission mode. For tackling the problems, further collaboration would be sought. While forging partnership in research; expertise, potential and strength of the cooperating institute(s) would be the guiding factor.

NRCE which is the apex institution in the realm of equine researches in India, will become a premier institution nationally and internationally. With the implementation of GATT and liberalization of economic policies, increasing interactions between countries and continents, will open many regional opportunities in Asia and Africa including SAARC countries for

sharing of the expertise and technologies. It is envisaged to share the infrastructure and expertise facilities available at NRCE for improving national and international training requirements.

Human resource development & capacity development

Training/teaching should be an important component of equine development programmes at national and state levels. Therefore, specific courses, seminars, summer institutes, workshops and exhibitions should be organized from time to time for the benefit of teachers, research workers and veterinarians from India and abroad.

HRD will be a critical factor to receive top priority for scientific, technical and administrative staff so as to meet out the new challenges in their respective areas. Building state-of-art capacity at NRCE for handling national and global training and technology requirement and to position it as a centre of excellence is the need of the hour.

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Strategy and Framework

In view of the contribution of equines in regional and national economy and also the futuristic roles the equines will play in Indian agriculture and transport in changing climate scenario, the research strategies and goals have been re-oriented with a view to help the equine husbandry (see Annexure-1). A brief framework of strategies are as follows :

Equine Production Optimization, Conservation and Management

A. Artificial insemination

- Establishment of a National Equine Semen Bank comprising of cryopreserved semen of all the equine breeds with special emphasis on Marwari and Kathiawari horses and indigenous (large white) and exotic donkeys. This bank will serve for *in vitro* conservation of elite/precious germplasm of equines, and as a resource centre for equine semen for use in the field by stakeholders. This bank will have all the facilities for production of semen of international standard in quality including microbiological analysis.
- Technology for low-dose insemination for better utilization of good quality semen of true-to-breed equids. Beside this, sexed semen and intra-cytoplasmic sperm injection has evoked great interest in equine reproduction and work on these lines will be taken up to utilize the semen of very few elite stallions available in India, for covering mares of indigenous breeds.

B. *In vivo* and *in vitro* conservation of elite and endangered breeds

- Equine sanctuary: *in-situ* and *ex-situ* conservation of all the precious and endangered equine species for their future use
- Embryo transfer technology: for production and conservation of precious animals.
- Good quality stallions (horses & donkeys) for high quality semen production.

C. Equine production management

- Hormonal and ionic imbalance profiling: This is very important for assessing various reproductive disorders such as infertility, delayed and prolonged estrous and other hormonal deficiency problems commonly seen in equines.

- Equine nutrition and production management
  - Survey and compilation of data on equine managemental practices adopted by equine owners in different agro-ecological zones.
  - Nutritional evaluation of different feed and fodder available in for area-specific package of practices to provide balanced ration & devising low cost, high energy feed for meeting natural calamities.
  - Utility of equine draught power in field and agricultural operations.
  - Equine byproducts utilization: donkey milk for cosmetics and therapeutics (lactotransferrin), equine dung for organic manure/vermi-compost preparation, etc.
  - Adaptation studies on equines keeping in view the changing climate through research on stress physiology, shelter management, and equine behavior.
  - Training and re-training of veterinarians, para-vets, breeders, and farmers in equine production and management.

Biological Resource Repository

Biological resources constitute the basic resource for research and hence establishment of a strong resource repository is required. Following resource repositories are proposed to be strengthened/established at the Centre.

- Equine Genome and Gene Bank
- Equine Microbial Collection Bank
- Equine Semen Bank
- Equine Cell Line Bank including Equine Stem Cell Banking

Equine Genomics

- Phenotypic and genotypic characterization of six indigenous breeds *viz.* Kathiawari, Marwari, Spiti, Bhutia, Zanskari, and Manipuri have been completed. However, equine biological diversity of the country has not yet been addressed completely. Category of such equines which need further work on bio-diversity analysis and interrelationship among equine population include non descriptive and geographically distinct indigenous donkeys donkeys (large white, small gray, Spiti, Zanskari, others), wild ass (Kiang and Ghorkhurkar), wild horse of Assam, and horse/pony breeds *viz.*, Deccani, Chhumurthi and Sikang breeds. Animals of these breeds will be characterized (phenotypic and genetic) during this period.

- Whole genome sequencing of indigenous breeds of horses (Marwari and Kathiawari) will be initiated with a view of (i) generating data on indigenous equines as mentioned above, (ii) establishing breed signatures, (iii) comparative data of whole genome sequence of indigenous equines vis-à-vis Thoroughbred horse, (iv) studying evolutionary status of indigenous equines vis-à-vis Thoroughbred horse, donkeys and vis-à-vis Thoroughbred horse, (v) creating genomic library of important genes (reproduction related genes, disease resistance-related genes, athletics-related genes, etc.),
- Parentage testing: for registration of precious equines in stud book, for tagging performance evaluation of equines, and sale and purchase purpose etc.
- Athleticogenomics to identify animals at initial stages for their athletic potential and train them (rather than training every horse and then looking for its athletic potential). Specific traits need to be developed for screening of foals for their athletic potential.
- Breed signature for Marwari and Kathiawari horses.
- Export of Marwari horses is picking up. Further, Marwari horses are also now seen as alternative horse breed to Thoroughbreed horses in racing and equestrian event industry. As such, parentages testing would be routinely required in time to come. NRCE would be establishing facilities for parentage testing in horses in coming near future.

Development of Diagnostics, target driven Therapeutics and Vaccines

Diagnostics

- *Diagnostics for exotic diseases:* Trans-border movement of equines is taking place for trade and sports activities. All equines that enter India (either imported or equines returning after participation) need to be tested for battery of exotic viral, bacterial and other diseases. There is also need for emergency preparedness of the Centre for exotic diseases that have the potential of emergence in India. Exotic equine diseases (like EEE, VEE, WEE, AHS, CEM, Vesiviruses, Lawsonia, and others) that have the potential of emergence in India due to global movement of equines for trade and sports need preparedness in term of developing capacity for surveillance and diagnosis of these diseases. The Centre will develop capabilities for molecular and serological diagnosis of the exotic diseases, for emergency preparedness of the Country to face such threats.

- *Development and refinement of disease diagnostic assays:* The Centre has developed first and second generation diagnostics for emerging and existing equine diseases in India. The efforts will be focused on refinement of these diagnostics for quick, specific and sensitive diagnosis suitable for application at mass level. Special emphasis will be given to development of pen-side diagnostics, recombinant protein/peptide based assays, real time PCR, microarray and clinical proteomics using mass spectrometry. Refinement of field diagnostics will continue the priority of the centre. OIE Twinning program for equine piroplasmosis has already been initiated at the centre. Further attempts are being made this year for twinning of labs for Glanders, EI, and EIA. Capacity development through OIE-twinning program will help us in getting NRCE recognized as International Reference Centre for Equine Diseases.

Designing and development of drugs and chemotherapeutics against important equine ailments, employing different drug designing tools. The drugs and vaccines developed will be refined by using better delivery systems, including nanoparticles.

Stem cells in virology and equine therapy : Various cell lines are required for cultivation of viruses for *in vitro* recovery of viruses from field samples, for production of biologicals and vaccine virus in bulk. Very little number of cells lines of equine origin are currently available. NRCE has initiated work in this direction and we have had promising results in developing all lines which gave better yield of virus. These efforts would continue to realize our goal of using stem cells in biological production which will help in developing low-cost biologicals. Further, amongst different livestock, it is only equines where stem cells have applications and have been extensively used abroad successfully for therapy of injuries causing lameness, tendonitis, etc. As such, research initiatives in this direction are most imperative. Collection, characterization, storage of adult stem cells from various sources, including bone marrow, adipose tissue, umbilical cord blood, and umbilical cord matrix will be exploited for their potential use in therapeutics of joint, bone and other ailments of equines. Embryonic stem cells generated from inner cell mass of blastocysts collected from mares will be exploited for use in therapy and also in somatic nuclear transfer technologies for conservation of elite equine breeds.

Vaccines: Single and combination vaccines against important preventable equine diseases like JE, viral diarrhoea, foal pneumonia will be developed. The vaccines already developed - like EI vaccine - will be refined to make them more safe and efficacious. DIVA strategy for vaccines against equine influenza and equine herpes viruses will be attempted.

Equine Disease Surveillance and Monitoring

- The surveillance of equine diseases has been undertaken by the Centre during last two plans. A baseline data of equine diseases in different states of the country has been generated. However, more exhaustive data on temporal and geographic basis on equine diseases need to be generated to develop disease mapping, forecast and development of timely control strategies using remote sensing and GIS data. A network project with centres located in areas with significant equine population will help in real-time monitoring of diseases. Various stakeholders will be proposed as partners in this Network, including SAUs, State Animal Husbandry, RVC, SVUs, etc.
- Studies on "vector biology" for important different equine diseases.
- Microbial genomics emphasizing infectogenomics, pathogenomics and clinical proteomics: Important bacterial, viral, parasitic pathogens of equines will be characterized for their genomic, proteomic and host pathogen interaction. A library of various equine pathogens and their genome will be made. The information will be utilized for development of diagnostics, vaccines and control strategies.

HRD & Capacity Development

- Skill development/up-gradation of all stakeholders connected with equine farming.
- Building state-of-art capacity at NRCE for handling national and global training and technology requirement and to position it as a centre of excellence.
- Development of national and international linkages for up-scaling the knowledge base in equine husbandry.

Extension/ Outreach Programme

- For augmenting income generation and improving socio-economic status of equine owners.
- Package of practices for better equine health and management etc.

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Epilogue

For centuries, horses have been intimate human companions. The animals were first domesticated 4,000 to 6,000 years ago and were harnessed primarily for power and transportation. Men and horses share an evolutionary history that has implications for the health of both the species. In India, equines are contributing significantly towards the livelihood of landless and marginal farmers, especially in hilly and difficult terrain. In the past two decades, immense advancements have been made in our understanding of equine production and diseases. A much more research framework needs to be drawn by way of developing improved and effective diagnostics, vaccines, chemotherapeutics, biosecurity, and managemental strategies. We have devised programmes for improvement of health and managemental conditions, optimization of equine production through better housing, nutrition, breeding and management, by tackling field-oriented equine problems, transferring the research output directly to equine owners, and enhancing opportunities for better economic gains using equine power for energy generation and utilization of equine byproducts for the welfare of the society. New viable linkages and inter-disciplinary research approaches are required for developing user-friendly technologies and know-how so as to improve equine productivity and hence stake-holders share in growth of equine husbandry.

In this document, we have identified many opportunities in the areas of equine research to improve equine health, production and productivity, and welfare. Collaborative research efforts are required by concerned research communities for improving/developing diagnostic tools, vaccination strategies, and therapeutic interventions, biosecurity measures, and also exploiting equine genomics/proteomics - especially athleticogenomics, so as to enhance the production and productivity of equines by addressing the health and production constraints.

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Annexure 1 : Strategic framework

Goal	Approach	Performance measure
Equine genomics including next generation sequencing	Whole genome sequencing of indigenous breeds of horses (Marwari and Kathiawari) Genotypic characterization of six indigenous horse breeds viz. Kathiawari, Marwari, Spiti, Bhutia, Zanskari, and Manipuri along with different donkey populations in different States. Genomic library of important genes (reproduction related genes, disease resistance-related genes, athleticgenomics, etc.) of indigenous equine breeds	Comparative data of whole genome sequence of Marwari vis-à-vis Thoroughbred horse Studying evolutionary status of indigenous equines Breed signature Parentage testing Disease resistance Endurance capacity Vaccine and drug design Atheletcogenomics
Equine production optimization and conservation	Equine sanctuary development. Technology for low-dose insemination for better utilization of good quality semen of true-to-breed equids Embryo transfer technology Hormonal and ionic imbalance profiling Survey and compilation of data on equine managemental practices Nutritional evaluation of different feed and fodder available in different agro-climatic zones Understanding equine production vis-à-vis' climate change Utility of equine draught power	*In vitro* conservation of elite/ precious germplasm of equines Quality semen for AI Cryopreserved embryo for production and conservation of the threatened breeds *Ex situ* conservation and breed improvement Enhanced productivity by providing improved package of practices for better management of equine husbandry on scientific bases Area-specific package-of-practices for feed and fodder requirement along with mineral requirement. For disaster management, good quality feed and fodder in the form of pellets/ block Energy generation - inverter battery charging-rotary mode, machine or similar machine including pony tonga etc. Work efficiency of equines as pack & transport animal. Use of equine in agricultural operations.

Equine byproducts utilization	Milk - lactoferrin, hair, dung, placenta, navel cord, PMSG from serum etc.	Equine milk as functional/ therapeutic food for humans. Use of equine milk as anti-microbial medicine/supplements. PMSG in superovulation in animals other than equines and pregnancy diagnosis of mares. Vermi-composting for safe human and animal health for food safety, eco-system conservation, safe environment, creating more job opportunity, income augmentation. Use of equine hair for multi-purpose carpets.
Biological resource repository	Equine Microbial Collection Bank Equine Semen Bank Equine Embryo Bank Equine Cell Line Bank Equine Stem Cell Bank	Source of equine biological for better management of equine health and production.
Development of diagnostics, target driven therapeutics and vaccines	Diagnostics for exotic diseases (EEE, VEE, WEE, AHS, CEM, Vesiviruses, Lawsonia, and others) Development and refinement of existing diagnostic assays Designing and development of new drugs and chemotherapeutics Stem cell (from bone marrow, adipose tissue, umbilical cord blood, and umbilical cord matrix) in therapy and also in delivery of therapeutics Development of new vaccines and updation of existing vaccines	The Centre will develop capabilities for molecular and serological diagnosis of the exotic diseases, emergency preparedness of the country Special emphasis for development of pen-side diagnostics, recombinant protein/peptide based assays, real time PCR, microarray and clinical proteomics using mass spectrometry. Drug designing using bioinformatics tools and devise better drug delivery system by way of nano-particle approaches. Use in therapeutics of joint, bone and other ailments of equines. Single and combination vaccines against important preventable equine diseases DIVA strategy for vaccines against equine influenza and equine herpes viruses Preparedness for emergency response against exotic,

Equine disease surveillance and monitoring	A network project with centres located in areas with significant equine population will help in real-time monitoring of diseases Studies on "vector biology" for important different equine diseases Microbial genomics emphasizing infectogenomics, pathogenomics and clinical proteomics Baseline data on equine diseases Data on microbial genome/ proteome/host pathogen interaction	emerging, re-emerging diseases Data will help in research prioritization and strategizing disease control programme Understanding the pathogen evolution, disease pathogenesis designing of newer immuno-prophylatics including vaccines, therapotics (drugs & other strategies), and improved rapid and user friendly dignostic tests/ assays/kit including pen-side tests.
HRD & capacity development	Skill development/up-gradation of all stakeholders connected with equine farming Building state-of-art capacity at NRCE for handling national and global training and technology requirement	Capacity building will enhance the competence of the NRCE at par with international laboratories Development of novel technologies for augmentation of equine productivity
Linkages and collaborations	The collaborative work through mutually beneficial linkages Collaborate with national and international nodal agency for research and development.	Generation of need-based skills, knowledge and technologies Enhancement of research & development outcome
Extension/Outreach program	Validation of health and production packages at farm-gate level in a participatory mode, refine them wherever necessary for adoption Technology generator - user linkage development through e-village/e-Choupal/consultancy services and other means Development of equine farmer's club/self-help groups for technology access and service delivery	For improving socio-economic status of equine owners Idea development/programme to enhance equine utilization Transfer of technology to end-user

Part II

Veterinary Type Culture Centre (VTCC)

proposed to be upgraded as

National Bureau of Veterinary Type Culture (NBVTC)

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Preamble

Microbes have shaped the path of human evolution, and continue to influence human and animal life. Microorganisms have acquired a special status since time immemorial for their use in enhancing livestock productivity. They have been also dreaded for their role in causing diseases in animals and human beings. The emergence and re-emergence of a number of diseases both in human and animals - majority being zoonotic in nature - pose significant global challenges to health researchers, food producers and traders, policy planners, administrators, public health officials, government and public. The research in microbiology is based on harnessing immense potential of the microbes to make animal and human lives secure and to study ways in which microorganisms act for utilizing resources or causing disease. The research pertaining to use of microbes of animal origin is based on the following fundamental features; firstly to search for novel products from the microbes for the benefit of human kind, secondly, to study the pattern in which these organisms behave so as to harness them for overall livestock development and improving human health. This could be achieved through the search of newer products and processes in order to develop safer and cheaper diagnostics, vaccines and therapeutic strategies to combat the harmful organisms on one side and utilizing the useful microbes for efficient utilization of feed and fodder. The third fundamental feature is their application in development of livestock products (including dairy products) where in dairy and rumen microbes play significant roles. To understand microbial evolution in general and the changing pattern of infectious diseases in particular for preparedness in emergency situations will give an edge.

Agriculture is the lifeline of our nation and agricultural research has always been the priority. The Indian Council of Agricultural Research is also engaged in developing resistant varieties of plants to resist abiotic stresses, for which useful traits of microbes capable of growing naturally in such conditions can be exploited. The understanding of mechanisms of their survival in such conditions will lead to finding ways to use them favorably and effectively. The Veterinary Type Culture is one such step of ICAR in this direction, where microbes of animal origin will be utilized effectively for boosting livestock & human health through conserving microbial biodiversity, and thereby realizing the goal of "One-Health" which will ensure a sustainably healthy ecosystem.

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Microbial Scenario

Research on animal microbes in the country is progressing well, though with certain limitations. In microbiological research, the most important of the resources include the microbes and in this context microbial repositories have an important role in conservation of this resource. A number of microbes are acquired and lost every year by different researchers which could be of immense value in future for understanding pathogen evolution besides developing newer diagnostic tools or immunobiologicals. The microbes would be invaluable for research and development in improving livestock production either through direct interventions or by way of improvement in health. This would help in food security and advances in human health researches apart from the direct benefit of enhancing livestock productivity and production.

A number of small microbial culture collections exist in the country *viz*., MTCC which house microbes of industrial importance, NIV repositions include viruses (mainly of medical and zoonotic significance), and National Collection of Industrial Micro-organisms maintaining organisms of value to research and industry. However, none of them covers the microbes of animal origin comprehensively. World Federation for Culture Collections lists more than 20 such repositories in India but none of them cater to the entire gamut of animal microbes.

A number of international repositories like ATCC, NCTC etc. are catering to a wide variety of reference microbes for use by researches/industry. However, similar facilities, especially in agricultural and livestock sectors, were lacking in our country. Considering this, NAIMCC, dedicated to the microbes in agriculture, has been established at NBAIM, Mau Nath Bhanjan in Uttar Pradesh and a similar facility has been established at VTCC, Hisar for the livestock sector which will include animal microbes comprising of veterinary microbes, rumen microbes, and dairy microbes.

Issues in Microbial Reposition

- In the present context, the issues of apprehensions of depositors regarding the ownership of cultures, access and use of these cultures and re-distribution of deposits need a special mention. These issues are

being addressed effectively through fast-track communications with depositor/institutions regarding the mechanisms developed by VTCC to safeguard their IPR issues and related interest.

- Further, despite the constraints like limitations of manpower and space, cross-contamination between microbes of varying origins and nature (bacteria/virus/recombinant clones etc.) are also being taken care of through adopting "Safe Microbiological Techniques (SMTs)" and "Good Laboratory Practices (GLPs)". All the laboratories under the network will have a minimum of BSL-II facility along with adequate facilities for freeze-drying and cryopreservation.
- The time-consuming process of microbial identification and characterization needs to be overcome by use of high-end equipments and platforms like, automated bacterial identification system, sequencers, mass spectrometer, computing systems, and bioinformatics software.
- Biosafety and biosecurity issues also need to be addressed.

NARS : National Bureau of Veterinary Type Culture

Many institutions in NARS are engaged in researches involving microbes. While NBAIM takes care of agriculturally important microbes in terms of their collection, characterization and reposition for use in plant research, a need was felt to have an institution-on the lines of NBAIM- for veterinary, dairy and rumen-microbes. In this endeavor, ICAR promptly sanctioned a network project on Veterinary Type Culture.

Veterinary Type Culture was sanctioned by DARE, ICAR in April, 2004 during the X Plan period as a new activity under the aegis of National Research Centre on Equines, Hisar. However, the actual functioning of Veterinary Type Cultures started at NRCE in June, 2005 and the work of establishment of the VTC facilities began in right earnest in June 2006. During XI Plan, further strengthening and overall expansion in terms of scientific and technical manpower, supporting staff, works and equipments was proposed to achieve the proposed objectives being a new Centre. The XI Plan was approved with an overall budget of Rs 2897.42 lakh. However, no additional posts of technical, administrative or supporting staff could be created during the period, although posts in the technical and supporting categories were approved. Presently, there are nine scientists in position against a cadre strength of ten.

Mandate

- To act as a national repository of microorganisms of animal origin, including recombinant cultures and plasmids.
- Exploration, collection, identification, characterization and documentation of animal microbes.
- Conservation, maintenance, surveillance and utilization of animal microbes for R&D.
- Human Resource Development (HRD).

VTCC Present Scenario

The activity was approved to function in Network mode during the XI Plan with nineteen network units located across the country. These include seven units in Veterinary Microbes component [IVRI, Izatnagar (Uttar

Pradesh), CSWRI, Avikanagar (Rajasthan), CIRG, Makhdoom (Uttar Pradesh), COVS, HPKVV, Palampur (Himachal Pradesh), COVAS, AAU, Khanapara (Assam), COVAS, SKUAST, (Jammu & Kashmir), COVAS, TANUVAS, Chennai (Tamil Nadu)]; four units in Dairy microbes component [NDRI, Karnal (Haryana), COVAS, AAU, Anand (Gujarat), COVS, GBPUA&T, Pantnagar (Uttarakhand), Dairy Science College, UAS, Hebbal, Bengaluru (Karnataka)]; and eight units in Rumen Microbes component [NIANP, Bengaluru (Karnataka), NDRI, Karnal, (Haryana), IVRI, Izatnagar, Bareilly (Uttar Pradesh), CIRG, Makhdoom, Mathura (Uttar Pradesh), CSWRI, Avikanagar, Jaipur (Rajasthan), NRC on Yak, Dirang (Arunachal Pradesh), NRC on Camel, Bikaner (Rajasthan), NRC on Mithun, Medziphema (Nagaland)].

The Centre is in the process of development of laboratory and infrastructure facilities and equipping them with specialized equipments. First phase of the laboratory building has been constructed and its interior furnishing is likely to be completed shortly. The facilities available at the Centre are being utilized to achieve the proposed objectives. Being a relatively new Centre, it needs further strengthening and overall expansion in terms of scientific and technical manpower, supporting staff, works and equipments. Moreover, for wider coverage of the programmes in the country, some additional Units are being proposed to be added in the network from southern, western and north-western region *viz.,* College of Veterinary Sciences, Sardarkrushinagar-Dantiwada Agricultural University, Sardar Krushi Nagar, Gujarat, College of Veterinary and Animal Sciences, RAJUVAS, Bikaner, Rajasthan and College of Veterinary Sciences, Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh during XII Plan period and beyond.

Milestone Achievements of VTCC

The Veterinary Type Culture alongwith its network units catering to the conservation of veterinary, dairy and rumen microbes, strengthened its activities entailing collection of samples from different livestock species across different geographical regions, acquisition of microbial isolates from different institutes / network units along with their characterization and preservation. The major achievements include -

- First isolation of *Bordetella bronchiseptica* from horse.
- First isolation of *Actionobacillus equilli* isolate from foal.
- First isolation of *Staphylococcus hyicus* from goat milk.

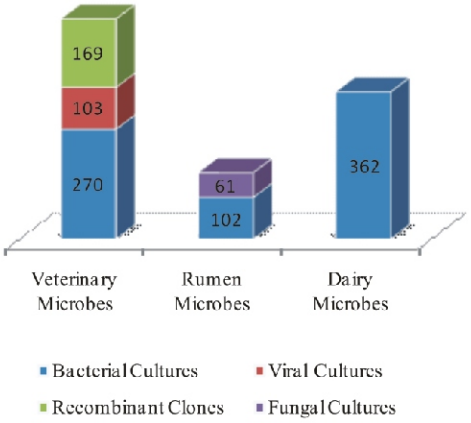
- First isolation of *Corynebacterium pseudotuberculosis* and a *C. bovis* from horse.
- Microbiological investigation and diagnosis of a case of vegetative endocarditis from horse by *Actinobacillus* and *Pseudomonas* spp.
- First detection of Methicillin-resistant Coagulase Negative *Staphylococcus sciuri* from pigs.
- First report of laboratory confirmed Camelpox zoonosis in the world (2009)
- Isolation and characterization of zoonotic camelpox virus (CMLV) from outbreaks in Delhi, Jaisalmer and Barmer (2009)
- Isolation and characterization of zoonotic buffalopox virus (BPXV) from outbreaks in Maharashtra (2010)
- First report on outbreak of zoonotic buffalopox involving buffalo, human, and cattle in the same time and space in Meerut U.P. (2011)
- Identification and molecular characterization of Bovine papillomavirus from an outbreak in cattle from Rajasthan (2011)
- The important microbial isolates and recombinant clones available in the repository include -
  - Veterinary microbes - viral isolates viz., buffalopox, camelpox, goatpox, equine influenza, Japanese encephalitis, bovine and human rotavirus, bovine herpes virus-1, equine herpes virus-1 & 4; bacterial isolates *viz., Bordetella bronchiseptica, Brucella melitensis, Rhodococcus equi, E. coli, Streptococcus* spp., *Pasteurella* spp., *Staphylococcus* spp., *Bacillus* spp., *Pseudomonas* spp., *Salmonella* spp., *Klebsilella* spp., *Aeromonas* spp., *Shigella* spp.
  - Dairy microbes *viz.*, *Lactobacillus* spp.
  - Rumen microbes viz., Methanogenic bacteria, *Pediococcus* spp., *Leuconostoc* spp.
  - Recombinant clones viz., specific genes of important viral and bacterial isolates available in the repository.

Present Status of the Microbial Repository

The microbial repository includes a total of 1084 microbial cultures including recombinant clones. Details are as under :

Veterinary Microbes

The veterinary microbes component possesses 270 numbers of bacterial cultures/isolates, 103 numbers of viral cultures/isolates and 169 numbers of recombinant clones.



Status of the microbial repository at VTCC

Rumen Microbes

The rumen microbes component includes 102 numbers of bacterial cultures/isolates along with 61 numbers of fungal cultures.

Dairy Microbes

362 numbers of bacterial cultures/isolates are available in the dairy microbes repository.

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VTCC- 2030

VTCC is one of the youngest culture collection Centre in ICAR system and is progressing with vigour while facing challenges in the budding phase. It's aim is to conserve microbial biodiversity for the benefit of end-users, comprising entrepreneurs in Biologicals development, food industry, researchers and practitioners. Efforts are aimed at becoming a leader in microbial repository management and research for enhancing livestock health and productivity.

Vision

Microbial Management programmes and microbial productivity-based research, conservation and utilization of animal microbes.

Mission

- Nodal Centre for acquisition and management of microbial resources of animal origin for sustainable growth of the livestock sector.
- Quality research on animal microbes for utilizing and exploiting their properties for the benefit of mankind through enhanced livestock productivity through translational research where ever applicable.
- Conservation and management of microbes for understanding the microbial evolution.
- Development of human resources to tackle the issues related to animal microbial research and application of scientific knowledge for the benefit of human being.

Focus

Veterinary Microbes

- Exploration and collection of microbes of Veterinary origin/ significance/relevance.
- To identify and characterize the isolated/collected microbial pathogens (viruses, bacteria, fungi, mollicutes, protozoa, etc.) isolated from different disease conditions and carrier animals by conventional and molecular techniques.
- Collection and central storage of animal microbes from existing culture collection centers, institutions and universities.

- To clone and sequence important genes to generate epidemiological information and to understand disease pathogenesis.
- To create a "Genome and Gene Bank" of different microbes by storing genomic DNA/RNA, recombinant plasmid clones, transfected cell lines, and transformed bacteria, etc. for conservation of microbial biodiversity.
- To procure and reposit reference microbial strains/isolates, vaccine strains, plasmids, genomic DNA/RNA, clones, cell lines, etc.
- To reposit, supply and use the microbes and/or other biological materials for validating assays.
- To identify suitable isolate/strains for development of biologicals including vaccines.
- Documentation and digitization of microbial database of cultures of veterinary microbes.

Rumen Microbes

- To isolate cellulolytic rumen bacteria from Indian cattle, sheep, goats and buffaloes.
- To isolate rumen fungi from domesticated and wild animals.
- To determine the best fibre digesting organism.
- Characterization of microbes by cloning and sequencing of at least 3 full-length genes including the cellulase gene from the best fibre digesting organism.
- Documentation and digitization of microbial database of cultures of rumen microbes.

Dairy Microbes

- To isolate indigenous strains of lactic acid bacteria including the ones with probiotic attributes from ethnic fermented milks and other foods prepared in various parts of India.
- To identify and characterize the isolated strains using conventional and molecular techniques based on 16S rRNA sequencing, PCR (Real time), DNA probes and Molecular Beacons / DNA Micro-assay.
- To analyse the plasmid pool encoding commercially important traits of selected cultures and their characterization at molecular level.
- To construct new recombinants with different phenotypes by gene transfer systems.

- To clone and sequence commercially important genes of lactic acid bacteria particularly related to probiotic functions.
- To identify the commercial potential of these diversified strains for designing novel starter cultures with functional/probiotic properties.
- To conserve these strains and their germplasm ex situ and create a repository of well catalogues dairy microbes.
- To establish a National Culture Bank of indigenous lactic acid strains at NDRI, Karnal.

Harnessing Science

The overall benefit of VTCC activities will result in enhancement of knowledge in all the spheres of animal microbes including utilization of their useful properties. The collection, identification and characterization of microbial pathogens at phenotypic and molecular level and their biotyping would result in development of a repository of the animal microbes. This would be useful in understanding microbial evolution and would help in (i) developing newer approaches towards development of diagnostics, drugs, vaccines, functional foods/feeds, (ii) enhancing utilization of cellulosic fodder and non-conventional feeds/fodder, and (iii) ensuring human and animal health as well as sustenance of ecosystem.

Potential of microbial resource management

The programme on development of a comprehensive microbial repository management system would lead to the development of Standard Operating Procedures (SOPs) and standards for acquisition and conservation of microbes alongwith knowledge on animal microbe signatures and their exploitation with passage of time. The conserved organisms and knowledge acquired through gene mining would be of great use in developing future strategies in dealing with the microbes and their exploitation for understanding pathogen evolution, enhanced livestock productivity, food safety, nutritional security, ecosystem and biodiversity utilization, as well as human and animal welfare.

Using bioinformatics and computational tools

Development of an Interactive Microbial Resource Database System would provide real time access and use of metadata on animal microbes. For this, a resource portal would be developed to share the knowledge acquired through the programmes. The available data would be shared and used by different work groups for application in technologies for enhanced livestock productivity and improvement of human health.

Understanding microbes through biotechnology

The microbes collected and maintained in VTCC would be of immense value to researchers. They would act as spatial and temporal reference in future for prospective and retrospective studies. The contemporary

biotechnological tools would facilitate researchers to understand the intricacies in their mechanisms of action, etiology of diseases or use in efficient feed utilization for the development of livestock sectors etc.. The future tools may be more sensitive and may make it possible to understand the existing organisms in order to exploit them more effectively. This would also assist the researchers in understanding the dynamics of changes in the microbes over time and space.

Synergism with other areas of science

Since the fruits of modern day research are effectively acquired by the synergism from various fields of science like biotechnology, bioinformatics, nano-technology, information and communication technology, their use in the repository would be of immense help in attaining the goals of the collection. The assistance of these branches will help in preserving and utilizing the collected microbes in a better way through understanding and taking advantage of intricate mechanisms involved in their functioning.

Exploiting microbial diversity

It is beyond any debate that the world is full of microbes, majority of which are generally beneficial to life on earth. However, many pathogenic and opportunistic microbes are harmful to livestock and human health. This diversity of microbes of animal origin would be harnessed and exploited by maintaining them as references for future and mining the meta-data associated with them in order to search for traits which may be useful for mankind. The research for utilizing such traits of microbes would lead to food safety, nutritional security, as well as human and animal welfare through disease control and eradication.

Translational research

The animal microbes would be used in translational research for societal benefit through development and utilization of microbial resources for posterity. The useful traits of the organisms would be used in veterinary biologicals, animal feeds for enhancing productivity, dairy products with value addition and development of probiotics. This would be helpful in enhancing the overall development of livestock sector.

Value addition of livestock products

The research on useful microbes in dairy sector would aid in value addition to the livestock products and thereby improving the quality of products in terms of palatability, aroma, taste, flavour etc. Furthermore,

high value livestock products have an indirect impact on food security, primarily through generating additional revenue through sale of value added products leading to improvement in the livelihood of farming community and small scale entrepreneurs.

Making livestock bio-waste safe for ecosystem

A lot of bio-waste is generated by the animals which are not being disposed off properly. Dumping of such waste is usually at the dumping grounds which are very close to human dwellings, on the sides of the road/highways, and/or near the water source which leads to contamination of water source itself thereby, the pathogens present in bio-waste spill back to humans and back to animals in cyclic manner which may be bi-directional or even multi-directional. The scientists at VTCC have already identified some important microbes in equine dung many of which are also zoonotic in nature. Such attempts would be expanded to bio-waste from other animal species. It has been evident from our results that microbial count reduced in descending order from normal dung to compost to vermin-compost where only one-tenth of the microbes were present in vermin-compost. Attempts would be made to identify the pathogens in such waste so as to develop remedial measures and general health protocols for use of general public in day-to-day life for ensuring better human and animal health.

Risk assessment and biosafety/biosecurity management

The collection of microbial cultures of different risk groups would enable us to understand the risk associated with different pathogens/microbes for devising bio-safety and bio-security strategies. This would enable researchers in adopting adequate precautions while handling such microbes. The insight of these aspects would be of immense value in (i) devising strategies for animal biosecurity not only for the country but entire Asian region, (ii) attaining international standards in manufacture of diagnostics/biologicals and various food products of livestock origin. Efforts are already on for establishment of a Microbial Containment Laboratory of BSL-III level.

Cooperation, education and capacity building

The linkage (national and international) would be developed for knowledge and skill development and up gradation, physical infrastructure develop/upgradation, benefit sharing and devising strategies to meet the challenges at global level. Strong linkages with the national and

international microbial resource and conservation Centers will be developed. In order to gain maximum output from the local resources, efforts will be made to develop strong linkages with all local institutes and other schemes and the resources would be used on sharing basis. Collaboration will be sought with a number of national and international organizations to fulfill the mandate. The established linkages will provide a platform for the workers to interact with diverse expert groups and acquire latest know-how in their respective fields. The programme will result in creating trained personnel to use the generated knowledge constructively through skill development and capacity enhancement of the network, besides developing a state-of-the-art microbial repository system including modern laboratories, animal house, microbial containment lab, and elaborate biosecurity and storage facilities. The entire physical infrastructure at VTCC would be developed in conformity to the other repositories in the world.

Transfer of technology

The know-how and technologies generated by VTCC would be show-cased to reach the end-users including researchers, drug-houses and biological production units and policy makers through the print and electronic media. The database and dynamic resource portal of VTCC would of immense help in this endeavour.

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Strategy and Framework

The strategy comprises following programmes for the network project to accomplish the vision of VTCC:

Collection, identification and characterization of microbial pathogens at phenotypic and molecular level and their biotyping

- Collection, receipt of standard/reference strains of microbial resources and cell-lines from accredited organizations/individuals, and/or isolation from field samples.
- Development of functional gene libraries and monoclonal antibodies for bio-molecules of various animal microbes.
- Development of animal models and studying their proteomes for detecting the receptor(s) of pathogens in animals.
- Application of metagenomics, microarray techniques, and mass spectrophotometry for identification of novel microbes.
- Development of cell lines of animal origin using somatic and stem cells from different animal species.

Development of a comprehensive microbial repository management system

- Development and documentation of standards, quality control processes and procedures for microbial repository.
- Development of modules for inventorization, cataloguing, conservation, revival, and retrieval of microbial resources.
- Development of a comprehensive biosecurity management system for securing the microbial repository.

Development of an Interactive Microbial Resource Database System

- Collection and compilation of microbial metadata towards development of database.
- Documentation and digitization of microbial database of cultures.
- Development of VTC Microbial Resource Centre Portal.

Use of animal microbes in translational research for societal benefit

- Development and utilization of microbial resources for research and development in future generation and posterity.
- Data mining and search for the useful traits of the organisms for use in veterinary biologicals, animal feeds for enhancing productivity, dairy products, and functional foods and nutraceuticals including value addition of food products and development of probiotics.

Linkage development for benefit sharing and strengthening

- Development of linkages with the national and international microbial resource and conservation Centers, SAUs / SVUs / other research institutes, general universities, medical colleges, resource personnel and organizations for acquisition, authentication and validation of microbial resources.
- Upgrading the skill and capacity of the Centre and Network Units so as to receive recognition by World Federation of Culture Collection and/or World Data Centre for Microbes, Japan.

Though the above mentioned programmes will include work on veterinary, rumen and dairy microbes, the specific work to be undertaken by rumen and dairy microbes includes -

Rumen Microbe Component

- Isolation and characterization (phenotypic and phylogenetic) of fibrolytic anaerobic rumen microbes (bacteria and fungi) from domesticated and wild ruminants.
- Use of isolated microbes for improvement in fibre degradation in the rumen of economically important animals.
- Microbial diversity of rumen microbial eco-system of different ruminants.

Dairy Microbes Component

- Isolation and identification of lactic acid bacteria, propionibacteria, bifidobacteria and lactose fermenting yeasts and characterization of their techno-functional and health beneficial attributes for functional fermented dairy products.
- Isolation and characterization of lactic acid bacteria, *Propionibacterium* spp., *Bifidobacterium* spp. and dairy yeasts from fermented milks and plant samples collected from different regions in India.

- Evaluation for various technological properties of the identified isolates for the formulation of starter cultures for fermented dairy products.
- Long term preservation and storage of the characterized microbial isolates and deposition in the culture bank.
- Evaluation of functional properties/health beneficial attributes (e.g. probiotic properties) of the characterized microbial isolates.

In view of the significant role of microbial repositories on a global level, the strategies formulated to achieve the objectives and goals of VTCC would pave the way for achieving leadership in the mandated areas. The development of collection, management system for repository and its biosecurity, use of microbes for futuristic research, linkages and collaboration with associated facilities and interaction with all concerned would definitely pay dividends in terms of improved livestock productivity and human health. The cutting edge research would also help the policy makers use the knowledge generated in planning food safety, nutritional security, animal waste management, and tackling public health issues.

Epilogue

The utility of microbiology research is based on channelizing the immense potential of the microbes to secure mankind in terms of disease control and food safety. VTCC is committed to enhancing the livestock productivity and production; food safety and nutritional security; efficient utilization of resources and reducing methane production by livestock, and sustaining animal and human health. The VTCC is envisioned to become a nodal Centre for acquisition and management of microbial resources of animal origin for sustainable growth of the livestock sector. For this, quality research *at par* with international standards on animal microbes would be carried out. Human resources would be properly sensitized to develop their skills in the respective areas of their specialization at various levels and building the capacity of the Centre and associated agencies for overall livestock development in the country.

Proper institutional support in terms of infrastructure and administrative back up would be created which would be of immense value in promoting young, innovative brains to take up research in the mandated areas. Mechanisms would be put in place to monitor the development at national and international levels and efforts would be concentrated on more useful aspects through prioritization by involving various stake-holders at different levels. The system would work in participatory mode, in lines with those of ICAR, to be more foccused with responsibility and sincerity thereby assuming leadership in the assigned area.

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Annexure 2 : Strategic framework

Goal	Approach	Performance measure
National repository of microorganisms of animal origin	Nodal centre for acquisition and management of microbial resources of animal origin. Exploration, collection, identification, characterization and documentation of animal microbes Quality research on animal microbes for utilizing and exploiting their properties for the benefit of mankind through enhanced livestock productivity	Number and diversity of microbes collected, characterized and utilized
Future Expansion	Expansion of the network to cover the entire geographical regions of country	Number of states covered under the network
Augmenting opportunities for research on animal microbes	Conservation, maintenance, surveillance and utilization of animal microbes Management of microbes for understanding the microbial evolution	Identification of traits of animal microbes useful for livestock development Data on epidemiology and pathogen evolution
Capacity building	Development of human resources to tackle the issues related to animal microbial research and their application in resource management Development of state-of-the-art laboratory infrastructure alongwith biosecurity system of international standard	Generation of skilled human resources trained for research in microbiology and biotechnology laboratories for research and implementation of scientific knowledge Availability of state-of-the-art laboratory infrastructure as per international standards
Monitoring mechanism	A proforma will be developed on similar lines of AICRPs for monitoring the progress and subsequent grading of network units	Performance of every centre and unit will be available in terms of grades
Linkages	A strong network with national/international labs, and organizations to be established for upgrading the skill, knowledge, and sharing the latest development in science	Availability of skilled manpower, know-how and other resources as per international norms.

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भारतीय कृषि अनुसंधान परिषद

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