nianp

Annual Report
2021

ICAR-National Institute of Animal Nutrition and Physiology
Bengaluru

वार्षिक प्रतिवेदन

Annual Report 2021

भाकृअनुप - राष्ट्रीय पशु पोषण एवं शरीर क्रिया विज्ञान संस्थान बेंगलुरु

ICAR-National Institute of Animal Nutrition and Physiology Bengaluru

Citation

ICAR-NIANP Annual Report 2021

Editors

Dr A Dhali - Chairman
Dr AP Kolte
Dr N Ramachandran
Dr G Krishnan
Dr A Mech

Published by

Dr Raghavendra Bhatta
Director
ICAR-National Institute of Animal Nutrition and Physiology
Adugodi, Hosur Road, Bengaluru - 560 030, Karnataka, India
Tel. No: +91-80-25711304, 25711303, 25702546; Fax: +91-80-25711420
Email: director.nianp@icar.gov.in; Website: http://www.nianp.res.in

Printed and bound by

Colours Imprint
#475C, Adugodi Main Road, 8th Block, Koramangala
Bengaluru - 560 029

Published in

2022

ISBN

978-81-954201-0-0

Copyright

CONTENTS

Preface

The ICAR-NIANP has completed its journey through glorious past 26 years and served the livestock farmers, and other stakeholders and entrepreneurs with scientific inputs and advisories, apart from its mandated research agenda on the basic and fundamental research in the area of Animal Nutrition and Physiology. The ICAR-NIANP has established itself as an illustrious Research Institute in the field of Animal Nutrition and Physiology through its relentless efforts and contributions. Although, the unforeseen COVID-19 pandemic disrupted the normal functioning of the Institute during the year 2021, we could work meaningfully and achieved our prioritised goals.

The research contributions of the Institute are reflected in the 56 research and 14 review/technical articles that were published during the reported period in the national and international journals of repute. Further, the scientists contributed substantially towards knowledge repository by publishing six books and 19 book chapters. One patent was applied and three technologies were assessed and transferred to the AgrInnovate India Limited, State Govt and commercial firm. Additionally, the technologies of "Protocol for Producing Hydroponic Fodder" and "Area Specific Mineral Mixture for Four Different Regions" were commercialized through Agrinnovate India Limited. Scientists of the Institute were recognized on different platforms and received various awards and honours for the meritorious contribution, notably, the Fellowships of Karnataka Science and Technology Academy and National Academy of Dairy Science (India), and enlisting in the world top 2% scientists by the Stanford University, USA and top 1% researchers in the field of heat stress by Pubmed.

The honourable DDG (AS), ICAR, Dr BN Tripathi laid the foundation stone of the "Farmers Training cum Student's Hostel" and "Community Hall" at the Institute's campus on 23 January 2021 for the benefits of students, research scholars, farmers and staff. The Institute established linkages and actively took part in various collaborative programmes with the universities and organisations from Germany, Australia, France and CGIAR.

During the reported period, various human recourse development activities were organized at the Institute including the Australia-India Council workshop on heat stress in farm animals and ILRI-NIANP hands-on training on livestock methane emission. The staff attended various workshops, conferences, seminars, symposia and professional training for skill developments. Various workshops and trainings were also organised at field level for the benefits of the farmers and other stakeholders.

The 'Mera Gaon Mera Gaurav' programme and Farmer FIRST projects were effectively implemented at the adopted villages. Various inputs and technical advisory services related to animal husbandry and horticulture were provided to the farmers to improve the production systems and income of their farms. At the intervened locations, the technology adoption rate was found 69% that resulted 1.5 times increase in farm income by changing crops, 11% increase in milk production and 17% increase in gross income.

I am pleased to present various activities and achievements of ICAR-NIANP during the year 2021 in this report. This report will definitely serve as a source of valuable information to the personnel involved in the field of Animal Nutrition and Physiology. I am grateful to the Council for tremendous support, guidance and resources that were provided to the Institute. I convey my sincere gratitude to the honourable Secretary, DARE and DG, ICAR, Dr Trilochan Mohapatra for his constant support and guidance. I am grateful to Dr K Pradhan, the Chairman and the other members of RAC for reviewing the research activities and providing constructive suggestions and guidance. I sincerely acknowledge the encouragement and support from Dr BN Tripathi, the honourable DDG (AS), ICAR. I am also thankful for the constant support, guidance and coordination extended by Dr AK Tyagi (ADG, A&P), Dr Ashok Kumar (ADG, AH), Dr Rajan Gupta (Principal Scientist, AN) and Dr Vineet Bhasin (Principal Scientist, AGB) from the Council. My heartfelt appreciation goes to all the staff of ICAR-NIANP and the editorial Team for their dedication, contributions and hard work for compiling this valuable report in time.

Raghavendra Bhatta

Executive Summary

The ICAR-National Institute of Animal Nutrition and Physiology (ICAR-NIANP) has successfully completed 26 glorious years since its inception. Over the last 26 years, through relentless efforts and contributions, the ICAR-NIANP has become an illustrious research institute in the field of animal nutrition and physiology. Currently, ICAR-NIANP is considered as one of the most vibrant organizations under the "National Agricultural Research System" and it is an ISO 9001:2015 certified Institution.

During the reported period of January to December 2021, the Institute functioned with 39 scientists, 9 technical staff, 13 administrative and accounts personnel and 2 skilled supporting staff. The total budget allocation for the financial year 2021-2022 was ₹ 2328.26 lakh and the total expenditure was ₹ 1764.34 lakh during the period of April to December 2021. During the financial year of 2020-2021, total budget allocation was ₹ 2184.36 lakh and total expenditure was ₹ 2183.74 lakh (99.9%). The institute also generated ₹ 46.97 lakh revenue during the reported period. The scientists of the Institute dedicatedly worked for achieving the various targets related to research and technology development and demonstration, defined under the major programmes as per the mandate.

Research

Biogeography of Gut Microbes in Animals

Isolation and characterization of lipolytic/lipid biohydrogenation bacteria were done from the rumen of sheep supplemented with different fat sources. Biohydrogenation study of linoleic acid and arachidonic acid with pure culture (*Clostridium lundense* and *Clostridium tetanomorphum*) and mixed culture (rumen liquor) resulted in the formation of either cis-Vaccenic or trans-Vaccenic acid as intermediate products of biohydrogenation

Studies were conducted on the *in ovo* manipulation of gut microbes in broiler chicken. In ovo supplementation of prebiotics helped in the early establishment of beneficial gut microbiome population, which could be useful in preventing the pathogens attack during early life of broiler chicken.

A study was initiated on the production and evaluation of nutraceutical potential of post and parabiotics in lab animals. Incorporation of prebiotic (tagatose) to growth media (0.5 and 1.0%) reduced the pH from 5.95 to 4.48 and 4.45 irrespective of the organisms and no difference in pH values was observed among the levels of incorporation.

Under the ICAR-Network project on "Veterinary type culture - rumen microbes", a total of 381 bacterial cultures were revived and 82 bacteria were accessioned. A total of 381 bacterial cultures were also freeze dried.

Novel Approaches for Assessing and Improving Nutrient Bioavailability, Animal Reproduction and Productivity

Studies were conducted for the laboratory production of metal-carnitine chelates for improving bioavailability and tissue utilization of trace minerals and production performance in animals. Bioavailability of trace minerals (Cu, Zn, Mn and Cr) from metal-carnitine chelated products was found more than inorganic salts of these metals and ranged from 125 to 146% (bioavailability of inorganic salts was considered 100%). Further, the level of carnitine increased by 73.5%, which could be useful in the body for energy utilization in animals.

The method of green synthesis of zinc nano particle was standardized and particle was evaluated for size and found to be 10.8nm.

The potential of grain sprouts as fodder for livestock was evaluated. Replacement of compounded feed

mixture or conventional green fodder at higher level with maize grain sprouts adversely affected the growth performance in lambs and was not economical in terms of feeding cost and growth performance. However, maize grain sprouts with straw bedding technique as a strategic additional feed supplement for dairy animals under field condition can improve milk yield and milk quality.

Under the AICRP on nutritional and physiological interventions for enhancing reproductive performance in animals, moringa forage meal (MFM) was found as a good source protein, energy, minerals, phenolics and flavonoids. The feeding of MFM to rams by replacing 15% of the compounded feed mixture improved semen quality and fibre utilization. Further, under the project, *E coli* clones were produced in laboratory for expressing recombinant buffalo α chain of LH/FSH and β chains of LH and FSH. Livestock inputs were provided to SC farmers that resulted in improved fodder availability, milk production and thereby their family income.

Nutritional modules for commercial broiler sheep production were developed. Performance of Avishaan lambs fed finger millet straw based total mixed rations (80:20 and 70:30 C:R) were found to be encouraging with good average daily gain and feed conversion ratios.

Work was conducted to develop precise delivery system for improving bioavailability of zinc in poultry. Feeding of encapsulated zinc at two levels (50%) caused improvement in ileal digestibility of zinc in encapsulated group compared to control. Plasma zinc status improved by 19.9 and 11.9% in encapsulated zinc supplemented groups at 100 and 50 %, respectively.

Biological activities of rare earth elements (REE) in relationship to production performance of egg and egg and meat type chicken were assessed. Supplementation of REE in broilers improved their performance in terms of improved growth, feed intake and efficient FCR. The increase of bone strength and egg shell breaking strength in broilers and layers supplemented with REE showed a plausible action REE as a calcium agonist.

A study had been initiated on complementary physiological and molecular mechanisms and fine-tuning research tools for holistic poultry production with the objectives to understand the proximate mechanism of sex reversal and production of single sex chicks, to examine the dynamics of oestrogen receptors and shell gland function during long laying cycle, and to develop strategies for supporting persistency of egg production beyond 72 weeks.

The role of G-protein coupled receptors and gut hormones in gut chemosensing and regulation of fat digestion and absorption was studied in sheep. Supplementation of additional calcium salts of long chain fatty acids upregulated the expression of CD36 in various segments of GIT and chemosensing of long chain fatty acids by this gene triggered the signalling transduction that enhances chylomicron formation. This was further evident from the significant upregulation of MTTP and APOB in the various segments of GIT that supported the high content of dietary fat at cellular fat metabolism in the gut, regulating the uptake of fatty acid.

The role of uric acid in alleviating oxidative stress induced mitochondrial dysfunction during different production cycles in poultry was investigated. The results indicated that the beneficial effects of supplementation of 0.5% allicin and 1% garlic on egg production was due to increased level and antioxidant activity of uric acid that minimized the age related increase in lipid peroxidation of mitochondrial membrane thereby restored membrane integrity and membrane potential of mitochondria in duodenum and shell gland.

Experiments were conducted for unravelling the physiological role of adiponectin in the regulation of energy metabolism in sheep. Plasma levels of adiponectin, AdipoR2, NEFA, IGF1 and cortisol were significantly enhanced in LE (low energy) group as compared to CON (control) and HE (high energy) group. Whereas plasma level of AdipoR1 was significantly lower in the LE and HE groups as compared to CON group. Plasma levels of leptin, insulin, T3 and T4 were significantly elevated in HE group as compared to CON or LE group. The mRNA expression of leptin and GH significantly upregulated in the HE group than that of the CON and LE groups. The mRNA expression of IGF-1 significantly was upregulated in the LE than the CON and LE groups.

The GnRH system was modulated using novel neuropeptides during embryogenesis and physiological responses in post hatch broiler chicken. In ovo luzindol administration (50μM) during hatching in broiler chicken advanced the body weight gain by 30 days relative to 35 days in controls. Luzindol effectively down regulated pituitary GnIH-R and upregulated steroids and somatotrophic hormones and facilitated the rapid growth rate in post hatch broiler chicken. Embryonated eggs injected in ovo with GnRH consumed less feed and grew most during the test period (1.99kg body weight at day 30 in the treatment group as compared to 1.81kg in the control group). FCR in the control group was 1.62 as compared to 1.51 in the treated group.

Comparative assessment of the resilience capacity of different indigenous goat breeds to summer heat stress was done based on selective thermo-tolerant gene expression pattern. Based on the differences in productive performance and changes associated with phenotypic and genotypic traits as well as based on the results from rumen metagenomics, whole transcriptomics, and epigenetic changes were studied in five goat breeds (Osmanabadi, Malabari, Salem Black, Kanni Aadu and Kodi Aadu), Kodi Aadu breed was observed to be the best climate resilient breed in Southern India.

Under the ECLIPSE project, productive and adaptive capabilities of two different goat breeds (Nandidurga and Bidri) to heat stress were assessed based on differences in the phenotypic and genotypic traits. The results indicated that Nandidurga breed apart from adapting very effectively to extremely severe heat stress, also maintained its growth and meat production and quality reflecting its better climate resilient potential.

An egg yolk-free, ready to use, semen extender with higher shelf-life (≥18 months) was developed for cryopreservation of buffalo semen for the first time in India. The post-thaw progressive motility of cryopreserved buffalo sperm in the new egg-yolk free semen extender was significantly higher as compared to that in traditional egg-yolk-based semen extender.

A study was initiated to elucidate the cryo-tolerance and its mechanism in buffalo spermatozoa. Individual variability with respect to sperm freezability was observed in breeding bulls. Post-thaw velocity parameters like VCL, VAP and VSL were significantly higher in the good than the poor freezable semen producing bulls.

The investigations conducted under the ICAR-National Fellow project on development of buffalo bull fertility diagnostic chip based on sperm transcripts signatures had revealed that embryonic organ development and reproduction processes were enriched in the X-linked genes of cattle and buffalo sperm, respectively. Further, it was evident that X-linked genes RPL10 and ZCCHC13 in cattle and AKAP4, TSPAN6, RPL10 and RPS4X in buffalo influenced sperm kinematics.

The experiments conducted under the ICAR-NASF project on skewing the sex ratio towards female offspring in dairy cattle had revealed that the incorporation of calcium at 1 and 3mM in the incubation skewed the sex ratio of oviductal cells bound spermatozoa towards X-bearing spermatozoa, while incorporation of magnesium skewed the sex ratio towards Y-bearing spermatozoa.

Under the DST-SERB Project, attempts were made for establishing 3D in vitro culture conditions for maintaining long-term stemness in sheep spermatogonial stem cells (SSC). The 3D culture system (Geltrex) maintained long-term SSCs propagation and stemness. The stemness of cultured SSCs was significantly higher in hypoxic culture condition when compared to normoxic environment.

Modulation of sexual differentiation in embryos by altering oxidative status of in vitro culture system was attempted in sheep. It was evident that oxidative status-mediated alteration in pH of the medium modulated the intracellular positive ions, which was a critical factor in influencing the sex of embryos through fertilization with sex-specific sperms as per their polarity.

The influence of administration of prostaglandin modulators on embryo survivality was investigated in sheep. In endometrium, a significant decrease in the expression of PTGFS and Galactin mRNAs was observed with 1 and 5IU doses of oxytocin as compared to control group, and significant decrease in the expression of IFN mRNA was observed with 1IU dose of oxytocin as compared to control or 5IU oxytocin group. The administration of oxytocin increased the levels of PGF2α in sheep plasma.

Coumarin (an active ingredient of Leptadenia and Aegele leaves) and Diosmetin (an active ingredient of Leptadenia leaves) at the dose of 25-50μM promoted the preantral follicle (PF) and granulosa cell (GC) functions. Auraptene (10 to 25μM), a derivative of coumarin, was found to be beneficial on PF and GC growth, and PF enclosed oocyte development.

Under the ICAR-Extramural project, the use of previously developed product Reprovardhak along with ProKisAna protocol for induction of oestrous had led to successful pregnancy in sheep and goat with a significantly higher rate. The results indicated that the combination of Reprovardhak and ProKisAna could be used as a potential therapeutic strategy.

Studies on CRISPR/Cas9 guided functional analysis of genes regulating early embryonic survival in buffalo were carried out under the ICAR-NASF project. Significant decrease in PGF2 and PGE2 production and expression of PTGES and PTGFS mRNAs were observed following CRISPR/Cas9 based targeted editing of PTGES and PTGFS genes.

Feed Informatics, Feed Quality and Safety and Value Addition

Efforts were made to develop novel phytogenic blend to replace antibiotic growth promoters in broiler production. Based on the results of different experiments, previously a novel phytogenic blend "AB Free" was developed to replace antibiotic growth promoters in broiler chicken production. Further, to test the efficacy of essential oils in poultry, the essential oils of identified phytogenics were extracted and their in vitro antioxidant activity and anti-inflammatory activities were determined.

Assessment and characterization of antimicrobial resistance (AMR) genes in poultry production environment are in progress. Majority of the AMR genes detected in livestock production environment were the broad-spectrum tetracycline class of antibiotics and different Tet classes conferring resistance to various tetracycline classes.

Assessment and forecasting of feed resources at regional and national level for different production

scenarios were initiated. The demand for animal feed resources at national level was estimated as 412, 1030 and 126 million tons of crop residues, greens and concentrates, respectively.

Under the ICAR-CRP project on evaluation of value addition cereals and cereal by products for animal feeding, eight biofortified rice straw varieties were evaluated. The straw CP was found negatively correlated with crude fibre (CF) of straw and positively correlated with iron and zinc content of brown rice and zinc content of polished rice. CF of rice straw was negatively correlated with important plant breeding parameters such as single plant dry weight, flag leaf length, iron content of brown rice, zinc content both brown and polished rice.

Under the ICAR-Outreach Project on monitoring of drug residues and environmental pollutants, Qualitative screening of milk samples revealed 10% prevalence of antibiotic residues under field conditions.

A study was conducted to assess the potential of azolla for removing heavy metals, lead and cadmium from sewage water under the AICRP Project on micro and secondary nutrients and pollutant elements in soil and plants. The results indicated that azolla absorbed over 71% of lead and 95% of cadmium from the contaminated water, confirming its potential as an economical and practical means for bioremediation of sewage water used for irrigating vegetable and fodder crops.

Climate Change Impact on Livestock

The study on life cycle assessment of sheep farming in Bengaluru rural was in progress and four rounds of data were collected from the 17 sheep farms. Average growth rates (g/d) were found 63.8 and 17.8, and 36.9 and 25.7 in male and female sheep during the first one year and second year of age respectively. The body weight at marketing was 20-28kg. The average ratio of ram and ewe recorded was lower (1:6) and average lambing percentage was recorded as 55.8%.

Investigations were carried out under the ICAR-Outreach project on estimation of methane emission under different feeding systems and development of mitigation strategies. An in vivo study was conducted on sheep to ascertain the impact of divi-divi (*Caesalpinia coriaria*) pod supplementation on enteric methane emission, rumen microbial diversity including methanogens, and rumen fermentation characteristics. Supplementation of divi-divi pods at a level of 3.5% in concentrate decreased the daily enteric methane emission in sheep by 15%.

Under the ICAR-ILRI Project on methane emission and its mitigation, study was conducted to compare the archaeal community composition in cattle and buffaloes fed on a similar diet comprising 70% finger millet straw and 30% concentrate. The results indicated that the daily enteric methane emission between cattle and buffaloes did not vary when fed similar diet under similar environmental conditions.

An Indo-German collaborative research project was initiated on the study of contamination of feed and fodders with heavy metals and agro-chemicals and impact on milk composition, rumen microbes and methanogenesis in dairy cattle along the rural-urban Interface of Bengaluru. Various farm records and milk and dung samples were collected from the 15 dairy farms. The analysis revealed that the milk fat depression was a major issue in the farms and nearly 30% animals were positive for the internal parasites.

Technology Translation to Connect Discovery with Application

The economics of milk production under different systems of dairy farm management in Karnataka was assessed. The estimated cost of milk production (/lit) varied from 23.4 to 25.7 under the semi-intensive system and 21.9 to 23.9 under the extensive system. In contrast, the cost was estimated as 27.3 under the intensive system.

A new project was initiated to study the effect of ground water levels on livelihoods of dairy farmers. Secondary data were collected from the Central Ground Water Board, and primary data were

collected from 27 farms (13 critical, 7 safe and 6 semi critical and 1 over exploited) located in Chamarajnagar. The study is in progress.

Study was initiated to assess the economics of sheep rearing under different systems of management in Karnataka. Parameters to be studied were screened, questionnaire for primary data collection was developed from the sample farmer respondents and validated, and part of secondary data were collected from the line departments on district wise and taluk wise sheep population and sheep developmental programmes. The study is under progress.

The ICAR-Farmer FIRST project on improving livelihood security of farmers through technological interventions for sustainable livestock farming was implemented in a cluster of four villages covering 550 households. Various inputs and training related to animal husbandry and horticulture were provided to the farmers. Thirteen technology interventions were implemented under six modules either alone or in combinations, for doubling their income. It was evident that area under fodder crops increased by 4 times, and 59% of farmers adopted mastitis management protocol, leading to reduction in mastitis incidence by 56%. Technology adoption rate was 69% across different interventions. Area under vegetable crops increased by 3 times, and there was 1.5 times increase in farm income by changing crops. On an average, 11% increase in milk production was reported in the study villages, and 17% gross income increased across different technology interventions as compared to the previous year.

Activities were conducted under the other ICAR-Farmer FIRST project on enriching knowledge, integrating technology and institutions for holistic village development in horticulture based farming system. It was noticed that the supplementation of mineral mixture and protein source to sheep and goat improved their performances and enhanced farmers' income by 35%.

Training and Capacity Building

During the reported period, various human recourse development activities were organized at the Institute. The following activities were organized: Australia-India Council workshop on transfer of mitigation technologies for heat stress in farm animals; ILRI-NIANP hands-on training on livestock methane emission: assessment, impact and amelioration strategies; NIANP-MANAGE online training programme on nutrition and fertility management of dairy animals in changing climate scenario; Hands-on training programme on semen evaluation techniques and nutritional management of breeding bulls; Online training programme on feed and fertility management; Technical seminar on feeding and semen quality management in breeding bulls; Technical workshop on livestock feeding management and production; Technical workshop on improved methods of small ruminant farming for higher income; Technical seminar on sustainability of dairy production.

The scientists, technical staff and administrative personnel attended various workshops, conferences, seminars, symposia and professional training for skill development. Further, various workshops and trainings were conducted at field level for the benefits of the farmers and other stakeholders.

Seven scholars were supported by the Institute for conducting research at various laboratories with external research grants from DST, DBT, CSIR, UGC and KSTePS. Further, 10 students registered under different universities, conducted their MVSc and PhD dissertation works at various laboratories of the Institute.

Publications, Patent and Technology Assessment and Commercialization

During the reported period, 56 research papers, 14 review/technical articles, six books and 19 book chapters were published by the scientists of the Institute. Further, six technical documents/folders were published and four software/android applications were developed during the reported period.

One new patent application on "Enteric methane reduction using biowaste of *Padina gymnospora* obtained after the supercritical fluid extraction" was

submitted to the Indian patent office.

The following three technologies were assessed and transferred to the AgrInnovate India Limited/ State Govt/ commercial firm: The anti-methanogenic product Harit Dhara; Protocol for producing hydroponic fodder; NIANP milk replacer for lambs . Further, the technology of "Protocol for Producing Hydroponic Fodder" and "Area Specific Mineral Mixture for Four Different Regions" were commercialized through Agrinnovate India Limited.

Linkage and Collaboration

The Institute established linkage and actively took part in the following collaborative programme: Research collaboration with the University of Gottingen and University of Kassel, Germany under the Indo-German (DBT-DFG) collaborative research programme; Research collaboration with the International Livestock Research Institute, CGIAR; Collaboration with the University of Melbourne, Australia for research and human resource development under the Australia India Council programme; Research collaboration with CIRAD, France; Functional-industry-linkage with M/s Radiant Chem Industries for developing anti-methanogenic products.

Others

The 26th meeting of the Research Advisory Committee of the institute was held on virtual mode for two days and several recommendations are made by the committee. The Annual Institute Research Committee (IRC) meeting was also conducted during the reported period. A total of 51 projects (30 Institute projects and 21 externally funded projects) were reviewed during the Annual IRC Meeting. The 42nd and 43rd Institute Management Committee (IMC) meetings were held during the reported period and different agenda items such as procurement of equipment, manpower and infrastructure development were discussed in the meeting and the proposals were recommended by the IMC.

The "Official Language Implementation Cell" worked with the objective of smooth implementation of Hindi as Official Language in the institute. Quarterly meetings were conducted by the cell to review the progress in implementation of Official Language in different divisions and sections. Three Hindi workshops were conducted for the staff to promote correspondence and usage of Official Language in the day-to-day work. The institute also observed Hindi Diwas and Hindi Week.

The DDG (Animal Science), ICAR, Dr BN Tripathi laid the foundation stone of the Farmers Training cum Student's Hostel and Community Hall at the Institute's campus on 23 January 2021.

The Institute regularly conducted activities under the "Swachh Bharat Abhiyan" with the resolution to work towards Swachhta. Various initiatives were taken to maintain the office and campus premises clean and environment friendly and the "Swachhta Pakhwada" was observed. The Institute implemented digitalization of office records through e-office, GeM, PFMS, FMS etc. The scientists were also actively involved in the programme "Mera Gaon Mera Gaurav" for extending technical expertise for the benefit of farmers.

CHAPTER 1

Introduction

Genesis

The ICAR-National Institute of Animal Nutrition and Physiology (ICAR-NIANP) has successfully completed 26 years since its inception. The Institute has imprinted its footprints during the past 26 precious years. It has certainly marked its glorious presence with its substantial progress on all counts during these years. Currently, ICAR-NIANP is considered as one of the most vibrant organizations under the "National Agricultural Research System" and it is an ISO 9001:2015 certified Institution.

The National Commission on Agriculture recommended the creation of the ICAR-NIANP during the year 1976 to work on the fundamental and the basic principles involved in optimum nutrient utilization. Subsequently, realizing the national need for improvement of feed resources and their utilization by unravelling basic physiological and nutritional principles to improve animal productivity, the proposal for establishment of the institute was approved by the Planning Commission in the VIII five-year plan. The ICAR constituted a committee of experts in October 1992 to suggest the location, structure, function and other related issues for establishment of the Institute. Consequently, the institute was established on 24 November 1995 as per the recommendations of the Stripe Review Committee. The Institute is primarily involved in conducting fundamental studies on basic nutritional and physiological aspects related to bio-physical translation of nutrients for productive functions in livestock.

Location

The institute is located in the heart of sprawling Bengaluru city on the National Highway 7, Bengaluru-Hosur Road. The institute is approximately 8 km away from the Bengaluru City Railway Station and 40 km from the Kempegowda International Airport.

Staff

The Institute is headed by the Director and currently 39 scientists including four women scientists are in position.

Staff Position as on 31 December, 2021		
Category	Sanctioned Posts	Staff in position
Director	1	1
Scientific	44	39
Technical	12	9
Administration and Accounts	17	13
Skilled supporting staff	3	2
Total	77	64

VISION

Productivity enhancement for profitable and sustainable livestock production.

MISSION

Improving production and reproductive efficiency in livestock through basic physiological and nutritional approaches.

MANDATE

Basic and strategic research on physiology and nutrition for efficient livestock production.

Capacity development in animal nutrition and physiology.

OBJECTIVES

To carry out quantitative and qualitative assessment of feed resources and to develop district-wise information system.

To enhance availability of nutrients through various approaches such as strategic supplementation, biotechnological interventions and feed-processing technologies.

To enhance reproductive efficiency of livestock through physiological and nutritional interventions.

To address issues of feed quality and safety.

To develop strategies for validation of evolved technologies at users' level for production enhancement.

Priority Setting and Management

The Institute has a high-powered Research Advisory Committee (RAC) comprising of eminent scientists and professors, who guide the research agenda of the institute and set research priorities. Dr K Pradhan, Chancellor, SOA University, Bhubaneswar is the chairman of the committee. The other members of the committee are scientists and professors from the field of animal nutrition, physiology and biotechnology.

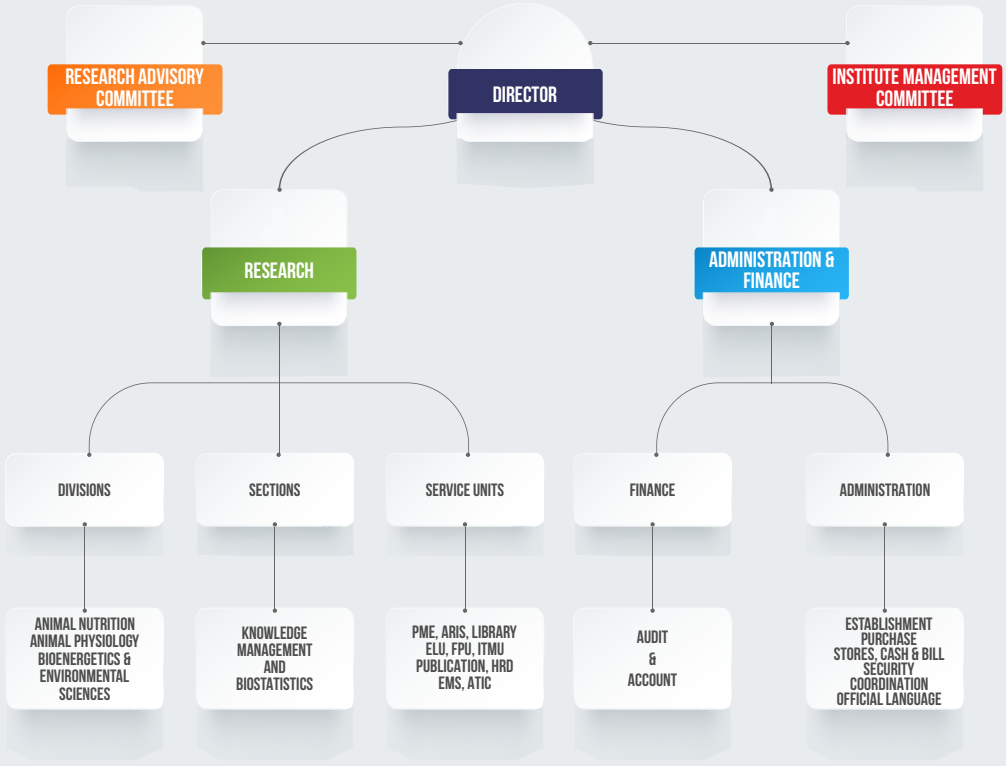
The functioning of the institute is supervised by the Institute Management Committee (IMC) headed by the Director of the institute as Chairman and members drawn from state government, university and public including industry personnel. A number of internal committees such as Central Purchase, Library, Official Language Implementation, Grievance, Publication, Priority Setting Monitoring and Evaluation (PME) Cell, Staff Welfare Club, IPR Cell and Institute Technology Management Unit have been constituted to decentralize the management with developed responsibilities for smooth functioning of the institute. The Institute Joint Staff Council promotes healthy and congenial work environment. The Institute Research Council (IRC) provides a platform for effective professional interactions in respect of review and implementation of various research projects, which are also supported by an external evaluation committee. The PME Cell of the Institute plays a major role in prioritising the internal and external projects based on the mandate and thrust areas. Moreover, it has forward and backward linkages with the QRT, RAC and IRC in project monitoring and evaluation.

The Institute provides priority to the identified thrust areas to strengthen the basic and fundamental research. The Institute is coordinating the AICRP on "Nutritional and Physiological Approaches for Enhancing Reproductive Performance in Animal" with 11 collaborating centres and an Outreach project on "Estimation of methane emission under different feeding systems and development of mitigation strategies" with five collaborating centres. The prestigious Farmer FIRST Project on "Improving Livelihood Security of Farmers through Technological Interventions for Sustainable Livestock Farming" is implemented at two different locations in Bengaluru. The Institute is also a partner in the Outreach project on "Drug Residues and Environmental Pollutants", ICAR-CRP project on "Evaluating Value Added Cereal By Products for Animal Feeding", ICAR-Network project on "Veterinary Type Culture Collection" and Farmer FIRST Project on "Enriching Knowledge and Integrating Technology and Institutions for Holistic Village Development in Horticultural Based Farming Systems". In addition, the Institute is also involved in the international research collaborations with Germany, Hungary and International Livestock Research Institute (ILRI). Besides, the scientists were involved with several externally funded research projects. The institute is effectively implementing the programme "Mera Gaon Mera Gaurav" and "Swachh Bharat Abhiyan", and several trainings and workshops are regularly being organized for the stakeholders.

Research Programme

- Biogeography of gut microbes in animals.
- Novel approaches for assessing and improving nutrient bioavailability, animal reproduction and productivity.
- Feed informatics, feed quality and safety and value addition.
- Climate change impact on livestock.
- Technology translation to connect discovery with application.

Organizational Setup



The matrix mode of management is adopted in the research activities, which provide devolved responsibilities for effective implementation of multidisciplinary/ interdisciplinary programmes. For administrative purposes, the Institute has identified three research divisions and one section with strong support of central facilities and computerized administrative set up. Director is the Head of the Institute, supported by administrative and financial wings. To strengthen the local decision-making and research monitoring, Research Advisory Committee, Institute Management Committee, Institute Research Council and PME Cell play a vital role through periodical meetings.

Expenditure Statement

Statement showing the sub head wise allocation and expenditure (April to December 2021) of fund for the financial year 2021-2022.

Sub heads	RE (FY 2021-22) (₹ in lakh)	Expenditure (Apr-Dec 2021) (₹ in lakh)
A. Institute		
1. Works	5.98	0.00
2. Equipment and other capital expenditure	39.52	0.00
3. Establishment charges	1528.64	1266.89
4. Pension and other retirement benefits	25.87	19.20
5. Travelling allowances	1.00	0.74
6. HRD	0.20	0.04
7. Research and operational expenses	211.58	105.53
8. Administrative expenses	339.37	225.78
9. Miscellaneous expenses	4.10	3.70
10. Loans and advances	0.00	0.00
Total A	2156.26	1621.88
B. AICRP and Outreach projects	172.00	142.46
Grand total (A+B)	2328.26	1764.34

Statement showing the sub head wise allocation and expenditure of fund for the financial year 2020-2021.

Sub heads	RE (FY 2020-21) (₹ in lakh)	Expenditure (FY 2020-21) (₹ in lakh)
A. Institute		
1. Works	35.51	35.51
2. Equipment and other capital expenditure	21.49	21.16
3. Establishment charges	1397.12	1397.11
4. Pension and other retirement benefits	16.64	16.47
5. Travelling allowances	0.27	0.27
6. HRD	0.60	0.60
7. Research and operational expenses	226.29	226.29
8. Administrative expenses	299.57	299.55
9. Miscellaneous expenses	6.87	6.87
10. Loans and advances	0.00	0.00
Total A	2004.36	2003.83
B. AICRP and Outreach projects	180.00	179.91
Grand total (A+B)	2184.36	2183.74

Revenue Generation

Statement showing the sub head wise revenue generation (January to December 2021).

Sub heads	Amount (₹ in lakh)
A. Sale of farm products, livestock etc.	7.53
B. Other receipts	
1. Sale of publications, CDs/royalty etc.	0.11
2. Analytical testing fees	4.09
3. Other receipts including LF/ Interest/ IRGS/ LS&PC	35.24
Grand total (A+B)	46.97

CHAPTER 2

Research Projects

Biogeography of Gut Microbes in Animals

BGM 2.4: Isolation and characterization of lipolytic/lipid biohydrogenation bacteria from the rumen of sheep supplemented with different fat sources

NM Soren, M Chandrasekharaiah, SBN Rao, M Bagath

Biohydrogenation study of linoleic acid and arachidonic acid with pure culture *(Clostridium lundense and Clostridium tetanomorphum)* and mixed culture (rumen liquor) resulted in the formation of either cis-Vaccenic or trans-Vaccenic acid as intermediate products of biohydrogenation.

Rumen bacteria play an important role in lipid digestion and metabolism in the rumen. Dietary lipids entering the rumen are hydrolysed into their constituent fatty acids by the lipase secreted by lipolytic bacteria. The hydrolysed products are further fermented and the fatty acids that are liberated are either sequestered by microbial cells or undergo biohydrogenation to convert toxic unsaturated fatty acids into their nontoxic saturated forms. Both lipolysis and biohydrogenation occur simultaneously in the rumen ecosystem mediated exclusively by the resident bacterial species.

Biohydrogenation study of two unsaturated fatty acids linoleic (C18:2) acid and arachidonic acid (C20:4) was carried out with two pure bacterial isolates from flaxseed oil supplemented sheep viz. *Clostridium lundense* (CL) and *Clostridium tetanomorphum* (CT). Rumen fluid collected from sheep served as a source of mixed bacterial culture (MBC). The two unsaturated fatty acids linoleic acid and arachidonic acid were incubated with the pure (CL and CT) as well as with mixed bacterial cultures in Hungate's roll tubes anaerobically containing special growth media. All the tubes were incubated in a shaking water bath at 39°C in triplicates. For each fatty acid and bacterial isolate, the incubation was repeated three times. The biohydrogenation pattern of the fatty acids was studied by incubating the culture tubes for 0, 1, 2, 4, 6, 8, and 10h along with respective blank and control tubes in a shaking water bath at 39°C. Immediately after the incubation, the tubes were placed in ice to stop the fermentation process and pH was recorded immediately for the test, control, and blank for respective hours of incubation. From each incubation hour, sampling was done for the determination of intermediate metabolites (cis-vaccenic acid and trans-vaccenic acid) as well as volatile fatty acids (acetate, propionate, isobutyrate, butyrate, isovalerate, and valerate). Gas chromatographic conditions were standardized for separating both cis-vaccenic acid and trans-vaccenic acid in a single run. The two intermediate metabolites (cis-vaccenic acid and trans-vaccenic acid) of biohydrogenation of linoleic acid and arachidonic acid as well as volatile fatty acids fractions were detected in the incubation media and quantified by GC (Fig. 1).

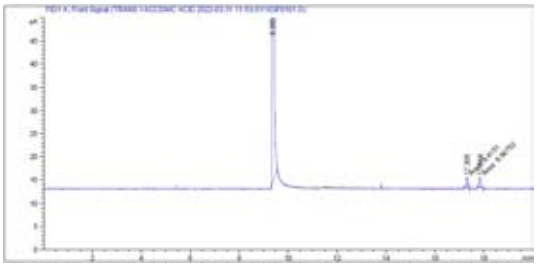


Fig. 1: Chromatogram showing the peaks of trans-Vaccenic acid (RT 17.305 min) and cis- Vaccenic acid (RT 17.844 min).

BGM 2.5: In ovo manipulation of gut microbes in broiler chicken

AV Elangovan, AP Kolte, A Dhali, KVH Sastry, VB Awachat

In ovo supplementation of prebiotics helps in the early establishment of beneficial microbiome population, which could be useful in preventing the pathogens attack during early life of broiler chicken.

For enhancing the early establishment of beneficial GIT microbes, different prebiotics viz., xylooligosaccharide (XOS), fructooligosaccharide (FOS) and inulin were injected (2mg/egg) on day 12 (air sac) and day 18 (amnion) of egg incubation. The hatchability was recorded and the gut samples were collected at hatch and 3 weeks of age to study gut microbial composition (Fig. 2). The results indicated the in ovo supplementation of prebiotics on day 12 and day 18 of incubation did not affect the hatchability of the eggs except in the inulin group. The alpha diversity at day 1 of sampling revealed significant effect of the XOS and inulin irrespective of the day of injection (12 vs 18) however, the effect of the FOS injection on day 12 was less as compared to the day 18. The in ovo prebiotic supplementation increased the beneficial microbes like Bacteroides, Turicibacter and Clostridium_sensu_stricto_1 group and reduced the abundance of Prevotella9 group that is regarded as opportunistic pathogen. The day 21 sampling did not reveal any specific effect of the prebiotic injection either at Day12 or Day 18 of incubation, indicating the transient nature of the effect and the dose used did not affect the long term change in the microbiota composition. However, the early beneficial effect could be useful in preventing the establishment of the pathogens.

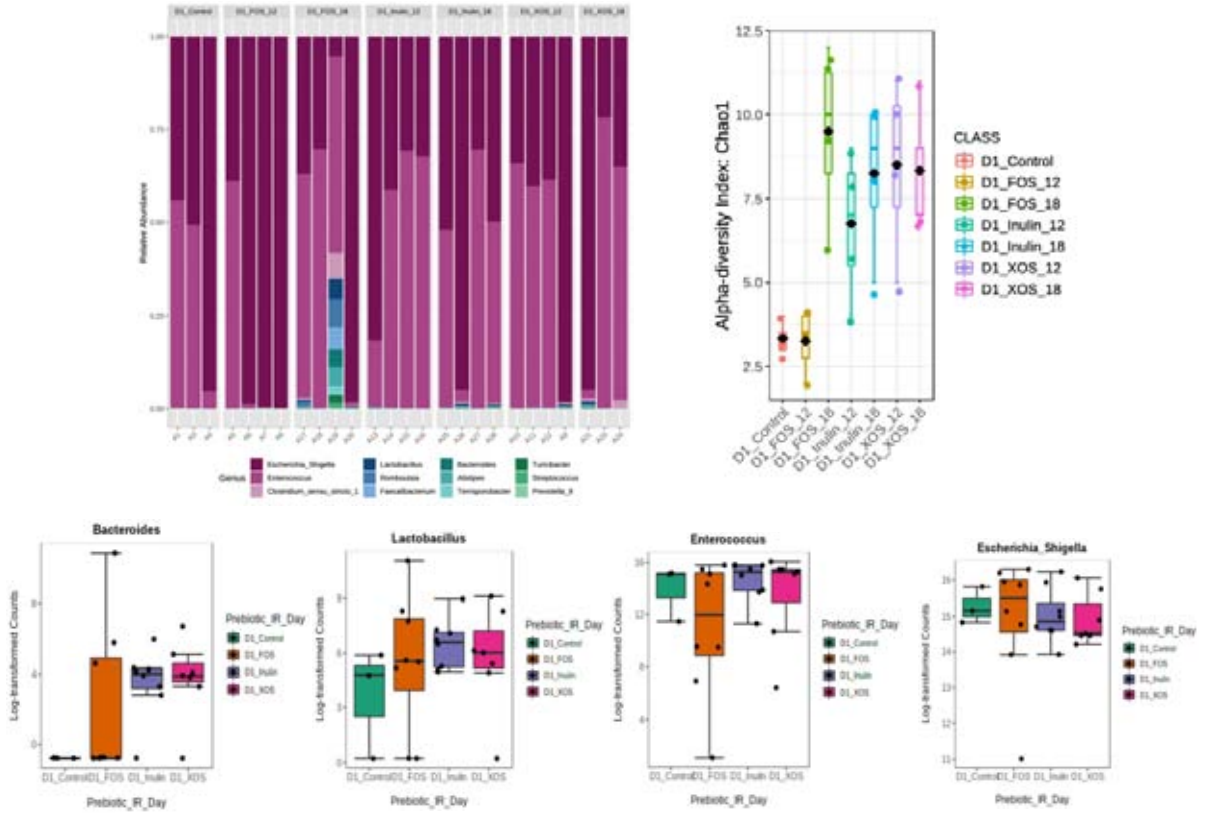


Fig. 2: Effect of in ovo supplementation of prebiotics on gut microbial composition.

BGM 2.6: Production and evaluation of nutraceutical potential of post and parabiotics in lab animals

M Gopi, AP Kolte, RU Suganthi, N Ramachandran

Incorporation of prebiotic (tagatose) to growth media (0.5 and 1.0%) reduced the pH from 5.95 to 4.48 and 4.45 irrespective of the organisms and no difference in pH values was observed among the levels of incorporation.

Increased growth rate, improved feed efficiency and prevention of sub clinical diseases are the main reasons, why dietary antibiotic growth promoters (AGP) have been practiced in food animals during the last 60 years. However, their constant use, at low dosage, leads to development of antimicrobial resistance in bacteria and also leaves antibiotic residues in animal products. In the face of remarkable progress, concerns have been raised with regard to the safety and quality of food products due to the panic of transferring these antibiotic resistant bacteria to humans via food chain. There has been a global effort to limit the sub-therapeutic use of feed antibiotics such as in the European Union and in the United States. Debates in India in the context of use of antibiotics in food animal production has sought for withdrawal of antibiotics from feeds and the need for alternatives that would influence improvement of healthy production for safety of humans.

Probiotics are beneficial bacteria that are able to colonize the host digestive system, increasing the natural flora and preventing colonization of pathogenic organisms and thus, securing optimal utility of the feed. A recent study indicated that probiotics acquire resistance to antimicrobials and these acquired resistance traits can be transferred easily over species by conjugative plasmids and transposons. Hence, there is a need to identify a novel agent which could render similar benefits as probiotics. One such agent is postbiotic, which are the intermediate or final metabolites produced by probiotic organisms. Therefore, the study was designed with the following objectives: 1) To screen postbiotics and/or parabiotics for its *in vitro* antibacterial activity of probiotics grown in the presence of different prebiotics; 2) To evaluate the nutraceutical property and safety of postbiotics and/or parabiotics in laboratory animal models.

Two probiotic organisms *Lactobacillus casei* and *Lactobacillus rhamnosus* were used in the study (Fig. 3). The inoculated and un-inoculated broths were incubated at 37°C for 24h and the postbiotic metabolites and parabiotics were collected by centrifugation (10,000*g*). The bacterial cell sediments were inactivated by autoclaving (parabiotics) and both post and parabiotics were stored at 4°C. The postbiotic metabolites were collected after 24 and 48h incubation. There was a linear decrease in pH of the media with respect to period of incubation (24 *vs*. 48h) over the control. The values were 5.95 *vs*. 4.47 and 4.52 at 24h, and 5.95 *vs*. 4.37 and 4.42 for *L. casei* and *L. rhamnosus* respectively. The incorporation of prebiotic (tagatose) to growth media at the rate of 0.5 and 1.0% reduced the pH from 5.95 to 4.48 and 4.45, irrespective of the organisms and also there were no difference in pH values between the levels of incorporation (Fig. 4).

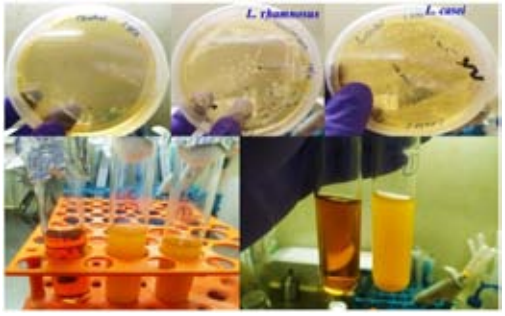


Fig. 3: Lactobacillus cultures at different stages of growth.

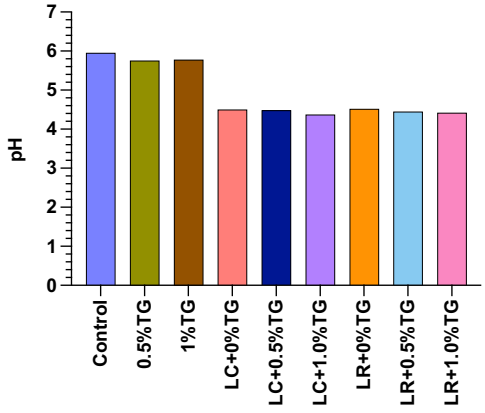


Fig. 4: pH change in postbiotic metabolites of probiotics grown in tagatose (TG) incorporated media. *Lactobacillus casei* (LC); *Lactobacillus rhamnosus* (LR).

ICAR-Network: Veterinary type culture collection – rumen microbes

D Rajendran, M Gopi

A total of 381 bacterial cultures were revived and 82 bacteria were accessioned.

National centre for veterinary type culture (NCVTC) - Rumen Microbes, is an initiative of ICAR. Under this project ICAR-IVRI, ICAR-NDRI, ICAR-NRCC, ICAR-CIRG and ICAR-CSWRI are acting as networking centre and ICAR-NIANP is playing a role as Co-ordinating centre. Major objectives of this project are to isolate and purify anaerobic gut microbes, study the morphological, biochemical, enzymatic characteristics, and molecular identification of gut microbes. Culture submitted by the various centres were accessioned after characterization and preserved at repository and revived the cultures periodically to check their viability.

During the reporting period, rumen liquor from sheep, cattle, camel, and faeces sample from tiger were collected anaerobically. The collected rumen liquor filtered through 4-layer cheese cloth. Faeces and filtered rumen samples were then serially diluted up to 10^{-7} in anaerobic dilution solution (ADS). About 0.1 ml of serially diluted rumen liquor and faeces samples were taken, inoculated by streak plate method in MRS, CMC and anaerobic basal medium. Morphological, biochemical and enzymatic studies were conducted for the isolated pure cultures. The cultures were characterized based on 16S rRNA gene sequencing, and the isolated organisms were identified as *Enterococcus gallinarum* LMG 13129, *Enterococcus faecium* DSM 20477, *Enterococcus casseliflavus* NBRC 100478, *Enterococcus hirae* NBRC 3181, *Enterococcus faecium* NBRC 100486, *Escherichia fergusonii* ATCC 35469, *Shigella boydii* P288, *Shigella flexneri* ATCC 29903, *Streptococcus lutetiensis* CIP 106849, *Streptococcus equines* NBRC 12553, *Streptococcus lutetiensis* HDP90246, *Enterococcus faecium* ATCC 19434, *Enterococcus hirae* DSM 20160, *Enterococcus faecalis* ATCC 19433, *Clostridium perfringens* ATCC 13124, *Enterococcus durans* NBRC100479, *Clostridium sporogenes* JCM 1416, *Enterococcus gallinarum* NBRC 100675, *Enterococcus casseliflavus* NCIMB 11449, *Enterococcus avium* ATCC 14025 and *Clostridium sporogens* JCM 1416, and were accessioned at ICAR-NIANP. In this reporting year 82 cultures were accessioned at NIANP including the cultures submitted by other Institutes. A total of 381 organisms were revived and glycerol stock were made and stored at -80°C. Revived organisms were also freeze dried (Fig. 5).

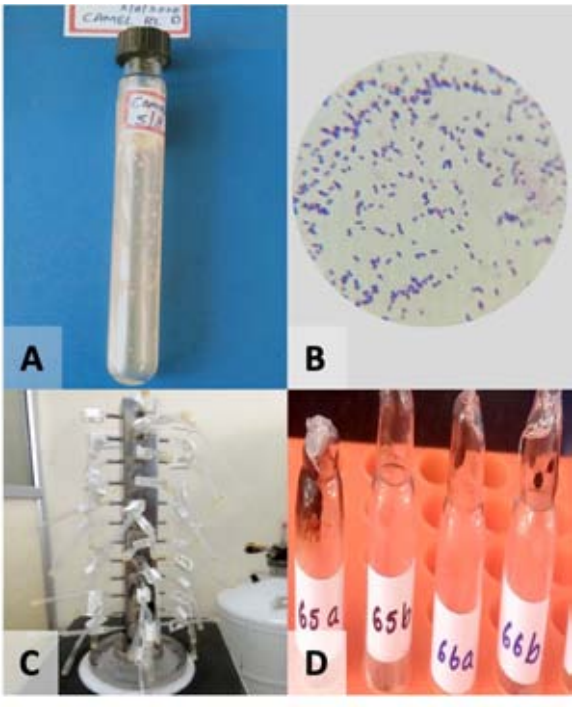


Fig. 5: A: Isolated colonies by Roll tube technique; B: *Enterococcus faecium*; C: Freeze drying of rumen anaerobic bacteria; D: Sealed glass ampoules contains freeze dried cultures.

Novel Approaches for Assessing and Improving Nutrient Bioavailability, Animal Reproduction and Productivity

APR 3.14: Comparative assessment of the resilience capacity of different indigenous goat breeds to summer heat stress based on selective thermo-tolerant gene expression pattern

V Sejian, G Krishnan, M Bagath, RK Veeranna, R Bhatta

Based on the differences in productive performance and changes associated with phenotypic and genotypic traits as well as based on the results from rumen metagenomics, whole transcriptomics, and epigenetic changes studied in Osmanabadi, Malabari, Salem Black, Kanni Aadu and Kodi Aadu goat breeds, Kodi Aadu breed was observed to be the best climate resilient breed in Southern India.

The objectives of the study were: a) To evaluate the resilience capacity of different indigenous goat breeds to heat stress; b) To compare differences in economically important thermo-tolerant gene expression in different indigenous goat breeds exposed to heat stress; c) Association analysis of gene expression data with different phenotype traits related to heat stress during summer season.

Based on the results, it was concluded that among the five breeds studied, Kodi Aadu was the stand apart breed for climate resilience in Southern India. Apart from adapting to adverse environment, Kodi Aadu goats also maintained their productive performance such as growth, meat production and quality. This was evident from the non-significant effect of heat stress on the growth, carcass traits and meat quality variables. Further, the results on metagenomics, transcriptomics and epigenetic changes clearly reflected the better potential of this breed to cope with heat stress. Apart from Kodi Aadu, Kanni Aadu and Salem Black goats also showed great promise.

The following traits (Adaptation traits: heat shock protein 70 (HSP70), HSP90, HSP27, HSP110 and heat shock factor 1; Growth Traits: growth hormone receptor, insulin like growth factor-1, thyroid hormone receptor, leptin receptor; Reproduction traits: prolactin receptor (PLR), follicle stimulating hormone receptor (FSHR), leutinizing hormone receptor (LHR), oestradiol receptor (ESTR); Immune related traits: toll-like receptor 3 (TLR3), TLR6, TLR8, interleukin 10 (IL10), IL18, tumour necrosis factor-α, interferon-β, and IFN-γ), were identified as potential biomarkers for heat stress in Indigenous goats.

Thus, propagating Kodi Aadu, Kanni Aadu and Salem Black breeds among the poor and marginal farmers can help to sustain their livelihood.

APR 3.15: Modulation of sexual differentiation in embryos altering oxidative status of in vitro culture system

A Mishra, A Dhali, IJ Reddy, PSP Gupta

Oxidative status-mediated alteration in pH of the medium to modulate the intracellular positive ions is the main critical factor to influence the sex of embryos through sex-specific sperms fertilization to the oocytes as per their polarity.

Our approach to produce sex-specific embryos in vitro has resulted in more female embryos production at low oxidative status and males at high oxidative status. Different levels of oxidative status during IVEP might be modulating the oocyte polarity for subsequent charged sex-specific sperm fertilization to produce selected sex embryos. The polarity or membrane potential of oocytes is maintained due to disparities in ion concentrations across the membrane (intra and extracellular component). The level of oxidative status of culture condition might be influencing the intracellular ions concentration of oocytes to change their polarity. Hence, the primary objective of the study is to observe the intracellular ions concentration of oocytes matured at different levels of oxidative status to observe their polarity.

Different levels of oxidative status during IVEP were created by supplementing free radical scavenger in maturation media. The intracellular ions concentrations of the matured oocytes were estimated using ICP-OES analytical technique. Oocyte's membrane polarity was calculated by the Goldman-Hodgkin-Katz equation and expressed in millivolts. Intracellular positive ions were significantly ($P<0.05$) high in the oocytes matured with free radical scavenger than without. Depolarization of the plasma membrane causes a shift towards positive potential and hyperpolarization negative. Oocytes matured at high oxidative status produced more ROS, making the maturation medium alkaline and kept the oocytes in the repolarized state (negative potential) due to low intracellular positive ions, thereby favouring fertilization of positively charged Y sperm resulting in significantly ($P<0.05$) more male embryos. In the same fashion, low oxidative status significantly reduced ROS production and elicited acidification of medium and kept the oocytes in the depolarized state (positive potential) by a significant increase in intracellular positive ions, thereby favouring fertilization of negatively charged X sperm resulting in significantly ($P<0.05$) more female embryos. The study concluded that the oxidative status-mediated alteration in pH of the medium to modulate the intracellular positive ions is the main critical factor to influence the sex of embryos through sex-specific sperms fertilization to the oocytes as per their polarity.

APR 3.16: G-protein coupled receptors and gut hormones in gut chemosensing and regulation of fat digestion and absorption in sheep

G Krishnan, V Sejian, M Bagath, MN Soren, C Devaraj, RK Veeranna

Supplementation of additional calcium salts of long chain fatty acids upregulated the expression of CD36 in various segments of GIT and chemosensing of long chain fatty acids by this gene triggered the signalling transduction that enhances chylomicron formation. This was further evidenced from the significant upregulation of MTTP and APOB in the various segments of GIT and supported the high content of dietary fat at cellular fat metabolism in the gut that regulates the fatty acid uptake.

Current evidence confirm that fatty acid translocase (CD36/FAT) regulates chemosensing of lipids in different tissues and organs including gustatory papillae and hypothalamus in mammals. CD36 is present in the proximal small intestine and expressed in enterocytes, which regulates LCFA and cholesterol uptake by participating in the processes of chylomicron formation. The micelle or chylomicron formation is the foremost important in the process of effective fatty acid absorption. The lipids in the intestinal lumen induce CD36-dependent upregulation of key proteins of chylomicron formation, microsomal triglyceride transfer protein (MTTP) and apolipoprotein B (APOB). The freshly produced triglycerides are translocated into the lumen of the endoplasmic reticulum with phospholipids and APOB by interacting with MTTP to form a primordial lipoprotein in the lumen that promotes effective fatty acid absorption. Hence, the present study aimed to understand the chemosensing of fat digestion and absorption by the expression patterns of CD36, chylomicron forming genes in the different segments of GIT in sheep supplemented with calcium salts of long chain fatty acids (CSFAs).

The study was carried out for a period 60 days with eighteen adult ewes (8-12 months) and they were divided into three groups ($N=6$ in each group), group-I, group-II and group-III. All the experimental animals were stall fed with a basal diet; group-II and group-III were supplemented additionally with 3% and 5% CSFAs, respectively on dry matter intake. The results from the study indicated that the supplementation of CSFAs upregulated ($P<0.05$) the relative mRNA expression of CD36 (Fig 6) in the various segments of GIT of sheep in correspondence to level of dietary CSFAs. Abundance of mRNA expression of MTTP and APOB increased ($P<0.05$) in the GIT of sheep in accordance with quantity of LCFAs in the diet, where these genes facilitate fatty acid uptake (Fig 7).

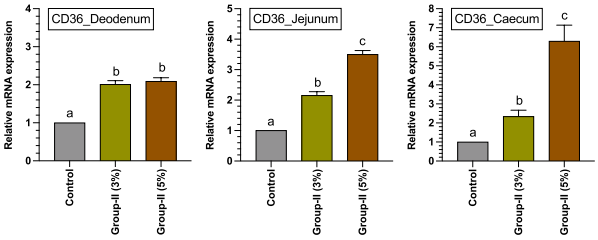


Fig. 6: The relative expression of mRNA of CD36 in duodenum, jejunum and caecum of sheep supplemented with calcium salts of long chain fatty acids. The values are normalized with a housekeeping gene, GAPDH. CSLCFAs supplementation groups (II and III) were expressed relative to gene expression of control (group-I). The bars bearing with different superscripts a, b and c differ significantly (P<0.05). The values are mean ± standard error.

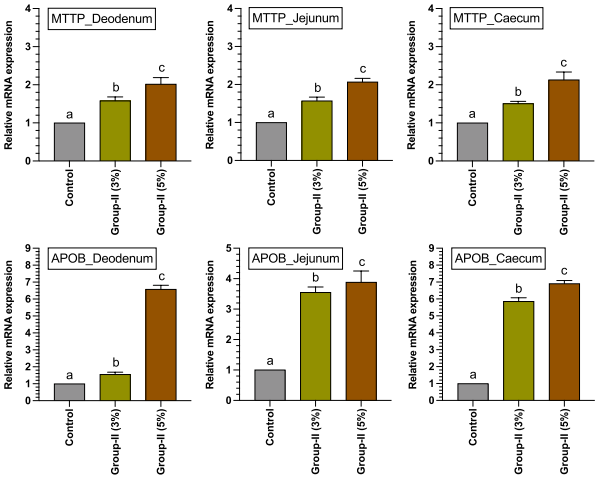


Fig. 7: The relative expression of mRNA of MTTP (panel-I) and APOB (panel-II) in duodenum, jejunum and caecum of sheep supplemented with calcium salts of long chain fatty acids. The values are normalized with a housekeeping gene, GAPDH. CSLCFAs supplementation groups (II and III) were expressed relative to gene expression of control (group-I). The bars bearing with different superscripts a, b and c differ significantly (P<0.05). The values are mean ± standard error.

APR 3.18: Role of uric acid in alleviating oxidative stress induced mitochondrial dysfunction during different production cycles in poultry: Regulation by organosulphur compounds

CG David, RK Gorti, IJ Reddy, AB Vaibhav

The beneficial effects of supplementation of 0.5% allicin and 1% garlic on egg production was due to increased level and antioxidant activity of uric acid that minimized the age related increase in lipid peroxidation of mitochondrial membrane thereby restored membrane integrity and membrane potential of mitochondria in duodenum and shell gland.

Production cycles impart oxidative stress in livestock including poultry. The energy demands for egg and meat production is met through efficient utilization of nutrients and production of ATP in the mitochondria. In the process mitochondria also contributes to ROS production, a delicate balance has to be maintained via anti-oxidant defence to maintain the structural and functional homeostasis of the mitochondria for sustained production. The changes in the mitochondrial efficiency will have large impact on energy and feed efficiencies. In our earlier studies we found supplementing garlic to layer hens enhanced egg production and sustained persistency beyond one laying cycle. There was a concomitant increase in

the level of uric acid- a potent antioxidant in poultry. The mechanism behind was not fully understood with respect to the role of garlic in combating oxidative stress induced mitochondrial dysfunction.

In meat type chicken, feeding of high energy diet and rapid growth rate to achieving target body weight within stipulated period of time subjects the meat type chicken to production stress. The impact of production stress on mitochondrial structural and functional homeostasis has not been clearly delineated. This project envisages: a) how cumulative effect of oxidative stress contribute to age related changes in the mitochondrial function impeding production performance and b) the effect of supplementing garlic and /or allicin in restoring mitochondrial integrity in egg and meat type chicken.

Trials conducted in layer hens, wherein birds were fed on basal diet, basal diet + 0.5% allicin and basal diet +1% garlic from 16 weeks of age. Results showed age related significant ($P<0.05$) decrease in the membrane potential (Table 1) with a concomitant increase in lipid peroxidation in the mitochondria isolated from duodenum and shell gland of 35 and 45 week old layer hens. The age-related changes in membrane potential were in the order control<allicin <garlic and that of LPO in the order control>allicin>garlic. Uric acid levels in the serum, duodenum and shell gland significantly increased with age in all groups. However, the levels were significantly lower in treated groups. Hen day egg production (HDEP) did not vary significantly during 21-40 weeks of age among the groups, but HDEP was significantly higher during 41-50 weeks of age in the treated groups compared to control.

Table 1: Age related changes in the membrane potential of mitochondria isolated from duodenum and shell gland of commercial white leghorn strain chicken. Means having different superscript within each row and column differ significantly ($P<0.05$).

Group	Duodenum MMP (-mV)		Shell gland MMP (-mV)	
	Wk 35	Wk 45	Wk 35	Wk 45
Control	155^{aA}±2.41	150^{aB}±2.62	148^{aA}±2.62	141^{aB}±1.74
Allicin	158^{bA}±2.11	153^{bB}±1.52	150^{bB}±2.27	146^{bB}±2.14
Garlic	158^{bA}±1.77	156^{cB}±1.69	152^{bA}±1.82	151^{cA}±1.85

A trial was conducted in meat type chicken to study the effect of feeding garlic and /or allicin on circulating levels of uric acid and its impact on feed intake, body weight gain and FCR. Further, the effect of treatment on mitochondrial integrity was also studied. Supplementation of 1% garlic and 0.5% allicin significantly improved feed intake, body weight gain and FCR between 0-35 and 0-45 days (Table 2).

Table 2: Effect of supplementation of allicin and garlic on feed intake, body weight and FCR of broiler chicken.

Group	Feed intake (g/bird)		Body weight (g/bird)		FCR (g:g)	
	0-35d	0-42d	0-35d	0-42d	0-35d	0-42d
Control	3100	4432	1987	2652	1.56	1.67
Allicin	3045	4400	2020	2750	1.52	1.60
Garlic	3060	4405	2035	2752	1.51	1.60
SE	62	132	34	57	0.004	0.006

Serum uric acid and that of duodenum increased significantly with age. The results will be correlated with changes in the surface area of mitochondrial membrane, lipid peroxidation and antioxidative enzyme status. A second and third trial were conducted in broiler hens to study the link between reduced uric acid in tissues and indices of mitochondrial function and effect of altered mitochondrial function on feed efficiency. Biochemical analysis and compilation of data are in progress. The supplementation of 1% garlic and 0.5% allicin resulted a comparative increase in hen day egg production by minimizing oxidative stress to membrane lipids (low lipid peroxidation) and maintaining mitochondrial membrane integrity of duodenum and shell gland (increased membrane potential) brought about by improved antioxidant defence (increased serum and tissue uric acid). Further, the supplementation significantly improved feed intake, body weight gain and FCR between 0-35 and 0-45 days in broiler chicken.

APR3.19: Studies on metal carnitine chelates for improving bioavailability and tissue utilization of trace minerals and production performance in animals

DT Pal, NKS Gowda, D Rajendran

Bioavailability of trace minerals (Cu, Zn, Mn and Cr) from metal-carnitine chelated products were found more than inorganic salts of these metals and ranged from 125 to 146% while inorganic salts as standards considered 100% bioavailable. Further, the level of carnitine increased by 73.5% which could be useful in the body for energy utilization in animals.

The study was aimed at to develop carnitine chelated trace minerals for improving the bioavailability of critical trace elements and to simultaneously deliver physiological biomolecule for efficient energy utilization to supplementing to high yielding dairy animals during transition period. In the proposed project, the hypothesis of enhancing the trace minerals as well as carnitine level in animal body could help in production performance by enhancing the tissue level utilization of critical trace minerals and energy in lactating animals. The process for preparing Metal-Carnitine chelates has been developed in the laboratory. Metal-Carnitine chelates such as Cu-Carnitine, Zn-Carnitine, Mn-Carnitine and Cr-Carnitine products were prepared in large scale for feeding of sheep. A feeding trial has been conducted in sheep to determine the bioavailability and tissue utilization of above trace minerals.

The bioavailability study in sheep revealed that the body weight, feed intake and macro nutrient utilization of sheep were not affected by supplementing metal-carnitine chelates. Further, the physiological biomolecule, carnitine level increased on supplementing metal-carnitine chelates (Table 3). It was found that there was 73.5% increase in carnitine level on supplementing the chelated products as compared to inorganic minerals supplementation. Further the supplementation has increased the plasma levels of the supplemented minerals (Table 3) and bioavailability (Table 3) in the carnitine chelated groups.

Table 3: Effect of supplementation of metal-carnitine chelates on bioavailability and plasma levels of carnitine and trace minerals in sheep. Group-I: inorganic minerals; Group-II: metal-carnitine chelates. * indicates treatment, period and groupperiod interactions are significant (P<0.01); a, b indicates significant (P<0.01) difference between columns; A, B indicates significant (P<0.01) difference among rows.

Particulars	Group-I	Group-II
Plasma carnitine level (mg/L)		
0 day	0.69±0.05^{aA}	0.68±0.04^{aA}
7 day**	0.76±0.05^{bB}	1.06±0.05^{aB}
30 day**	0.88±0.04^{bC}	1.18±0.04^{aC}
Bioavailability (%) of metal-carnitine chelates based on plasma carnitine level regressed to inorganic minerals supplementation		
0-7 day	100	139
0-30 day	100	134
Plasma trace mineral level (mg/L)		
Cu	1.04±0.19	1.30±0.36
Zn	1.17±0.35	1.70±0.69
Mn	0.12±0.02	0.15±0.05
Cr	0.03±0.00	0.04±0.02
Bioavailability (%) of trace minerals from metal carnitine chelates based on plasma minerals regressed to inorganic minerals supplementation		
Cu	100	125
Zn	100	145
Mn	100	125
Cr	100	148

APR3.20: Evaluation of grain sprouts as fodder for livestock

NKS Gowda, S Anandan , K Giridhar, NM Soren

Replacement of compounded feed mixture or conventional green fodder at higher level with maize grain sprouts adversely affected the growth performance in lambs and was not economical in terms of feeding cost and growth performance. However, maize grain sprouts with straw bedding technique as a strategic additional feed supplement for dairy animals under field condition can improve milk yield and milk quality.

Nutritional evaluation of hydroponic maize grain sprouts (MGS) for its potential as ruminant feedstuff was carried out by chemical, in vitro and in vivo methods. The MGS was produced in a green shade net polyhouse and harvested on 10th day. The maximum yield of MGS (16.5% DM) was 4.5kg per kg of maize grain. Beyond 10d, there was a reduction in the biomass yield (4.56 vs 3.75kg/kg grain). There was increase in nutrient composition with respect to CP (13.0 vs 8.50%), EE (4.40 vs 2.41%), NDF (32.9 vs 13.3%), ADF (15.5 vs 3.42%), TA (2.89 vs 1.42%) and decrease in ME (9.78 vs 11.5MJ/Kg DM) and DM loss (14-17%) on sprouting as compared to the maize grain. Whereas, conventional

maize fodder (CMF) contained lesser CP (7.81%), EE (1.93%), ME (9.18MJ/kg DM) and higher NDF (52.8%), ADF (25.7%), TA (5.49%) as compared to MGS. The data on mineral profile showed higher content of many elements in MGS as compared to maize grain, whereas the amino acids composition did not show any variation. Among the vitamins, vitamin E, K and C content was more in MGS as compared to both maize grain and CMF. The feeding cum growth trial was conducted for a period of 120 days. Twenty four healthy male lambs of comparable age (Mandya crossbreed, 3-4 months old) and body weight (12±0.2 kg) were randomly allotted in a complete randomized design (CRD) to four dietary groups of six each. The control (T1) group lambs were fed with diet comprising conventional maize fodder (CMF), finger millet straw (FMS) and compounded feed mixture (CFM) at 50:10:40 ratio, respectively on DM basis. In treatment group two (T2), proportion of CMF and CFM was reduced by 50% and substituted with 45% MGS on dry matter basis. In treatment group three (T3), CMF was completely replaced with MGS (80%) and CFM was reduced to 25% of control. For treatment group four (T4), no CFM was offered and instead, maize grain was fed which was proportionately equivalent to produce 80 parts of MGS (1kg grain equivalent to 5kg HMF) and urea (1.20%) to match with CP of control diet. The DMI (g/d) for T1, T2, T3 and T4 was 763, 582, 399 and 521, respectively and intake of MGS (g/d) for T3 and T4 was 241 and 276, respectively. The ADG (g) for T1, T2, T3 and T4 was 77.3, 48.5, 20.9 and 30.2, respectively. There was significant ($P<0.05$) decrease in DMI and ADG in lambs fed MGS as a source of green fodder. However, the digestibility of nutrients, blood biochemical profile, immunity and serum mineral profile were not affected adversely among the treatment groups. Feed efficiency (g DMI/Kg live weight gain) for T1, T2, T3 and T4 was 7.88, 10.6, 16.3 and 13.5, respectively. The cost of feeding was significantly higher for the groups fed MGS as compared to T1 and T4 groups which received CMF. Significantly lower concentration of TVFA was found in T3 group fed 80% MGS as compared to control at 0, 4 and 8h post feeding. It is concluded that nutritive value of maize grain sprouts on DM basis in terms of protein and fibre is almost similar to wheat bran. Feeding diets with maize grain sprouts at 50 and 100% of maize green fodder replacement resulted in lower DM intake and reduced growth. It is concluded that MGS can be considered as green feed supplement and cannot replace conventional green fodder. Instead, it can be a green feed supplement along with dry fodder. Feeding study in dairy cows in field condition fed 4-5kg of grain sprout as green supplement in addition to the existing feeding schedule showed increase in milk yield of 0.8 to 1lit per animal. Maize grain sprout production with ragi straw bedding at a ratio of 7:1 (w/w) following hydroponic technique was done and evaluated. The average DM (%) in maize grain sprout with ragi straw bedding (MGSRSB) was 18% and the fresh biomass yield was 4.2 kg. Nutritive value of MGSRSB was CP: 9.37%, NDF: 50.7%, ADF: 22.1, TDN: 58.6% and in vitro organic matter digestibility (IVOMD): 59.8%. Feeding of MGSRSB to crossbred dairy cows (N=16) during early to mid lactation in addition to the existing feeding practice for 150 days showed average increase of 1.40lit milk/ cow/ day with marginal increase in milk fat and SNF as compared to control cows(N=16). Cost-benefit ratio of feeding MGSRSB was 1:2.

APR3.21: Influence of administration of prostaglandin modulators on embryo survivality in sheep

S Mondal, IJ Reddy, S Nandi, PSP Gupta, NM Soren, A Mishra

In endometrium, a significant decrease in the expression of PTGFS and Galactin mRNAs was observed in both 1IU and 5IU doses of oxytocin as compared to control group, and significant decrease in the expression of IFN mRNA was observed in 1 IU dose of oxytocin as compared to control group and 5 IU Oxytocin group. Administration of oxytocin had been found to increase the levels of PGF2α in sheep plasma.

Early embryonic mortality is one of the main sources of reproductive wastages and major constraints to full exploitation of the production potential of livestock. One of the major constraints to full exploitation of the production potential of sheep industry is of low reproductive efficiency as reflected by early embryo loss of 20-30% between days 8 and 16 of pregnancy. The survivality of embryo during early embryonic life is mostly dependent on the efficiency with which the maternal recognition of pregnancy (MRP) is established. Prostaglandins are the major contributors of different reproductive events in ruminant such as ovulation, implantation, parturition, luteolysis and

recognition of pregnancy. The candidate genes responsible for prostaglandin biosynthesis, transport and signal transduction are among the first to consider for major involvement in MRP. The synthesis of prostaglandins (PGE2 and PGF2) is controlled by enzymes prostaglandin E synthase (PGES) and prostaglandin F synthase (PGFS). PGF2 acts as the luteolytic agent to control oestrous cycle, whereas PGE2 helps in blastocyst apposition, decidualization, implantation and maintenance of pregnancy. Various modulators like oxytocin, lipopolysaccharide, hormones (oxytocin, oestrogen and progesterone), fatty acids (linoleic acid, linolenic acid), and interferons alter the prostaglandin biosynthesis through modulation of expression of different components of prostaglandin biosynthetic machinery. Keeping this in view, the present investigation is aimed to study the effect of administration of oxytocin and LPS on prostaglandin production and MRP related gene expression in sheep.

For synchronization of oestrus, two doses of Lutalyse (dinoprost tromethamine; 1ml) were administered at 9 days apart in Bannur ewes. Out of 15 ewes, 14 ewes exhibited oestrus symptoms. Natural mating was done for all 14 ewes. Oxytocin (1 and 5IU) were administered twice daily by intramuscular injection to treated ewes and sterile saline to control ewes 4-7 days after mating. Blood samples were collected via jugular vein puncture every day from day 4 to 8 and every alternate day until day 13 following mating. Endometrium was collected on day 13 after slaughter. Total RNA was isolated from endometrium and cDNA was synthesized. The quality of cDNA was checked through β-actin primers. Significant ($P<0.05$) decrease in expression of PTGFS and Galactin mRNAs was observed in both 1 and 5IU doses of oxytocin as compared to control group (Fig. 8). There were significant ($P<0.05$) decrease in expression of IFN mRNA in 1 IU dose of oxytocin as compared to control group and 5 IU oxytocin group. No significant ($P>0.05$) decrease in expression of PTGES mRNA was observed in endometrium following administration of oxytocin. Administration of oxytocin had been found to increase the levels of PGF2a in sheep plasma.

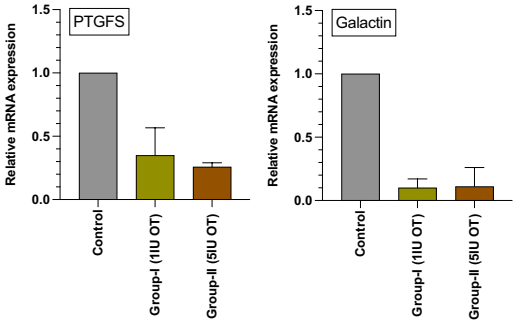


Fig. 8: Expression profiling of PTGFS and Galactin mRNA following administration of oxytocin (OT).

APR 3.22: Development of nutritional modules for commercial broiler sheep production

S Anandan, NM Soren, T Chandrappa, VB Awachat

Performance of Avishaan lambs fed finger millet straw based total mixed rations (80:20 and 70:30 C:R) were found to be encouraging with good average daily gain and feed conversion ratios

The project aims at developing appropriate feeding modules for different stages of growth in sheep for maximizing meat production potential. Lambs at the end of three months were subjected to total mixed rations using finger millet straw as roughage source to assess the post weaning performance of lambs for meat production potential. Two dietary treatments consisting of 20% finger millet straw (80 concentrate; 20 roughage) and 30% finger millet straw (70 concentrate: 30 roughage) total mixed rations were formulated and fed ad libitum for three months and the growth rate, feed efficiency and feed economics was worked out. The performance of lambs fed total mixed rations at varying roughage levels is presented in Table 4. The rumen fermentation pattern in TMR fed groups at zero and four hour post feeding were estimated and the results are given in the Table 5.

Table 4: Growth performance of post weaned lambs fed finger millet straw based total mixed rations.

Parameter	80:20 Total mixed ration (20% finger millet straw)	70:30 Total mixed ration (30% finger millet straw)	SEM
Wt gain (kg)	12.7	11.4	0.56
ADG (g)	151	136	0.001
Feed intake (DMI g/d)	1032	987	0.06
Avg Feed intake (DMI%)	4.31	4.25	0.05
FCR (kg)	5.90	6.23	0.19
Feed cost (Rs/kg wt gain)	154	160	-

Table 5: Rumen fermentation pattern in sheep fed finger millet based Total Mixed Rations (TMR). Group-1: 80:20 TMR; Group-2: 70:30 TMR.

Parameter	Hour	Groups		SEM	P-value		
		Group-1	Group-2		Treatment	Hour	T×H
pH	0	6.80	6.81	0.11	0.004	<0.001	0.005
	4	5.73	6.42				
NH_3-N (mg/100ml)	0	40.7	41.7	1.34	0.575	0.121	0.833
	4	44.5	46.7				
Acetate (mM/L)	0	21.6	27.0	2.37	0.873	<0.001	0.074
	4	43.6	39.0				
Propionate (mM/L)	0	5.69	5.79	1.26	0.001	<0.001	0.001
	4	18.4	10.7				
Isobutyrate (mM/L)	0	0.46	0.66	0.34	0.019	0.004	0.134
	4	0.37	0.42				
Butyrate (mM/L)	0	4.37	3.79	0.53	0.014	0.003	0.067
	4	8.34	4.89				
Isovalerate (mM/L)	0	0.79	1.01	0.06	0.272	0.022	0.183
	4	0.69	0.67				
Valerate (mM/L)	0	0.29	0.26	0.09	<0.001	<0.001	<0.001
	4	1.15	0.44				
TVFA (mM/L)	0	33.1	38.5	3.90	0.129	<0.001	0.006
	4	72.5	56.0				

APR 3.23: Unravelling the physiological role of adiponectin in regulation of energy metabolism in sheep

C Devaraj, M Bagath, G Krishnan, PK Malik, V Sejian, S Anandan

Plasma levels of adiponectin, AdipoR2, NEFA, IGF1 and cortisol were significantly enhanced in LE group as compared to CON and HE group. Whereas plasma level of AdipoR1 was significantly lower in LE and HE groups as compared to CON group. Plasma levels of leptin, insulin, T3 and T4 were significantly elevated in HE group as compared to CON and LE groups. The mRNA expression of leptin and GH significantly upregulated in the HE group than that of CON and LE groups. The mRNA expression of IGF-1 significantly upregulated in the LE group than that of CON and LE groups.

Adiponectin is a novel adipokines plays a crucial role in regulation energy metabolism by enhancing the insulin sensitivity and the fatty acid oxidation thus, maintaining the energy homeostasis. This project designed to assess the impact of energy restriction on the expression pattern of adiponectin and its receptors and to study the interrelationship of adiponectin with carcass characteristics and other metabolic hormones associated with energy metabolism pathways during energy restriction in sheep. The current experiment investigates the changes in the plasma concentrations of adiponectin, adipoR1, adipoR2, leptin, growth hormone (GH), insulin like growth factor-1(IGF-1), insulin, non-esterified fatty acids (NEFA), thyroid stimulating hormone (TSH), triiodothyronine (T3), thyroxine (T4), cortisol, ghrelin (Table 6), and the expression pattern of leptin, GH and IGF-1 in PBMC of sheep fed a diet containing different energy levels (Fig. 9). A total of 21 adult sheep (average body weight 18.0 kg) were used in this study. The animals were randomly divided into three groups viz., control (CON, N=7; 100% energy), low energy (LE, N=7; 80% energy) and high energy (HE, N=7; 120% energy). The experimental duration was 60 days and sheep were fed diet containing 100, 80 and 120% energy. Blood samples were collected at fortnightly interval, plasma and peripheral blood mononuclear cells (PBMC) were isolated to study the endocrine changes in plasma and the gene expression pattern of leptin, GH and IGF1, respectively. The plasma adiponectin and adipoR2 levels were significantly ($P<0.05$) increased in LE group as compared to the CON and HE group. The plasma concentration of adipoR1 was significantly low in LE and HE group than that of CON group. In LE group, the plasma levels of NEFA, IGF1 and cortisol were significantly ($P<0.05$) higher while, GH and TSH levels were significantly lower. The plasma concentrations of leptin, insulin, T3 and T4 were significantly ($P<0.05$) enhanced in HE group as compared to CON and LE group. The plasma level of ghrelin did not differ significantly among the treatment groups. It was evident that the mRNA expression of leptin and GH in PBMC was significantly ($P<0.05$) upregulated in HE as compared to CON and LE group. Whereas the gene expression of IGF-1 was significantly ($P<0.05$) higher in LE group as compared to CON and HE group.

Table 6: Impact of different energy levels on the plasma concentrations of hormones in sheep. Different superscripts within a row indicate a significant difference at $P<0.05$.

Parameters	Treatments			SEM
	CON Group	LE Group	HE Group	
AdipoQ (mg/L)	7.82^{b}	11.99^{a}	7.07^{b}	0.82
AdipoR1 (ng/mL)	20.0^{a}	8.95^{b}	10.2^{b}	2.05
AdipoR2 (ng/mL)	8.02^{b}	18.7^{a}	11.5^{b}	1.64
Leptin (ng/mL)	51.0^{b}	44.9^{b}	80.4^{a}	5.23

GH (ng/mL)	2.33[a]	1.04[b]	2.19[a]	0.34
IGF1 (ng/mL)	104[b]	231[a]	111[b]	24.4
Insulin (mIU/L)	6.65[b]	4.85[b]	9.35[a]	0.54
NEFA (mmol/L)	263[b]	591[a]	265[b]	41.5
Ghrelin (ng/L)	65.3	61.0	68.3	2.67
Cortisol (ng/mL)	4.62[a]	10.2[a]	5.28[b]	0.78
T3 (nmol/L)	9.02[b]	6.54[b]	15.9[a]	0.70
T4 (nmol/L)	99.5[b]	84.8[b]	134[a]	7.89
TSH (ng/L)	838[a]	499[b]	859[a]	84.7

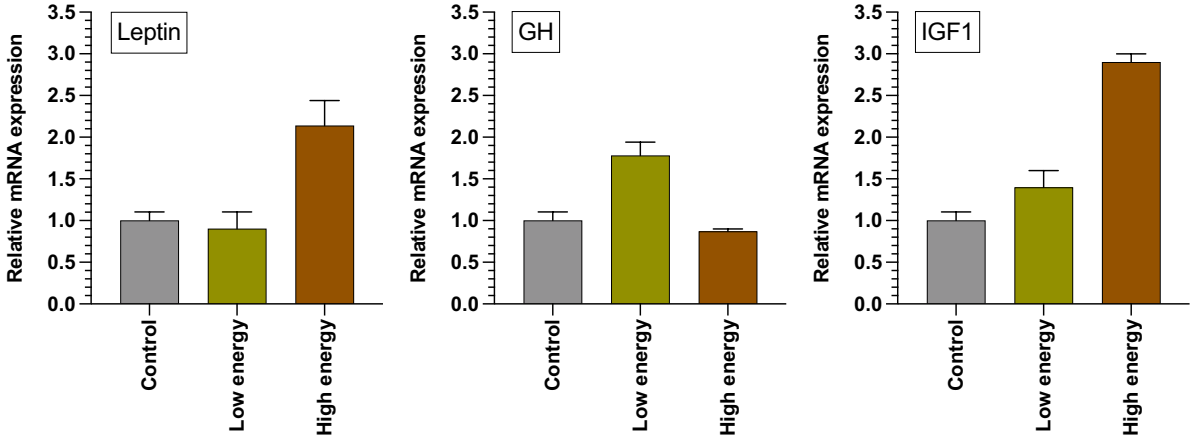


Fig. 9: Relative mRNA expression (mean±SE) of leptin, growth hormone (GH) and IGF-1 in PBMC of sheep fed different levels of energy.

APR 3.24: Modulation of GnRH system through novel neuropeptides during embryogenesis and physiological responses in post hatch broiler chicken

IJ Reddy, A Mishra, S Mondal, RK Gorti, AB Vaibhav

In ovo luzindol administration (50μM) during hatching in broiler chicken advanced the early body weight gain by 30 days relative to 35 days in controls. Luzindol effectively down regulated pituitary GnIH-R and upregulated steroids and somatotrophic hormones and facilitated the rapid growth rate in post hatch broiler chicken. Embryonated eggs injected in ovo with GnRH consumed less feed and grew most during the test period i.e., 1.99kg (treated) in body weight at day 30 as against 1.81kg in controls. FCR in the control group was 1.62 as against 1.51 in treated group.

Gonadotropin-inhibitory hormone (GnIH), a neuropeptide that inhibits gonadotropin synthesis and release, was first identified in quail hypothalamus. GnIH acts on the pituitary and GnRH neurons in the hypothalamus via GnIH receptor to inhibit gonadal development and maintenance. In addition, GnIH neurons express melatonin receptor and melatonin induces GnIH expression in the avian brain. Thus, it seems that melatonin is a key factor controlling GnIH neural

function. Earlier studies have investigated the role of melatonin in the regulation of GnIH release and the correlation of GnIH release with LH release in avian. Melatonin administration dose-dependently increased GnIH release from hypothalamic explants in vitro. Thus, melatonin may play a role in stimulating not only GnIH expression, but also GnIH release, thus inhibiting FSH, LH and somatotropic hormone concentrations in avian through specific melatonin receptor (Mel1c). Suppression of melatonin receptor Mel1c specifically through melatonin receptor Mel1c antagonists (luzindol) during embryogenesis may decrease the synthesis and release of GnIH and increase the secretion of other gonadotrophic and somatotrophic hormones for rapid growth in post hatch broiler chicken. The objectives of this study were to develop the GnRH, GnRH receptor system at critical embryonic phases through exogenous neuropeptides and to study their impact on productive performance in post hatch broiler chicken. To modulate melatonin receptors through exogenous modulators and in turn suppression of GnIH during embryonic stage to study post hatch broiler chicken production.

Two hundred uniform sized Cobb broiler eggs were set for incubation. The fertile eggs were divided into two groups; one group was administered with in ovo luzindol (50nM) and other group without in ovo administration on day 12 of incubation into the amniotic cavity. The chicks hatched from the different treatment groups were randomly distributed into battery cages (11 replicates with 7 chicks in each replicate). Body weight gain, feed intake and FCR were calculated. Endocrine and mRNA abundance of GnIH, GnRH, GH, IGF1 and their receptors in the pituitary and other tissues were studied at weekly interval. The results showed that hatchability of fertile eggs, egg weight and chick weight did not differ significantly ($P>0.05$) due to in ovo administration of luzindo 50μM. Embryonated eggs injected in ovo with luzindol consumed less feed and grew most during the test period i.e.,1.99 kg (treated) at day 30 as against 1.81kg in controls. FCR in the control group was 1.62 as against 1.51 in treated group. In ovo luzindol administration during hatching in broiler chicken advanced the early body weight gain by one week relative to in controls. In ovo administration of luzindol down regulated GnIH-R mRNA and up regulated the GnRH concentration in the cultured cells. chGnRH, chGH, estradiol, progesterone, testosterone, IGF-1, IGF2, T3, T4 and cortisol were quantified by species specific ELISA kits. Plasma estradiol-17β(32.7±0.99pg/ml), progesterone (2.86±0.28ng/ml) testosterone (172±0.18pg/ml), GH (8.67±0.22ng/ml), IGF-1 (16.9±0.28ng/ml) levels were significantly ($P<0.05$) higher in the treated group. chGnRH (4.22±0.10nM), IGF1-and growth hormone (chGH) were were significantly ($P<0.05$) higher in the treated group. mRNA abundances of chGnRH, GnRHR, GHR, FSHR, LHR, pituitary and hypothalamic tissues were significantly ($P<0.05$) higher in the treated group. Endocrine profiles were positively correlated ($P<0.01$) with weight gain. GnIH, melatonin and myostatin levels were significantly low in treated birds. The results suggest that luzindol effectively up regulates pituitary GnRH-R, steroids and somatotrophic hormones and facilitated the rapid growth rate in post hatch broiler chicken. Further, it is highly cost effective and could reduce the feed costs and saved highly valuable feed ingredients.

APR 3.25: Development of precise delivery system for improved bioavailability of zinc for poultry

SBN Rao, D Rajendran, M Bagath, AV Elangovan, F. Magdaline

Feeding of encapsulated zinc at two levels (50%) caused improvement in ileal digestibility of zinc improved in encapsulated group compared to control. Plasma zinc status improved by 19.9 and 11.9 % in encapsulated zinc supplemented groups at 100 and 50 %, respectively.

Experiment was conducted in broiler birds to find out the effect of incorporating two levels of encapsulated zinc (100 and 50%), organic zinc (50%) For this purpose, day old broiler chicks were distributed in four treatment groups in six replications having eight birds each. The four treatment groups comprised on control (birds received inorganic source of zinc), En-Zn-100, (birds received encapsulated source of zinc at 100% of control), En-Zn-50 (birds received encapsulated source of zinc at 50% of control) and Or-Zn-50 (birds received Zn-methionine at 50% control). The birds were fed for five weeks. Trace mineral premix was prepared using different sources of zinc (zinc oxide, encapsulated zinc and Zn-methionine), copper sulphate, ferrous sulphate and selenium. They were mixed in finely ground maize powder and added 150g per 100kg of diet. The body weight gain, feed intake and FCR (0-3; 4-5 and 0-5wk) was found to be similar in all the groups of birds fed different sources of zinc in the diets (Table 7).

Table 7: Body weight gain, feed intake (g/bird) and FCR in birds fed different sources of zinc.

Groups	Body weight gain (g/bird)			Feed intake (g/bird)			FCR		
	0-3wk	4-5wk	0-5wk	0-3wk	4-5wk	0-5wk	0-3wk	4-5wk	0-5wk
Control	952	1179	2131	1326	1893	3219	1.39	1.61	1.51
EnZn-100	952	1201	2153	1352	1885	3236	1.42	1.57	1.50
EnZn-50	977	1181	2158	1362	1932	3294	1.40	1.65	1.53
OZn-50	966	1124	2091	1345	1847	3192	1.39	1.65	1.53
SEM	8.46	19.8	18.16	14.88	26.70	34.26	0.01	0.02	0.01
P value	0.71	0.56	0.56	0.87	0.75	0.78	0.73	0.56	0.84

The apparent ileal digestibility coefficient (AIDC) of CP was found to be similar in all the groups fed different sources of zinc (Fig. 10), however, AIDC of zinc was higher in birds fed EnZn-50 compared to control and similar in other groups. Plasma zinc status was similar across different groups (Fig. 10). However, improvement of plasma zinc status was noticed in EnZn-100 (19.9%) and EnZn-50 (11.9%) groups where birds were fed zinc in encapsulated form.

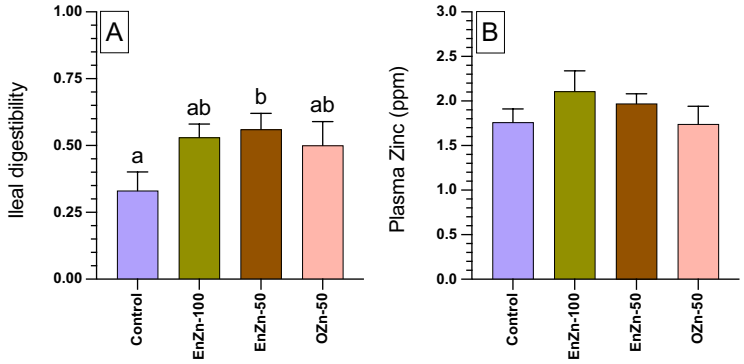


Fig. 10: Panel-A: Apparent Ileal digestibility coefficients of zinc in birds fed different sources of zinc. Panel-B: Plasma zinc (ppm) status in birds fed different sources of zinc.

APR 3.26: Biological activities of rare earth elements in relationship to production performance of egg and egg and meat type chicken

G Ravi Kiran, CG David, IJ Reddy, AB Vaibhav, PA Heartwin, KP Suresh

Supplementation of REE in broilers improved broiler performance in terms of improved growth, feed intake and efficient FCR. The increase of bone strength and egg shell breaking strength in broilers and layers supplemented with REE shows a plausible action REE as a calcium agonist.

Rare earth minerals (REE) such as lanthanides have been shown to increase FCR, egg production and body weight gain in case of egg and meat type chicken respectively over the past 4 decades. Lanthanide share chemical properties with that of calcium, yet their use as calcium analogues in egg and meat type chicken have not been fully explored. Secondly, it has been shown to act as non-antibiotic growth promoter in mono-gastric animals especially pigs and broilers. Further, lanthanides also have been shown to exert maximum beneficial effect on animal growth and immunity to yield enhanced productivity. Hence, the exact biological mechanism behind the beneficial action of lanthanides (owing to their poor bioavailability) is yet to be fully elucidated. This project was envisaged to unravel the basic physiological mechanism(s) behind the action of lanthanides a) in sustaining peak productivity and laying persistency of egg-type chicken with improved feeding efficiency and b) in promoting growth of meat-type chicken with improved feeding efficiency.

A trial was conducted in broilers to study the effect of supplementation of lanthanides in promoting growth and improving bone strength. 144 Cobb strain broiler chicks were fed on standard broiler pre starter, starter and finisher basal diet (Group I and IV) and basal diet+rare earth elements (REE, Lanthanum acetate: Cerium acetate - 1:3; Group II; 100mg/kg feed). Basal diet was fed from 0-21 days to groups I and IV and basal diet+REE was fed to Groups II and III. From day 22, REE was added to the diets of birds in Group IV to study the effect of late inclusion of REE and removed from that of Group III birds to study the withdrawal effect on bone strength and growth. Two birds per replicate were sacrificed on days 35 and 42 to study the effect of REE on bone strength. Supplementation of REE significantly ($P<0.05$) increased body weight gain with significant ($P<0.05$) decrease in feed intake and improved FCR (Table 8).

Table 8: Effect of supplementation of rare earth elements on performance of commercial Cobb strain broilers.

Groups	Feed intake (g/bird)		Body weight gain (g/bird)		FCR	
	0-35 day	0-42 day	0-35 day	0-42 day	0-35 day	0-42 day
I	2981	5595	1861	3190	1.60	1.75
II	2886	5310	1890	3222	1.53	1.65
III	2945	5475	1932	3245	1.52	1.69
IV	2930	5373	1940	3332	1.51	1.61
SE	57	121	33	59	0.00	0.01

The time of feeding of REE did not significantly influence the body weight gain and FCR. However, inclusion of REE from day 22 resulted in better body weight and FCR. The breaking strength of bone was significantly ($P<0.05$) higher in birds supplemented with REE. On the other hand, reversal of basal to REE diet and vice versa affected bone breaking strength (Table 9). These findings suggest supplementation of REE improves growth and bone strength plausibly by acting as calcium agonist.

Table 9: Effect of supplementation of rare earth elements on egg shell strength of commercial white leghorn strain chicken.

Groups	Force (N)	
	35 weeks	45 weeks
I	30.3±2.22	32.5±2.73
II	36.2±2.54	39.9±1.73
III	-	36.3±1.42
IV	-	32.2±1.79
P value	0.05*	0.25

An earlier trial conducted in layer hens supplemented with lanthanides (lanthanum acetate + cerium acetate 1:3; 20g/100kg feed) revealed supplementation to improve egg shell breaking strength (26.1±2.54 vs. 20.3±2.22). However, reversal of basal diet to REE and vice versa affected egg shell breaking strength (25.3±1.99 vs 24.2±2.38).

APR 3.28: Elucidation of cryo-tolerance and its mechanism in buffalo spermatozoa

B Krishnappa, BK Binsila, A Arangasamy, S Selvaraju, A Prasad

Individual variability with respect to sperm freezability was observed in breeding bulls. Post-thaw velocity parameters like VCL, VAP and VSL were significantly higher in the good than the poor freezable semen producing bull.

India is confounded with a rich resource of buffalo germplasm, contributing 45% of total milk produced from Indian dairy sector. Profitability of dairy farming mainly depends on high conception rates following artificial insemination. However, more than 50% of sperm die during cryopreservation and the mechanism responsible for sperm to evade the cryo-damage still remains unexplored completely. A small number of motile frozen thawed sperm might not be enough to fertilize the ova in low fertile or repeat breeding animals and is one of the important reasons for reduced acceptability of AI in buffalo. Identifying the high freezable semen producing bulls and AI with highly viable and fertile sperm would be a way forward to improve the conception rate in buffalo. Hence, the project has been proposed with an approach to identify the possible mechanisms of cryotolerance in buffalo spermatozoa.

Semen samples of 14 Murrah buffalo bulls (N= 14) were procured from bull semen banks to study the freezability and sperm kinematics. All the samples were analysed for viability count. The mean values for pre-freeze and post-thaw samples of each bull (four replicates/bull) were calculated. The percentile drop in the mean viability ranged from 8.71 to 34.6 between bulls during cryopreservation. The mean (N=14) of percentile drop was 16.7 and is used as cut-off for categorizing the buffalo bulls into two groups; good freezable (GF<mean percentile drop) and poor freezable (PF>mean percentile drop) semen producers. All pre-freeze and post-thaw semen samples of GF (N=6) and PF (N=6) semen producers were analysed objectively by CASA following standard procedure. The sperm kinematics was subjected for independent student t-test to study the significance between the groups for pre-freeze and post-thaw samples at 95% confidence interval. There was no significant difference between the groups with respect to progressive, total motile, rapid, medium slow, rapid progressive, medium progressive, oscillation index, amplitude lateral head displacement, beat frequency, hyperactive sperm, mucous penetration, head area, velocity (velocity curvilinear-VCL, velocity average path-VAP and velocity straight line-VSL) and velocity ratio (straightness index and linearity index) parameters in pre-freeze samples (Fig. 11). Similar findings were observed in post-thaw samples except the VCL, VAP and VSL which were significantly high (P<0.05) in GF (74.47±3.32; 55.57±2.46; 45.59±1.98μm/sec) than PF (65.7±2.03; 48.3±1.88; 40.03±1.77μm/sec) semen producing bulls (Fig.

12). The preliminary analysis revealed that there is bull to bull variation in freezability of spermatozoa and the post-thaw velocity parameters were higher in the good than the poor freezable semen producing bull.

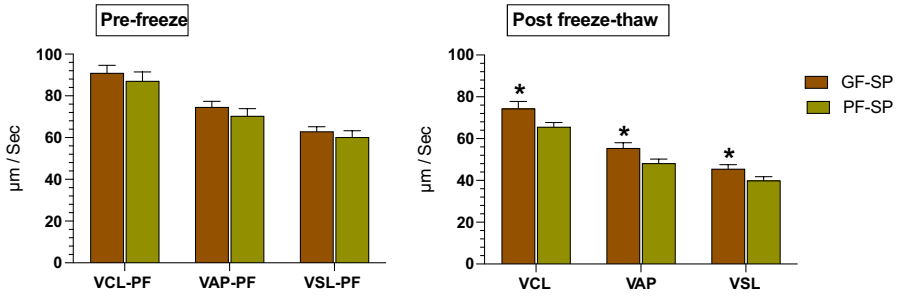


Fig. 11: Sperm velocity variables (VCL: velocity curvilinear; VAP: velocity average path; VSL: velocity straight line) of pre-freeze and post freeze-thaw samples in good (GF-SP) and poor (PF-SP) freezable semen producing bulls. * indicates a significant difference between the groups ($P<0.05$).

APR 3.29: Development of a synthetic semen extender for cryopreservation of buffalo semen

SC Roy, A Dhali

An egg yolk-free, ready to use, semen extender with higher shelf-life (≥18 months) was developed for cryopreservation of buffalo semen for the first time in India. The post-thaw progressive motility of cryopreserved buffalo sperm in the new egg-yolk free semen extender was significantly higher as compared to that in traditional egg-yolk-based semen extender.

Semen of an elite bull is cryopreserved at -196°C for its future use in breeding and improvement of the species through artificial insemination. But, compared with the fresh semen, the post-thaw motility and fertility of cryopreserved semen is significantly low. Even after about five decades of invention of semen extender and the associated semen cryopreservation technique, we could not achieve the desired level of success as, depending upon the species, only about 40-60% of spermatozoa remain motile and viable after semen cryopreservation. The cryopreservation procedure induces a number of stresses in mammalian sperm including the osmotic and cold stresses. Egg yolk is commonly used at 20% (v/v) in traditional tris-citrate-fructose-glycerol-egg yolk (TCFGEY)-based semen extender to preserve the mammalian sperm against cold shock during free-thaw procedure. However, using of egg yolk in semen extender is associated with several issues. The egg yolk contains some unknown factors that inhibit the respiration of spermatozoa thus diminish their motility. The egg yolk has to be fresh as its shelf-life is just a few hours. Egg yolk may be contaminated with several pathogenic microbes posing risk to its use in animal breeding. Extensive batch to batch variability in the quality of egg yolk leads to unequal post-thaw motility and viability of spermatozoa. Separating of an egg-yolk from the egg albumin is also a cumbersome process on the day of semen collection. For the reason, in recent years, attempts are being made to develop an egg yolk-free semen extender. An egg yolk- free semen extender has been developed by a foreign commercial firm for cattle semen. To the best of our knowledge, no such egg yolk-free semen extender is available for buffalo. Thus, in the current study, it is proposed to develop an egg yolk-free, ready to use, semen extender with higher shelf-life for cryopreservation of buffalo semen. Initially, a few commercially available pure proteins were tried that yielded limited success. Ultimately, a mixture of naturally occurring proteins coded as Protein-W (names of these proteins are not disclosed at this time due to IPR issues) was used to develop an egg yolk-free semen extender and this yielded highly satisfactory results, even better than fresh egg yolk-based semen extender (Fig. 12). The post-thaw total and progressive motility of cryopreserved buffalo sperm in Protein-W-based semen extender was

significantly higher (P≤0.05) as compared to that in traditional egg-yolk-based semen extender (total motility: 68.6±5.62% vs. 41.6±2.55%;progressive motility: 41.5±4.01% vs. 18.7±1.70%; N=8). The shelf-life this egg yolk-free, ready to use, semen extender has been estimated to be ≥18 months. The performance of the newly developed semen extender is being tested in large number of bulls.

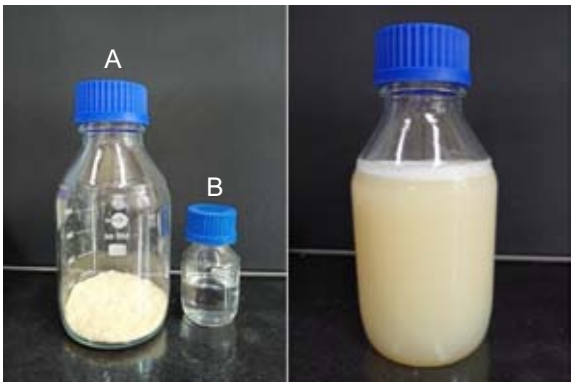


Fig. 12: Ready to use egg yolk-free semen extender for buffaloes. Shelf life: ≥18 months if kept in a refrigerator (4°C). Direction for use: Add 250mL of double distilled water to Component-A (mix of proteins+buffers+other salts) and mix well until the suspension is homogenous; to it add Component-B and then add double distilled water up to the mark (500mL) and mix well and then it is ready for buffalo semen dilution and cryopreservation.

APR 3.30: Studies on complementary physiological and molecular mechanisms and fine-tuning research tools for holistic poultry production

KVH Sastry, AV Elangovan, IJ Reddy, G Ravi Kiran, CG David, A Mishra, M Bagath, M Gopi

The study has been initiated to understand the proximate mechanism of Sex reversal and production of single sex chicks, and to examine the dynamics of oestrogen receptors and shell gland function during long laying cycle and to develop strategies for supporting persistency of egg production beyond 72 weeks.

In the layer industry, around 2 billion male chicks co-hatched with female chicks killed immediately after birth worldwide. Millions of spent hens are culled or disposed at throw away price after one laying cycle (72 Weeks). There are several economic and welfare benefits to produce only female chicks for egg production. Modulating the sex ratio towards female for layer industry has universal appeal. Fine tuning strategies for ZW males to produce spermatozoa bearing W chromosome and manipulation of sex specific gene expression to produce ZW males will be attempted in the proposed study.

The strategies will be developed to address the shell strength issues in long life layer. The role of oestrogen and its receptors in regulating calcium metabolism in different organs will be examined. Actual role of nuclear receptors of oestrogen along with their counterpart, the membrane G coupled receptor (GPR30) receptor with respect to the calcium metabolism will be elucidated in chicken. The study is taken up with the following objectives: 1) To understand the proximate mechanism of sex reversal and production of single sex chicks; 2) To examine the dynamics of oestrogen receptors and shell gland function during long laying cycle; 3) To develop strategies for supporting persistency of egg production beyond 72 weeks.

AICRP: Nutritional and physiological interventions for enhancing reproductive performance in animals

Coordinator: R Bhatta

NKS Gowda, IJ Reddy, KS Roy, SC Roy, DT Pal, S Selvaraju, A Dhali , D Rajendran, BK Binsila

Moringa forage meal is a good source protein, energy, minerals, phenolics and flavonoids. MFM feeding in the diet of rams by replacing 15% of the compounded feed mixture improved semen quality and fibre utilization. E coli clones have been produced in laboratory for expressing recombinant buffalo β chain of LH/FSH, chain of LH and chain of FSH. Providing livestock inputs to SC farmers improved fodder availability, milk production and thereby their family income.

Study on semen quality in rams fed moringa forage meal

Rams of Mandya breed (N=18) of about 18 months of age with an average body weight of 25 kg were selected and divided into three groups (N= 6 each) based on body weight in a completely randomized design. The feeding trial was carried out for 10 weeks. Metabolism trial was conducted during the 6th week of feeding trial. The control diet T1, contained compounded feed mixture (CFM), finger millet straw (FMS) and hybrid Napier fodder (HNF) at 30, 20 and 50%, respectively (DM basis). While T2 and T3 groups diets contained 15 and 30% of moringa forage meal (MFM), respectively to replace CFM (w/w). Moringa forage meal (MFM) was prepared by harvesting the moringa forage (leaves with twigs) crop at the right stage cultivated in the fields of ICAR-NIANP, allowed it to dry under shade and analysed for chemical composition including bioactive compounds. The rams were fed with control and treatment diet for 60 days. The performance of rams in terms of dry matter intake, nutrient utilization and semen quality were studied.

MFM contained 88.1, 27.6, 5.7, 11.9, 29.3 and 14.2% with respect to organic matter (OM), crude protein (CP), ether extract (EE), total ash (TA), neutral detergent fibre (NDF) and acid detergent fibre (ADF), respectively. The metabolizable energy (ME) content (MJ/kg DM) and gas production (ml/200mg DM/24 h) were 9.24 and 35.1, respectively. The MFM with respect to mineral composition contained (%) 1.95, 0.34 and 0.46 of calcium (Ca), phosphorus (P) and magnesium (Mg), respectively. The zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu) content (ppm) were 55.4, 279, 25.8 and 14.5, respectively. Among the phenolic acids which present in higher quantity were p-Coumaric acid, o-Coumaric acid, Caffeic acid and Ferulic acid at a concentration of 2753, 347, 373 and 399 ppm, respectively. Among the flavonoids Luteolin, Naringenim, Quercetin and Myricetin were found to be in higher quantity at 12.10, 7.50, 5.31 and 5.09 ppm, respectively. There was no significant difference in the intake of nutrients among the treatment groups except for DM and OM, which was significantly ($P \leq 0.05$) lower in sheep fed 30% MFM. The apparent digestibility (%) for all nutrients was comparable except NDF and ADF which showed significantly ($P \leq 0.05$) higher digestibility in MFM fed groups. The volume of semen and total sperm output were significantly ($P < 0.05$), increased in rams fed diet with 15% MFM. The plasma mineral concentration and biochemical parameters (total protein, total albumin, total globulin and SOD activity) did not show any significant variation among the treatment groups.

Purification and production of buffalo pituitary hormones

Full length genes encoding the α and β chains of buffalo-specific LH and FSH were cloned using PCR technique. Briefly, total RNA was purified from buffalo pituitary and converted into cDNA and using the specific sets of designed primers, full length coding sequences of **α** and β chains of buffalo LH and FSH were cloned. Subsequently, the expression plasmids were constructed for heterologous expression of recombinant buffalo LH and FSH in bacterial system. The amplified PCR products were purified from agarose gel and ligated to pFN6A (HQ) vector for constructing the expression plasmids. A total of three different plasmids thus constructed for expressing buffalo β chain of LH/FSH, β chain of LH and β chain of FSH in E coli (Fig. 13). Subsequently, the competent E coli cells were

transformed with each of the plasmids individually, grown and subjected to plasmid isolation (Fig. 14). The open reading frames of the purified plasmids (N=5 for each construct) were checked following Sanger sequencing and clones with correct reading frames were selected for expression.

Two clones for buffalo α chain of LH/FSH, one clone for buffalo β chain of LH and two clones for buffalo β chain of FSH were found with correct reading frame. These were selected for expression of recombinants buffalo LH and FSH.

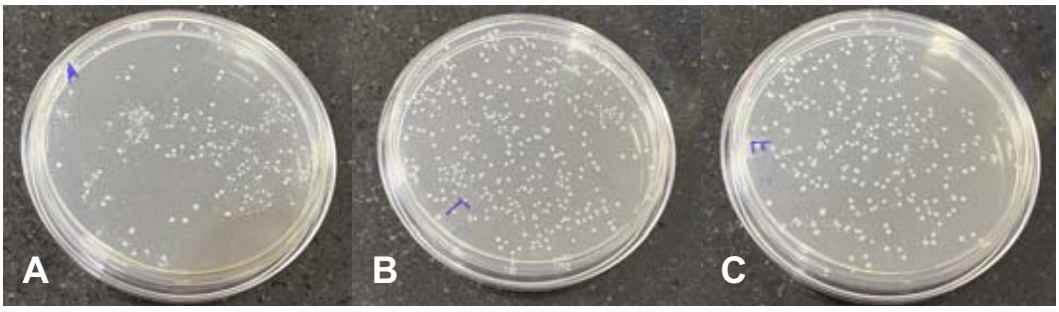


Fig. 13: Colonies following transformation with different plasmids and overnight incubation. Panel-A: α chain of buffalo LH/FSH; Panel-B: β chain of buffalo LH; Panel-C: β chain of buffalo FSH.

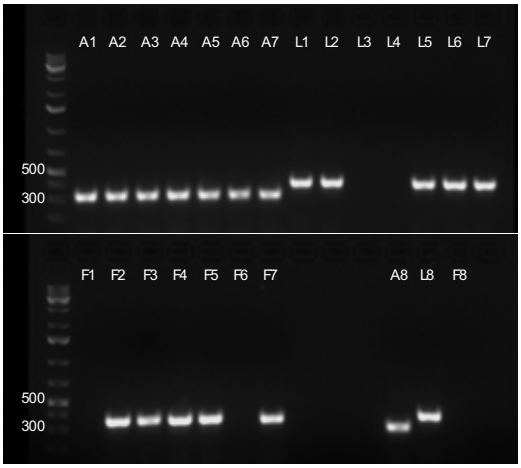


Fig. 14: Confirmation of the presence specific inserts in the selected clones by PCR assay. Lane A1-A8: α chain of buffalo LH/FSH; Lane L1-L8: β chain of buffalo LH; Lane F1-F8: β chain of buffalo FSH.

Extension work under Scheduled castes sub plan (SCSP)

Distribution of fodder seeds (CoFS 29) and fodder root slips (super napier) to SC farmers improved the green fodder cultivation in the village and availability of fodder to dairy animals (Fig. 15). This in turn increased the milk procurement at the society by more than 50-70 liters per day.

Fig. 15: Distribution of fodder seeds and fodder root slips among farmers.

ICAR-National Fellow: Development of buffalo bull fertility diagnostic chip based on sperm transcripts signatures

S Selvaraju

Embryonic organ development and reproduction processes are enriched in the X-linked genes of cattle and buffalo sperm, respectively. X-linked genes RPL10, ZCCHC13 in cattle and AKAP4, TSPAN6, RPL10 and RPS4X in buffalo influence sperm kinematics.

Bull fertility is traditionally evaluated using breeding soundness evaluation and laboratory tests measuring quality traits. However, fertility difference has been observed among the bulls producing semen with optimal concentration, morphology and motility. Sperm biomolecules impact the reproductive success of a bull. The endeavour of sperm towards successful fertilization is tremendously energy demanding. The energy produced by the sperm enables them to remain motile for the successful fertilization. The X-chromosome associated genes are involved in sperm function and fertility regulation. Hence, data generated from sperm transcriptomic profiling is employed to explore the relationship between the expressed genes and sperm functional attributes with an aim to develop bull fertility chip for the selection of superior breeding bulls.

The genes associated with energy production pathways and their expression level changes on the fertility rate of the bulls were deciphered. The post-thaw buffalo semen samples (N=21) were collected, and sperm functional attributes were evaluated. Based on the sperm functional attributes, top ranked (high fertile, N=5) and least ranked (low fertile, N=5) bulls were chosen for the downstream analysis. The sperm total RNAs were extracted and sequenced using the Illumina platform. The results showed that 14.6% of these genes were significantly ($P<0.05$) differentially expressed, comprising 12.0% up, 1.85% neutral and 0.53% downregulated genes in the high fertile bulls. These genes were involved in chemokine signalling pathway (ADCY2 and JAK2, P=0.0001), oxidative phosphorylation (ATP6V0B and ATP6V1G1, P=0.0002), calcium signalling pathway (AGTR1 and SLC25A4, P=0.0002) and oocyte meiosis (ADCY2 and ADCY3, P=0.049). The energy demand for the sperm to remain motile is higher, and the increased expression of these ATP producing genes in HF bulls substantiates the improved progressive motility (64.5±5.79 vs 33.1±3.34%), curvilinear velocity (70.6±4.32 vs 50.2±4.92 m/sec), straight-line velocity (39.8±3.16 vs 26.0±2.52 m/sec) and average path velocity (49.5±3.59 vs 33.0±3.45 m/sec). The expression levels of up-regulated genes such as JAK3, DDX5, PRKCZ, CHD4, CHD5, and ADCY3 had a strong positive correlation ($r>0.5$) with progressive motility and velocities (Fig. 16). The expression level differences of these genes and their associated pathways suggest that these genes influence the fertility status of the bull.

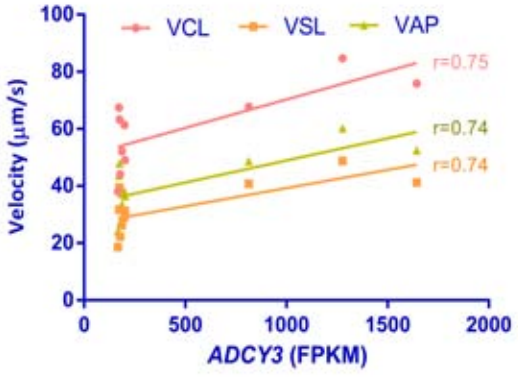


Fig. 16: Expression levels of up-regulated genes involved in energy production, such as ADCY3 had a strong positive correlation ($r>0.5$) with sperm velocities.

Since the role of X-linked genes expressed in sperm on bull fertility has not been studied in detail, the influence of X-linked genes on the sperm functional parameters and field fertility rate in the cattle (N=12) and Murrah buffalo bulls (N=7) were studied. The frozen semen samples were used for the assessment of functional parameters, RNA isolation and transcripts expression studies. Transcriptome data of cattle (N=8) and buffalo (N=8) sperm samples were used for the enrichment analysis. The expression levels of some of the relevant genes were validated using the RT-qPCR. The sperm transcriptome studies revealed that the total number and the expression levels of X-linked genes in the mature sperm were very low in both species, and only 23.3% of these genes were commonly expressed between them (Fig. 17). In the X-linked genes, embryonic

organ development (P=0.03) and reproduction (P=0.02) were enriched in cattle and buffalo sperm, respectively. The expression levels of X-linked genes RPL10 and ZCCHC13 in cattle; AKAP4, TSPAN6, RPL10 and RPS4X in buffalo were significantly (P<0.05) correlated with sperm kinematics. Importantly, the expression levels of the genes, RPL10 (r=-0.68) and RPS4X (r=0.81) had a significant correlation with the field fertility rate in cattle and buffalo, respectively. Multivariate regression models and receiver operating curve analysis suggest that the expression levels of X-linked genes may be useful in predicting the bull fertility rate. The study indicates that sperm-expressed X-linked genes influence semen quality and fertility in both cattle and buffalo.

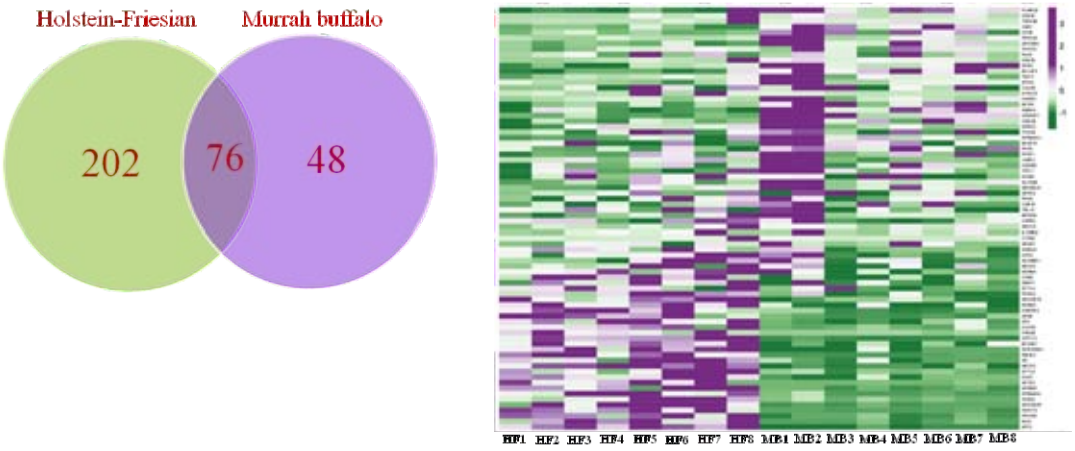


Fig. 17: Comparison of the X-linked genes expressed in both Holstein-Friesian cattle and Murrah buffalo sperm. (A) There were only 76 genes common to both species. Unique genes to cattle and buffalo were 202 and 48 genes, respectively. (B) The rate of divergence in the expression levels of commonly expressed genes in the X-linked genes was high between the cattle and buffalo.

ICAR-Extramural: Kisspeptin and its analogues as novel biomolecules to augment fertility in small and large ruminants under recent climate change scenario

KS Roy, J Ghosh

The synthesized product "Reprovardhak" along with "ProKisAna Protocol" for induction of estrous has lead to successful pregnancy in these animals in a significant higher rate; and as a result made it eligible to be recognized as potential therapeutic agent. It has already been made available in "Agrinnovate India" portal commercialization.

Among many synthesized and last year's tested products, in this period we conducted repeated trials of the best one "Reprovardhak" on sheep and goat to find out it's the efficacy as potential therapeutic agent towards induction of oestrous that led to successful pregnancy following "ProKisAna Protocol". Further, LH, FSH, oestradiol 17 and progesterone were estimated in blood plasma of treated as well as control group of animals during different time (prior, during and after) administration of "Reprovardhak". For effective induction of oestrous towards conception/pregnancy of synchronized animals, a different dose schedule of "Reprovardhak" had been established for the first time in this project. The rate of conception in these ewes after natural insemination with rams in treated group was significantly higher in comparison to control animals. Seven lambs were born out of 10 ewes in this repetitive trial (Fig. 18). It can be noted that for commercial availability and to show the expression of interest for national and international licensing of this product, the modalities had been made available to "Agrinnovate Web Portal, Govt. of India" for the pharma industry. Currently, we are trying to explore the possibility of having more potent products of similar line in this project.

Fig. 18: Lambs born through administration of "Reprovardhak®" following "ProKisAna Protocol" for induction of oestrous and augmentation of reproduction in livestock.

ICAR-NASF: Targeted immobilization of Y- bearing spermatozoa and modulation of oviduct milieu for skewing the sex ratio towards female offspring in dairy cattle

D Rajendran, A Arangasamy

Incorporation of calcium at 1mM and 3mM in the incubation skewed the sex ratio of oviductal cells bound spermatozoa towards X-bearing spermatozoa, while incorporation of magnesium skewed the sex ratio towards Y-bearing spermatozoa.

Oviduct selects spermatozoa for its phenotypic qualities such as acrosome integrity, high mitochondrial membrane potential, low protein tyrosine phosphorylation and un-capacitated spermatozoa. A recent study stated that the battle of sexes starts in oviduct and emphasized the ability of the oviduct to differentiate the spermatozoa of different sex. On this line, we studied the effect of modulating oviduct environment on sperm phenotype and sex ratio of bound spermatozoa. Under this project, oviduct explant model was developed and standardized sperm concentration, incubation time and staining techniques and also oviduct monolayer model was developed for separation of bound and free spermatozoa. We also assessed the sperm functional attributes and sex ratio of oviduct monolayer bound spermatozoa. Incubation of 2 million spermatozoa for 1h resulted in optimum sperm-oviduct explants binding index. Use of HOECHST 33342 dye for pre-staining of spermatozoa resulted in better visualization of bound spermatozoa. The proportion of live acrosome intact (42.9±3.27 vs 21.6±3.53) and high mitochondrial membrane potential sperm (50.7±1.12 vs 37.2±4.16) was significantly higher while the %DFI was significantly lower ($P<0.05$) in high-fertile crossbred bulls. Heparin at the dose rate of 100μg/mL successfully denuded oviduct bound spermatozoa. The oviduct bound population had significantly higher ($P<0.05$) viability (60.1% vs 40.9), acrosome intactness (82.3 vs 65.7) and mitochondrial membrane potential (39.2 vs 34.5) as compared to unbound sperm population Supplementation of Calcium at 1mM and 3mM in in vitro sperm-oviduct incubation medium resulted in 15 and 5 times more X-bearing sperm binding to oviduct monolayers, respectively. Supplementation of Magnesium at 1mM and 3mM in in vitro sperm-oviduct incubation medium resulted in 20 and 33 times more Y-bearing sperm binding to oviduct monolayers, respectively. The oviduct explants model standardized in the study could be used to study sperm-oviduct binding index in cattle. Sperm viability, acrosome intactness and high mitochondrial membrane potential are the prerequisite phenotypic characteristics to bind with oviductal cells. Incorporation of calcium at 1mM and 3mM concentrations in the incubation tend to skew sex ratio of oviductal cells bound spermatozoa towards X-bearing spermatozoa, while incorporation of magnesium skews the sex ratio towards Y-bearing spermatozoa. Supplementation of glucose had no effect in the sex ratio of oviduct monolayer bound spermatozoa

ICAR-NASF: CRISPR/Cas9 guided functional analysis of genes regulating early embryonic survival in buffalo

S Mondal, IJ Reddy, S Nandi, PSP Gupta

Significant decrease in PGF2**α** and PGE2 production and expression of PTGES and PTGFS mRNAs were observed following CRISPR/Cas9 based targeted editing of PTGES and PTGFS genes.

Early embryonic mortality is one of the major causes of reproductive failure in ruminants resulting in reduced pregnancy rate, slower genetic improvement and substantial economic loss to farmers. Prostaglandins (PGs) play an important role in regulation of oestrous cycle, recognition of pregnancy and implantation through autocrine, paracrine and endocrine actions. The first limiting step in the generation of PGs is the transformation of arachidonic acid by prostaglandin synthases 1 and 2 (PGHS-1, -2 or COX-1, -2). Downstream enzymes such as PGE synthase (PTGES) and PGF synthase (PTGFS) catalyse the conversion of PGH2 to PGE2 and PGF2**α**, respectively. The objectives of the present project are: 1) Studying the CRISPR-Cas9 based editing of COX-2, PTGES, PTGFS and AKR1B5 genes associated with prostaglandin biosynthetic pathways in buffalo; 2) Studying the in-vitro over-expression of COX-2, PTGES, PTGFS and AKR1B5 in mouse and buffalo uterine epithelial cells; 3) Generation of knockout mouse for most effective COX-2, PTGES, PTGFS and AKR1B5 gene for determination of their role in fertility.

A total of six SgRNAs were designed for PTGFS and PTGES genes (three SgRNA each) and they were analysed for their off-target effects. Cloning was performed with the best SgRNA. Upon digestion of the BbsI enzyme, the plasmid was linearized with the staggered ends for SgRNA directional cloning. The digested vector exhibited 9.1kb linearized size. The presence of the SgRNA in the plasmid was confirmed by PCR using U6 primers. All the ten plasmids (five each for PTGFS and PTGES genes) were subjected to PCR amplification at 58°C. On the basis of concentration and purity two plasmids were sent for sequencing for further confirmation of SgRNAs. The presence of SgRNAs was further confirmed by Sanger sequencing using U6 primers, nine purified plasmid samples were sent for sequencing. The sequence data was analysed by using CLUSTAL W, multiple alignment tool (Fig. 19 and 20).

Confluent endometrial epithelial cells (70-80%) were transfected with COX-2, PTGES and PTGFS CRISPR constructs. After 48 hrs culture was kept for puromycin selection for 12 days. Supernatant was collected for quantification of prostaglandin by ELISA. RNA was then isolated from pelleted cells and cDNA was synthesized. There was significant decrease ($P<0.05$) in PGF2 and PGE2 concentrations following CRISPR/Cas9 based editing of PTGES and PTGFS genes. Real time PCR showed a significant decrease ($P<0.05$) in COX-2, PTGEs and PTGFS mRNA expression following CRISPR/Cas9 based editing of COX-2, PTGES and PTGFS genes (Fig. 21)

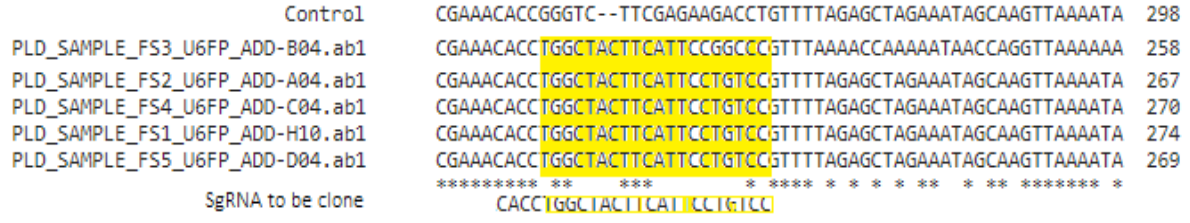


Fig. 19: Nucleotide BLAST analysis of the clone for the presence of PTGFS SgRNA sequence. PTGFS SgRNA sequence is highlighted in yellow colour.

```
                                Control      CGAAACACCGGGTCTTC--GAGAAGACCTGTTTTAGAGCTAGAAATAGCAAGTTAAAATA  298
_PLD_SAMPLEES2_U6_FP_ADD_H04.ab1           CGAAACACCGTCATCAAAATGTACGTGGTGTTTTAGAGCTAGAAATAGCAAGTTAAAATA  173
_PLD_SAMPLEES3_U6_FP_ADD_A05.ab1           CGAAACACCGTCATCAAAATGTACGTGGTGTTTTAGAGCTAGAAATAGCAAGTTAAAATA  252
_PLD_SAMPLEES4_U6_FP_ADD_B05.ab1           CGAAACACCGTCATCAAAATGTACGTGGTGTTTTAGAGCTAGAAATAGCAAGTTAAAATA  248
_PLD_SAMPLEES1_U6_FP_ADD-F09.ab1           CGAAACACCGTCATCAAAATGTACGTGGTGTTTTAGAGCTAGAAATAGCAAGTTAAAATA  272
_PLD_SAMPLEES5_U6_FP_ADD_C05.ab1           CGAAACACCGTCATCAAAATGTACGTGGTGTTTTAGAGCTAGAAATAGCAAGTTAAAATA  249
                                           **********           * *   *******************************

                          Sg RNA to be clone     CACCGTCATCAAAATGTACGTGGT
```

Fig 20: Nucleotide BLAST analysis of the clone for the presence of PTGES SgRNA sequence. PTGES SgRNA sequence is highlighted in yellow colour.

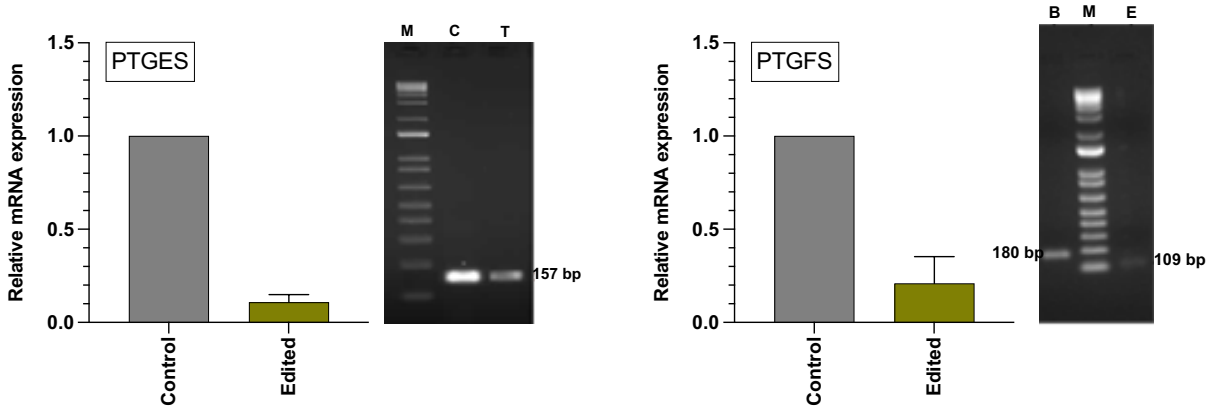


Fig. 21: Expression profiling of PTGES and PTGFS mRNAs following CRISPR/Cas9 based targeted editing.

DST-SERB: Establishment of 3D in vitro culture conditions for maintaining long-term stemness in sheep spermatogonial stem cells

BK Binsila

Three-dimensional culture system (Geltrex) maintained long-term SSCs propagation and stemness. The stemness of cultured SSCs was significantly higher in hypoxic culture condition when compared to normoxic environment.

Spermatogonial stem cells (SSC) are unipotent stem cells and serve as the precursor cells for the production of spermatozoa. SSCs play significant role in augmenting male fertility. SSCs isolated from the fertile donor can be transplanted to the infertile recipient for donor derived spermatogenesis. To achieve success in these applications, sufficient numbers of SSCs are required. The objectives of the project are: 1) To establish 3D culture condition for sheep spermatogonial stem cells (SSCs) stemness maintenance in vitro; 2) To understand the molecules involved in stemness associated pathways in SSCs culture systems; 3) To assess the cultured spermatogonial stem cell potency using in vivo mouse model.

SSCs were isolated from sheep testis and enriched using differential plating technique. Three-dimensional culture systems namely, Geltrex matrix plate and Spheroid culture system was compared for SSC culture and stemness maintenance. Stemness gene expressions was studied between long-term cultures of hypoxia and normoxia condition. The Geltrex coated plates out performed than the control plates (uncoated plates), in terms of culture morphology, growth rate and stemness maintenance (Fig. 22). The expression of stemness marker genes such as STAT3, FOXO1, CDH1, ETV5, UCHL1 and ITGB1 were maintained over the passages revealed the self-renewal capability of the cultured SSCs in Geltrex

coated plates when compared to the control. In spheroid culture, no significant cell growth was observed. SSCs propagated and subcultured for long-term (6 months; 14 passages) in Geltrex culture system under both hypoxia and normoxia conditions. In hypoxia condition the pluripotent and embryonic marker NANOG and stemness markers (THY1, and PIWIL4) were significantly ($P<0.05$) upregulated than in normoxia over the passages. However, there was no significant difference in apoptosis genes expression (BCL2 and BAX) between hypoxia and normoxia conditions. Metabolomic profiling (LC-MS and data analysis using Compound Discoverer 3.2) was done in the spermatogonial stem cells extracts cultured under hypoxia and normoxia condition. Differentially abundant metabolites were present in spermatogonial stem cells grown under hypoxia and normoxia condition (Table 10) and the changes in the stemness may be associated with the shift in the SSC metabolomes under reduced oxygen conditions.

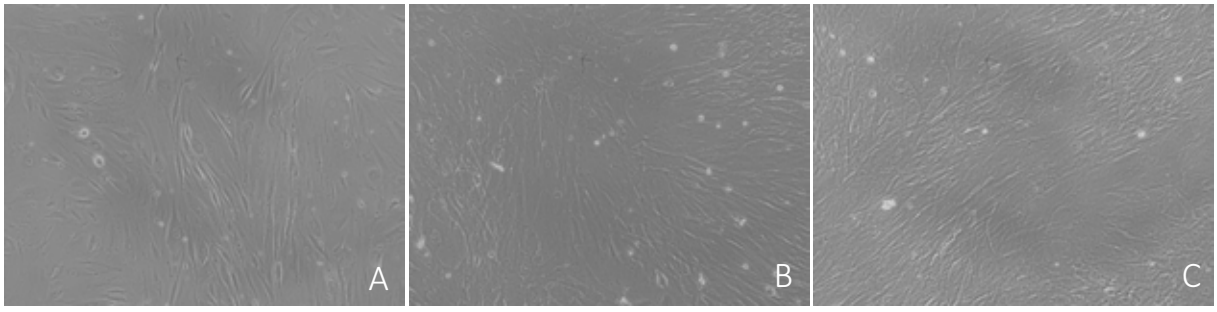


Fig. 22: Representative images of the long term culture of the spermatogonial stem cells in 3D culture system. A: passage 1; B: passage 5; C: passage 11.

Table 10: Metabolites differentially abundant in the hypoxia and normoxia cultured spermatogonial stem cells.

Metabolomes (Hypoxia)	Fold change	P-value
L-Histidine	1.59	0.03
L-Lactic acid	0.21	0.12
Prolyl leucine	-2.1	0.02
Uridine	-1.01	0.03

DBT-Twinning: Biotechnological interventions to augment productive performance of pigs on horticultural by-product based diet

M Chandrasekharaiah, NM Soren, AP Kolte

The horticultural by-products-based rations supplemented with pre and probiotics in the diet of grower pigs modulates the hindgut microbiota and were effective in establishing a favourable gut microbial composition., which might be beneficial to the health and performance of the pigs.

Pigs are concentrated in the NE Region where almost 40% of the country's total pig population is reared. Pork has a great demand in the NER. Shortage of livestock feed and the high cost of feed is a major problem for the farmers. The horticultural byproducts/waste including vegetables and fruit byproducts which are generally thrown away may be converted to suitable animal feed. Therefore, efforts were made to evaluate the horticultural by-products in pig rations by assessing the hindgut microbial diversity in response to horticultural by-products-based rations with pre and

probiotics in growing pigs. The faecal samples were collected from the growing pigs (AAU, Assam) fed with seven iso-nitrogenous experimental diets/rations viz., conventional ration/ standard ration which served as Control (R-I), horticultural by-products and conventional ration/ standard ration in 30:70 without prebiotic and probiotic (R-II), horticultural by-products and conventional ration/ standard ration in 30:70 with prebiotic and probiotic (R-III), horticultural by-products and conventional ration/ standard ration in 40:60 without prebiotic and probiotic (R-IV), horticultural by-products and conventional ration/ standard ration in 40:60 with prebiotic and probiotic (R-V), horticultural by-products and conventional ration/ standard ration in 50:50 without prebiotic and probiotic (R-VI), horticultural by-products and conventional ration/ standard ration in 50:50 with prebiotic and probiotic (R-VII). DNA was extracted by standard method and post-experiment samples were evaluated by V3-V4 region of the 16S rRNA gene sequencing, using amplicon sequencing and studied the microbial diversity. Assessment of hindgut microbial diversity in response to horticultural by-products-based rations with pre and probiotics in growing pigs indicated that pre and probiotic supplementations in the diet of grower pigs modulates the faecal microbiota and were effective in establishing a favourable gut microbial composition. Microbial diversity study indicated that the supplementation of pre and probiotic had profound effect on the pathogens as well as probionts and fibre degrading micro-organisms as revealed by the 16s rRNA amplicon sequencing of the V3-V4 regions. Analysis of the faecal microbial communities in grower pigs revealed significant changes in the overall structure, particularly in the abundance of Firmicutes. In addition, the levels of several pathogenic bacteria, in general were decreased and the abundance of several lactic acid bacteria species increased concurrently with pre and probiotic administration.

DST (Indo-Iran): Identification of potential biomarkers in donor cows for in vitro embryo production by integrative genomic and system biology approaches

S Mondal, IJ Reddy, S Nandi, PSP Gupta

Standardized in vitro maturation protocol in oocytes and optimized the expression profiling of FGF2, FGF8, IGF-1R, IGF-1, IGF-2 and IGF-2R genes in immature and matured oocytes.

Ovaries collected from slaughterhouse were washed with 70% ethanol to avoid contamination. Ovaries having visible follicles with a diameter of 2 to 6mm were aspirated. Cumulus oocytes complexes were graded by morphological appearance of the cumulus cells investments and homogeneity of ooplasm under a stereo zoom microscope. The oocytes were graded according to the cumulus cells investments and homogeneity of ooplasm. Grade 1: Oocytes with complete compact dense cumulus oophorus having >5 layers of cumulus cells and with transparent homogenous cytoplasm; grade 2: Oocytes with complete compact dense cumulus oophorus with <4 layers of cumulus cells and with transparent homogenous cytoplasm; and grade 3: oocytes without cumulus cells and with irregular (shrunken) cytoplasm. Oocytes having >5 layers of unexpanded cumulus cells and granular homogenous ooplasm were selected and cultured in maturation medium at 38.5°C, 5% CO2 and 95% humidity for 22-24h. The degree of cumulus cell expansion was determined after 22-24h of IVM and oocyte with expanded cumulus cell mass to at least 2 diameters away from the zona pellucida were considered as cumulus expanded. The maturation of oocytes was evaluated by identifying the first polar body in perivitelline space after denuding them. The maturation rate was 73.8±6.78%. Total RNA was isolated from the immature and mature oocytes (N=25) using Trizol and RNeasy Mini Kit (Qiagen, USA). The quality and integrity of the purified RNA was checked through agarose gel electrophoresis and quantity was measured using nanodrop spectrophotometer. The first strand cDNA was synthesized by using iScriptTM cDNA synthesis kit (BIORAD) following the protocol: Iscript reverse transcriptase (1µl), 5X iScript reaction mix (4µl), Nuclease free water (14µl) and 100ng RNA (1µl) to make total volume 20µl. The reaction was incubated at 25°C for 5 min, 42°C for 30min followed by 85°C for 5min. The PCR conditions for amplification of 172bp FGF2, 200bp FGF8, 156bp IGF-1R, 232bp IGF-1, 177bp IGF-2, and 205bp IGF-2R and 150bp of β-actin were optimized. Further work on expression of FGF2, FGF8, IGF-1, IGF-1R, IGF-2 and IGF-2R mRNAs in both mature and immature oocytes are on progress.

ECLIPSE: Assessing the productive and adaptive capability of two different goat breeds to heat stress based on differences in the phenotypic and genotypic traits

V Sejian, M Bagath, G Krishnan, R Bhatta

Nandidurga breed apart from adapting very effectively to extremely severe heat stress also maintained its growth and meat production and quality reflecting its better climate resilient potential.

The objectives of project were: a) To assess the local weather condition and program the THI/ HLI of the study locality; b) To study the impact of heat stress on growth and meat production characteristics of two different breeds of goat; c) To assess the impact of heat stress on the adaptive capabilities of two different breeds of goat; d) To compare differences in transcriptional profiles between normal and heat stressed goat breeds to identify thermo-tolerant genes; e) Identification and characterization of novel genes in two different breeds of goat to adapt to heat stress; f) Association analysis of gene expression data with THI/HLI indices and different phenotype traits related to heat stress.

A study was conducted in two indigenous goat breeds Nandidurga and Bidri for comparatively assessing their adaptive potential to heat stress challenges. The THI obtained in the control chambers was 71.8, while in heating chambers it was 95.6. Any value above 78 is considered extremely stressful. Therefore, the hypothesis of subjecting heat stress group animals to extremely severe heat stress was justified. The growth variables were maintained in Nandidurga goat breed, while in Bidri breed, only the body condition score was significantly reduced during heat stress. The major carcass traits, primal cuts, external carcass traits, and edible offals did not differed in both the breeds during heat stress. However, meat quality variables were affected significantly in Bidri breed, whereas Nandidurga breed was also able to maintain the meat quality. Both the breeds relied on behavioural mechanisms to adapt to heat stress challenges. However, in Bidri breed defecating frequency, urination time and defecation time additionally altered as compared to only feed intake variable in Nandidurga breed. Both the breeds significantly utilized the physiological variables such as respiration rate, rectal temperature and skin temperature to cope with heat stress. However as compared to Nandidurga breed, Bidri breed also used the pulse rate effectively to adapt to heat stress. Both the breeds kept intact most of the blood and endocrine variables. However, the lymphocyte percentage was significantly lower in Bidri breed. The results on the rumen metagenomics clearly projected the advantage of possessing more microbial diversity during heat stress exposure in Nandidurga breed as compared to Bidri breed (Fig. 23). The results on the liver transcriptomics established 53 common differentially expressed genes in both the breeds. However, the unique DEGs significantly altered in Nandidurga and Bidri breeds were 361 and 328 genes, respectively. The results on the skin transcriptomics established 14 common differentially expressed genes in both the breeds. However, the unique DEGs significantly altered in Nandidurga and Bidri breeds were 759 and 336 genes, respectively.

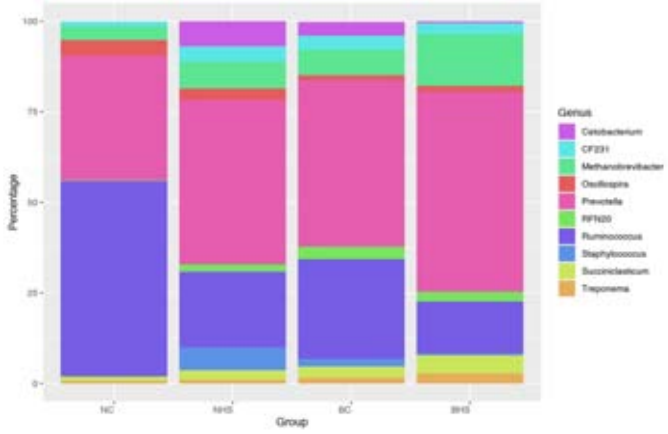


Fig. 23: Relative abundance of rumen microbiome at genus level between the control and heat stress groups of both Nandidurga and Bidri breeds.

The bisulfite sequencing results to establish DNA methylation pattern revealed less changes in Nandidurga breed as compared to Bidri breed (Table 11). The total hypomethylated and hypermethylated genes (DMGs) in Nandidurga breed were 275 and 252 respectively while in Bidri breed they were 1394 and 563 genes respectively. The molecular characterization of HSP70 gene revealed 1962bp, 641AA, 70.197KDa specification. The association analysis of all studied variables with THI revealed different biomarkers in both indigenous Nandidurga and Bidri goat breeds.

Table 11: Description of both differentially methylated regions and genes in Nandidurga and Bidri breeds. DMRs : Differential methylated regions; DMGs: Differential methylated genes.

Particulars	mCpG		mCHG		mCHH	
	Hypo-methylated	Hyper-methylated	Hypo-methylated	Hyper-methylated	Hypo-methylated	Hyper-methylated
Differential Methylated Regions (DMRs)						
NC vs NHS	200	205	31	32	142	112
BC_vs_BHS	394	443	411	58	1090	303
Differential Methylated Genes (DMGs)						
NC_vs_NHS	139	141	27	23	109	88
BC_vs_BHS	240	278	326	48	828	237

Inter-Institutional: Biosynthesis of different nano mineral particles using plant extracts and evaluation of their potential as feed supplement in poultry

D Rajendran

Method of green synthesis of zinc nano particle was standardized and particle was evaluated for its size and found to be 10.84 nm

The objective of this project are: 1) to biosynthesise different nano mineral particles using green processes utilizing plant extracts; 2) to evaluate nano mineral particles as feed supplements in broilers and layers.

Bulk Production of nano zinc oxide particles was done using aqueous leaf extract of neem or moringa tree leaves. Zinc nitrate was used as base material for preparation and leaf extract was used as reducing agent. After preparation of nano zinc particles with phytochemicals, products were subjected to ashing for removal of phytochemicals and other carbon particle to get pure zinc oxide nano particle. The prepared ZnO nano particles were characterized using various techniques such as UV–Vis absorption spectroscopy, particle size analyser, and transmission electron microscopy (TEM). The average particle size of the biosynthesized nano zinc oxide particles was 10.84nm. The TEM analysis also showed that most of the particles are in the range of 10-100nm. Finally, it was confirmed using UV visual spectroscope at 360-380nm and absorption peak was observed.

Inter-Institutional: Ethno-Veterinary study for enhancement of reproductive performance in livestock

S Nandi, PSP Gupta, S Mondal

Coumarin (an active ingredient of Leptadenia and Aegele leaves) and Diosmetin (an active ingredient of Leptadenia leaves) at the dose of 25-50μM promoted the preantral follicle and granulosa cells functions. Auraptene (10 to 25μM), a derivative of coumarin, was found to be beneficial on PFs and GCs growth, and PF enclosed oocyte development.

Future perspectives to ethno-veterinary research are developed parallel with the advances in laboratory and clinical sciences. Plant-derived bioactive chemicals are the viable agents for a broad range of mammalian reproductive disorders. It also minimizes the need for exogenous hormones or growth factors. However, these chemicals have dose-dependent effects, hence a thorough analysis of cellular and molecular pathways are needed. Phenolics (reported to regulate Foxo3 signal pathways) and alkaloids (reported to have effect on central nervous system) are phytochemicals found in medicinal plants that have a key role in improving mammalian reproductive ability. We hypothesized that plant based products (as plant extracts or their active ingredients) may be used to improve reproductive management and to overcome reproductive problems. The objectives were: a) To study the effect of the extracts from leaves of Murraya koenigii, Mimosa Pudica, Aegle marmelos, Bacopa monnieri, Curcuma longa, Leptadenia reticulate, Asparagus racemosus and Moringa oleifera on the ovarian responses in mice/rats; b) To study the effect of pure form of active ingredients of the above plants on ovine ovarian follicle development, granulosa and uterine cell functions and to elucidate the mechanisms of pro-fertility/anti-fertility responses; c) Validation of these practices on management of reproduction. In the present study, we examined the efficacy of plant extracts and active ingredients of leaves of Bacopa (Bacoside), Asparagus (saponin, sarsasapogenin) and Leptadenia (Coumarin, Diosmetin) on functional parameters of preantral follicles, granulosa and uterine cells. The preantral follicles (PFs), granulosa cells (GCs) and uterine cells (UCs) retrieved from abattoir derived ovine ovaries were treated with the plant molecules at the concentration of 0.1, 1, 2.5, 5, 10, 25, 50 and 100μM. The effect of the methanolic extracts from the leaves on the granulosa cell (GC) functions was performed at different doses (0, 5, 10, 25 and 50μg/ml). The preantral follicle growth rates, viability rates, antrum formation and apoptosis, and the functional parameters of the granulosa/uterine cells (viability, growth rates, monolayer formation rate, apoptosis) were evaluated. Asparagus and Leptidenia leaf extracts shown to have proliferative effects on granulosa and PFs, whereas Bacopa had no significant effect. Of all the bioactive compounds examined, Coumarin and Diosmetin had the beneficial effect on PF and GC functions. Coumarin (50μM) and Diosmetin (25μM) had shown a significantly higher PF growth rate (14.4$\pm$0.8 vs 18.2$\pm$1.1μm/day) and survival rates (75.3$\pm$3.6 vs. 80.4$\pm$4.2%) among all the treatment doses. Significant increase in PF and GC functions was observed in 50μM Sarsasapogenin group but the quality of PF and GC was deteriorated in long term culture. Likewise, granulosa cell number and viability were significantly increased at 25μM dose in both Coumarin and Diosmetin groups. Oestradiol production was significantly correlated with the granulosa cell number increment, where higher amount of oestradiol (pg/ml) was produced at 25μM doses of both Coumarin and Diosmetin. In a separate experiment, effective doses of the bioactive compounds were supplemented in culture medium of granulosa cells retrieved from preantral follicles. mRNA was isolated and gene (CYP19 (Steroidogenic), GDF9, FGF2 (Proliferative), BAX and BCl2 (apoptotic genes)) expression studies were carried by using qPCR. Coumarin (25μM) was shown to cause significantly higher gene expression compared to other phyto-bioactive compounds with respect to the Cyp19, GDF9 and BCl2 genes. The spent media collected

form cultured GCs and PFs of the bioactive compounds was subjected to ammonium sulphate precipitation at different percentages for fractionation. Size exclusion chromatography was performed using Sepahdex G-25 as a matrix. Pooled eluents were lyophilized and analysed by SDS PAGE. After running on the SDSPAGE obtained protein bands excised, trypsinized and further analysed by running the MALDI TOF (results awaited). Only Coumarin and Diosmetin had shown some beneficial effects on viability of uterine cells however, none had any significant role in UCs growth parameters. Auraptene (10 to 25μM), a derivative of coumarin, showed significant improvement in ovarian follicle and oocyte development.

Feed Informatics, Feed Quality and Safety and Value Addition

FQS 4.3: Development of a novel phytogenic blend to replace antibiotic growth promoters in broiler production

RU Suganthi, J Ghosh, VB Awachat

The in vitro studies revealed the antioxidant and anti-inflammatory potential of the studied essential oils.

Antimicrobial resistance is recognized as a major public health problem worldwide. A number of reports criticize the practice of using sub-therapeutic doses of antibiotics as growth promoters (AGP) in poultry production as one of the contributing factors for the surge in antimicrobial resistance. The indiscriminate use of AGPs to control sub-clinical infections, improve growth, feed conversion efficiency and the economics of broiler chicken production is associated with the emergence and transmission of antibiotic resistance in bacteria including zoonotic pathogens and carryover of antibiotic residues in poultry products intended for human consumption. Hence, AGPs are already banned in some countries and a similar call is expected from other counties as well. Therefore, products that could function as alternatives to AGPs are immediately needed for a sustainable poultry production. Phytogenics are widely explored as alternatives to AGPs in view of their excellent pharmacological properties. The present project was thus taken with the objective to complement broiler feed with a novel phytogenic blend as a replacement to AGP in broiler production.

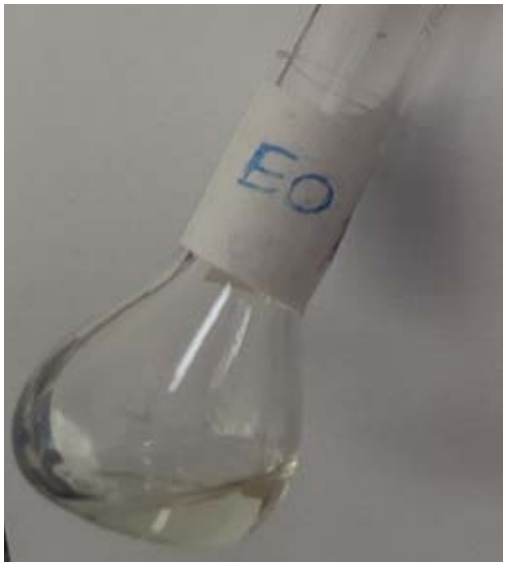


Fig. 24: Essential oil extracted from phytogenics.

During the period under report, literature was reviewed to identify the major phytochemicals present in each phytogenic constituent of AB Free and their antimicrobial activities. For future studies in broilers, the phytogenic blend to be evaluated was prepared and its phytochemical composition is being determined by LC-MS/MS. Further, to test the efficacy of essential oils in poultry, the essential oils of identified phytogenics were extracted (Fig. 24) and their in vitro antioxidant activity and anti-inflammatory activities were determined.

FQS 4.4: Assessment and characterization of antimicrobial resistance (AMR) genes in poultry production environment

AP Kolte, A Dhali, PK Malik, DT Pal, R Bhatta

Majority of the AMR genes detected in livestock production environment were the broad-spectrum tetracycline class of antibiotics and different Tet classes conferring resistance to various tetracycline classes.

The resistance to the antibiotics is either naturally present in the microbes associated with the animals or acquired through adaptation subsequent to the usage of the antibiotics in the animal feed, particularly in the pig and poultry, as growth promotors or for therapeutic purposes in suboptimal doses. Further as the microbes from the animals are released into the environment, the resistance may be transferred to the other microbes in the environment. The ability of the resistant microbes to thrive in presence of the therapeutic antibiotics is a major concern and has become a global public health concern and poses most serious health threat. More than 50% of the bacterial human pathogens developed resistance against third generation antibiotic cephalosporin and last resort antibiotics like carbapenem and colistin. Approximately 70% of the antibiotics produced are used in the animals for treatment, prophylaxis and growth promotion. Therefore, multiple drug resistant species of the animal and zoonotic bacteria were recently detected from the animals and their products. This project aims towards investigating the incidence of the AMR through whole metagenome sequencing approach in the poultry farms and correlation of the heavy metal levels with the AMR gene load in the poultry. To investigate the resistance profile of the environment of the farm, data was generated from the other livestock species (cattle, buffalo, sheep and goat) maintained on the same farm where the poultry is also housed to understand the environmental content of the antimicrobial genes. The prevalence of the AMR genes was estimated though the whole metagenome sequencing of the rumen contents of the other livestock species (Fig. 25). Majority of the AMR genes detected were for broad-spectrum tetracycline class of antibiotics and different Tet classes confers resistance to various tetracycline classes. These genes were detected in all the metagenomes investigated irrespective of the livestock species and thus can be considered as the part of natural resistome. Other classes of antibiotics resistance genes were detected occasionally only in one of the samples like lincosamide, erythromycin, streptomycin, kanamycin, gentamicin, and neomycin. The poultry faecal samples from the Institutional and commercial farms are collected and being investigated for presence of the AMR genes as well as levels of heavy metals in the faecal contents.

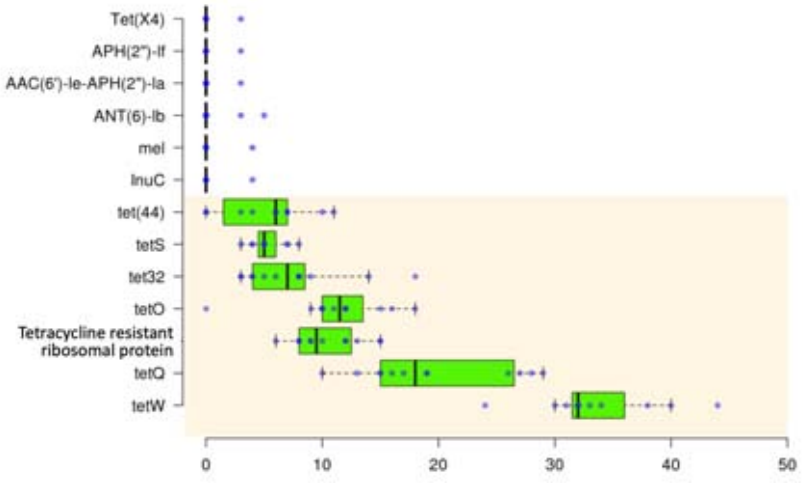


Fig. 25: Presence of antibiotic resistance genes in the rumen contents of the livestock species maintained on the farm where the antibiotic usage is strictly for therapeutic purpose.

FQS 4.5: Assessment and forecasting of feed resources at regional and national level for different production scenarios

S Anandan, K Giridhar, D Rajendran, NKS Gowda, S Jash, G Ravikiran

The demand for animal feed resources at national level works out to be 412, 1030 and 126 million tons of crop residues, greens and concentrates, respectively.

Assessing feed demand supply scenario precisely is quite a complicated task given the diverse production systems, feed resources and feeding systems coupled by limited or lack of information on diverse inputs required for the assessing the demand or supply of resources. However, given the importance of the livestock and its impact on the livelihood and food security, a broad based estimate is reasonably good enough to help the policy and development agencies in taking appropriate decisions and interventions in safeguarding the sustainability of the livestock production.

For the demand scenarios only the major livestock species - cattle, buffalo, sheep, goats, poultry and pigs have been considered and demand has been considered in terms of feed resources such as crop residues, green fodder and concentrates. Requirements for various categories of feed resources has been worked out based on recent livestock census as per the different age categories considering the feed requirement in terms of the dry matter sourcing from crop residues, green fodders and concentrates. The current estimates are based on the fact that given the shortage of feed resources estimates based on standard recommendations of fulfilling the dry matter, protein and energy is neither possible nor is practised in case of ruminants. Owing to the shortage of feed resources the actual practise followed in the field conditions has been used to arrive at the estimates, wherein concentrates are preferentially allotted to the milch animals followed by growing & working animals.

The current estimate is an attempt in this direction wherein allocation of feed resources has been simulated to be mimic the actual feeding practices observed in the field conditions. Generally, milch animals have been allotted concentrates as per the recommendations and rest of the categories of ruminant livestock have been allotted a nominal amount of concentrates. Using the above allocation, the demand for feed resources for all states and union territories has been estimated and the estimated annual demand at national level works out to be 412, 1030 and 126 million tons of crop residues, greens and concentrates respectively.

ICAR-CRP: Biofortification of cereals - evaluation of value addition cereals (VAC) and cereal by-products for animal feeding

SBN Rao, NM Soren, M Chandrasekharaiah

The straw CP was negatively correlated with CF of straw and positively correlated with iron and zinc content of brown rice and zinc content of polished rice. CF of rice straw was negatively correlated with important plant breeding parameters such as single plant dry weight, flag leaf length, iron content of brown rice, zinc content both brown and polished rice.

Eight bio-fortified varieties (BFV) namely, Zinco Rice, Surabhi, Protozin, CGZR2, DRR Dhan 45, DRR Dhan 48, DRR Dhan 49 and CR Dhan 311 obtained from IIRR, Rajendranagar were evaluated. The crude protein (%) of rice straw was ranging from 4.2 in Zinco Rice to 6.0 in CAZR2 with average of 5.05 in BFV. The Straw CP was negatively correlated with CF of straw and positively correlated with iron in brown rice, zinc in brown rice and zinc in polished rice. The CF (%) of rice straw was ranging from 38.1 in CAZR2 to 50.8 in DRR Dhan 49 with average of 45.2 in BFV. The straw crude fibre was negatively correlated with many plant phenological parameters such as Single Plant Dry weight (SPDW), Flag leaf length (FLL), Iron in Brown Rice, zinc in brown rice, zinc in polished rice and straw CP and positively correlated with Straw iron content.

The Zinc (ppm) of rice straw was ranging from 5.5 in Zinco Rice to 8.7 in DRR Dhan 49 in with average of

7.49 in BFV. The straw zinc was negatively correlated with iron in polished rice. The iron (ppm) of rice straw was ranging from 52.9 in Surabhi to 228 in DRR Dhan 48 with average of 135 in BFV. The straw iron was positively correlated with straw CF, and IVOMD. IVOMD ranged from 37.9 in DRR Dhan 45 to 49.6 in DRR Dhan49 with an average of 43.0 in BFV. The measure of VFA reflects fermentation potential of straw. Acetate is the end product of cellulose fermentation and concentrations (meq/1000ml) are ranging from 23.7 in DRR Dhan 45 to 34.1 in Zinco Rice with an average of 28.9 in BFV. Propionate is the end product of soluble carbohydrate fermentation and ranging from 6.5 in DRR Dhan 45 to 9.1 in Zinco Rice and CGZR2 with an average of 7.8 in BFV. Butyrate is the end product of carbohydrate fermentation important in maintaining rumen and colon epithelial health and ranging from 2.2 in DRR Dhan 45 to 3.5 in Zinco Rice and CGZR2 with an average of 2.8 in BFV.

Total VFA gives a measure of fermentation of complex carbohydrates present in the straw. The concentration ranged from 33.5 in DRR Dhan 45 to 48.6 in ZincoRice with averaging 40.9 in BFV. Correlation analysis revealed that individual VFA as well as TVFA did not have positive or negative significant correlation any of the plant phenological parameter or straw quality parameter. However, positive significant correlations were obtained between acetate and propionate, butyrate and TVFA. Similarly, propionate is positively correlated with butyrate and TVFA. Butyrate is also positively correlated with TVFA.

ICAR-Outreach: Monitoring of drug residues and environmental pollutants

S BN Rao, DT Pal, S Jash, A Manimaran

Mastitis is the most important reasons for AMU and the evidence generated in this study would be useful to make refinement of treatment protocol and prudent antimicrobials use in the study area.

The widespread use of antibiotics and pesticides in agriculture and animal husbandry practices leads to the presence of these residues in edible products of animal origin like milk, meat and eggs. This issue is very important in respect to consumers and international trade. In this context, monitoring of drug residues and environmental pollutants in livestock products for human consumption is becoming necessary. A study was conducted at Bengaluru Milk Union Limited (BAMUL), Devanahalli taluk (Bengaluru rural district) of Karnataka. A total of 6097 treatment records for the period of 2019-2020 during different seasons (summer: March-June; winter: November-February and rainy: July-October) were collected and proportional rate of various health disorders and their seasonal influence were analysed by log-linear model. Mastitis, digestive disorders, skin and musculo-skeletal disorders and infertility problems were the most common (80%) under field conditions. Proportional rate of endemic and infectious diseases were significantly higher in summer, while skin and musculo-skeletal disorders were higher in winter seasons. About 96% of the antimicrobials were used for mastitis (46%; 1.27 drugs/case), digestive disorders (16%; 0.43 drugs/case), endemic and infectious diseases (13%; 0.97 drugs/case), skin and musculo-skeletal disorders (11%; 0.57 drugs/case) and infertility problems (10%; 0.66 drugs/case). Aminoglycosides (21%), cephalosporins (20%) and tetracyclines (18%) were most commonly used than other groups of antibacterial drugs for above health disorders. Qualitative screening of milk samples (N=198) revealed 10% prevalence of antibiotic residues under field conditions.

ICAR-AICRP: Micro and secondary nutrients and pollutant elements in soils and plants

K Giridhar, NKS Gowda, DT Pal

Azolla absorbed over 71% of lead and 95% of cadmium from the contaminated water, confirming its potential as an economical and practical means for bioremediation of sewage water used for irrigating vegetable and fodder crops.

Heavy metals contribute to environmental pollution as they are non-biodegradable, and normally, do not leach from the topsoil. Irrigation with untreated sewage containing industrial effluents causes accumulation of heavy metals in soil and subsequently, in crops like fodders and vegetables, posing a health hazard to livestock and humans. Hence, a study was taken up with an objective to field test the potential of using Azolla for removal of heavy metals, lead and cadmium and help in the bioremediation of sewage water.

The farmers of Kalkunte village in Kolar district impound the untreated sewage water in the ponds and use it for drip irrigation of the fodder and vegetable crops. The water samples were taken and tested for the content of lead and cadmium. Azolla was placed on the bamboo rafts and grown in the pond for one week to remove the heavy metals (Fig. 26). First batch of Azolla was removed from the raft, water samples were collected and fresh Azolla was introduced into the pond and grown for another week. The water samples were analysed after first and second weeks to see the impact of Azolla on removal of heavy metals. The initial lead content of 0.035ppm was reduced by 43% in the first week, and by another 50% in the second week to 0.01ppm in view of the absorption by Azolla. Similarly, initial of level of cadmium (0.02ppm) declined by 50% in the first week to 0.01ppm and by further 90% to 0.001ppm in the second week due to Azolla's absorption.

Fig. 26: Azolla's growth on bamboo raft in the pond.

Climate Change Impact on Livestock

CCL 5.2: Life cycle assessment of sheep farming in Bengaluru rural

A Mech, G Letha Devi, PK Malik, M Sivaram, RK Veeranna

Respective average growth rates (g/d) were 63.8, 17.8 and 36.9 and 25.7 in male and female sheep during the first one year and second year of age respectively. The body weight at marketing was 20-28kg. The average ratio of ram and ewe recorded was lower (1:6) and average lambing percentage was recorded as 55.8%

Sheep rearing is very popular among landless labours, marginal and small farmers in arid, semi-arid and mountain areas. According to 20th livestock census report, total sheep population in India is 74.26 million (2019), constituting 13.8% of total livestock population in the country. The increase popularity of sheep rearing is evident from the fact that its population has gone up 14.1% since 2012 livestock census (19th) in the country. Global greenhouse emission (GHG) from livestock sector is estimated to be 6 billion tones (18% of total global emission). Contribution of sheep to global GHG emissions is 254.4 million tonnes CO2-eq of which respective contribution of milk and meat is 67.4 and 186.9 million tonnes CO2-eq (FAO, 2013). The impacts of production and consumption of agricultural products are best assessed by accounting for resource use and environmental emissions throughout the full life cycle of a product, by applying life cycle assessment (LCA) methodology. In sheep production system, the degree of complexity for conducting LCA studies is due to co-production of meat, wool and milk. India rank 3rd in sheep population, even then there is no LCA studies on GHG emissions from Indian sheep farming. With this background,

the study has been proposed with two major objectives: 1) Analysing carbon footprint of meat and greasy wool production from sheep farms of Bengaluru rural; 2) Development of model for GHG emission assessment from Sheep farming.

During the reported period, four rounds of data were collected in 17 sheep farms in Lakshmidevipura and S Nagenahalli village, located in Dodballapur Taluk, Bengaluru rural, Karnataka (Fig. 27). The flock size varied between 10-50 with an average flock size of 27. Information on farm as well as off farm feed production was also collected from all the farms. Feed samples from individual farms as well as grazing area were collected and were analysed for its nutritional constituents (AOAC, 2019). Nutrient compositions of the collected feed samples are depicted in Table 12. The size of the grazing areas was 50 and 300 acres in Lakshmidevpura as well as S.Nagenahalli respectively (Fig. 28). The approximate number of livestock that were grazing in the grazing land of Lakshmidevpura was 94 cattle, 160 sheep and 10 goats whereas in S.Nagenahalli there were 180 cattle, 320 sheep and 8 goats.

Fig. 27: Grazing area in Lakshmidevipura (A) and S. Nagenahalli (B and C) villages.

Average age of ewe at first lambing was 14 months and average lambing percentage was 55.8%. The ratio of ram and ewe varied between 1:5 to 1:13 with an average of 1:6. Information on farm feed production as well as off farm feed production was collected. Feed samples from individual farms as well as grazing area were collected and were analysed for its nutritional constituents. Body measurements of sheep were taken at two month intervals for body weight calculation. However, for validation of calculated body weight from body measurement, sheep of different age groups were randomly selected and their weights were taken in a platform balance (Fig. 28). The body weight of male and female sheep at birth, at 6 months, 1 year, 2 years and above 2 years of age has been depicted in Table 13. Average growth rate (g/d) of the male sheep was 63.8 and 17.8, and female sheep was 36.9 and 25.7 during the first one year and second year of age respectively. The body weight at marketing ranged between 20-28kg.

Fig. 28: Body measurement of sheep being taken for calculating body weight and direct weighing of body weight using platform balance.

Table 12: Nutritional evaluation of collected feed samples.

Feed Ingredient	DM (%)	CP (%)	EE (%)	Ash (%)	NDF %	ADF (%)	ADL (%)
Concentrate							
Concentrate (Nandini)	88.9	20.2	2.59	10.6	47.1	15.8	4.51
Maize	89.1	7.95	3.90	1.75	56.5	5.99	0.90
Ground nut cake (GNC)	93.0	41.3	7.95	7.00	31.3	18.3	5.40
Concentrate (NIANP)	89.8	19.4	4.44	5.63	49.2	5.42	0.42
Rava Bhoosa	88.9	15.6	3.28	4.55	40.7	9.33	2.37
Roughage							
Ragi Stover	90.9	4.59	0.43	8.05	82.9	49.3	6.62
Maize stalk (dried)	92.2	1.83	0.31	4.57	89.2	45.7	3.08
Ragi straw	87.5	4.85	0.70	12.0	72.4	48.4	5.49
Horse gram straw	93.5	4.58	0.58	7.72	74.9	62.1	12.0
Maize straw	57.2	8.90	1.01	4.15	71.9	35.5	6.23
Green							
Mixed grass	38.9	5.03	1.26	6.90	76.5	52.8	8.35
COFS31	40.1	8.20	1.21	10.7	72.0	46.3	7.08
Mixed grass (grazing area)	46.6	8.03	0.48	8.29	71.8	46.4	6.80
Castor leaves	20.5	30.9	1.91	8.00	41.4	17.2	2.70
Sere Hullu grass (local name)	14.2	18.5	2.77	14.7	65.3	31.3	3.11
Sesbania leaves	20.3	24.8	3.99	9.52	39.4	18.4	3.82
Thumbai straw grass	24.0	14.4	1.80	17.5	58.7	31.0	4.49
Maize leaves	35.6	3.20	0.96	15.0	75.6	43.7	4.40

Table 13: Body weight and daily weight gain at different ages in sheep.

Particulars	Male (N)	Female (N)
Body weight at birth (kg)	3.50±0.3 (9)	3.10±0.2 (7)
Body weight at 6 months (kg)	14.4±1.0 (8)	10.5±1.0 (10)
Body weight at 1-year age (kg)	26.8±2.1 (10)	16.6±2.5 (20)
Body weight at 2-year age (kg)	33.3±1.30 (10)	25.9±1.1 (23)
Daily weight gain until 1 year age (g/d)	63.8 (10)	36.9 (20)
Daily weight gain during 1 to 2 year age (g/d)	17.8 (10)	25.7 (20)

ICAR-Outreach: Estimation of methane emission under different feeding systems and development of mitigation strategies

Coordinator: R Bhatta
PK Malik, AP Kolte, C Devaraj

Supplementation of divi-divi (Caesalpinia coriaria) pods at a level of 3.5% in concentrate decreased the daily enteric methane emission by 15% in sheep.

Methane is the second most significant greenhouse gas present in the atmosphere and enteric fermentation is one of the largest sources of methane emission from agriculture sector. Apart from the contribution to global warming, enteric methane emission from livestock is also held accountable for a significant loss (2-12%) of feed energy. An in vivo study was conducted in 18 sheep to ascertain the impact of divi-divi (*Caesalpinia coriaria*) pod supplementation on enteric methane emission, rumen microbial diversity including methanogens and rumen fermentation characteristics (Fig. 29). The animals were divided into three groups (N=6) and fed a basal diet comprising finger millet straw and concentrate based diet (50:50), wherein divi-divi pods were included (3.5, 7 and 10% of concentrate) in the test groups.

In vitro results indicated a significant ($P<0.0001$) reduction in methane production with the graded supplementation of divi-divi pods at 3.5, 7 and 10% of the concentrate. However, a concurrent reduction ($P<0.05$) in dry matter digestibility was also recorded at the highest level (10%) of divi-divi pods supplementation. Therefore, this level was dropped for the further evaluation in sheep. Results from the study indicated a significant reduction in daily enteric methane emission at both the supplementation level of 3.5 and 7.0%, whereas the methane emission between two test groups did not differ significantly. Among the ruminal methanogens, *Methanobrevibacter gottschalkii* was the most abundant in control and test groups. In the study, *Methanomicrobium mobile* was adversely affected with the supplementation of divi-divi pods in sheep.

Fig. 29: Divi-divi pods evaluated for anti-methanogenic potential in sheep.

ICAR-ILRI: Methane emission and its mitigation

Coordinator: R Bhatta
PK Malik, AP Kolte, V Sejian

In vivo study indicated that the daily enteric methane emission between cattle and buffaloes did not vary if fed on the same diet under similar environmental conditions.

India alone holds about the world's 13% cattle and 53% of the buffalo population, which held accountable for the 4.92 and 2.91Tg annual enteric methane emission from the respective species. These two major bovine species are responsible for more than 85% of the enteric methane emission in India. Archaea with their limited distribution in the rumen, play a significant role in maintaining H2 pressure within the desirable limit. Host species play an important role in the distribution of methanogens and therefore in the variation of methane emission when fed on a similar diet. An

in vivo study was conducted to compare the archaeal community composition in cattle and buffaloes fed on a similar diet comprising 70% finger millet straw and 30% concentrate. After 30 days of feeding, the daily enteric methane emission in cattle and buffaloes was quantified using the sulphur hexafluoride (SF6) tracer technique for the consecutive 10 days (Fig. 30).

The Results indicated significantly higher ($P<0.01$) daily enteric methane emission in cattle (175g /day) as compared to the buffaloes (130g /day). However, the methane yield (MY) calculated by considering daily enteric methane on the consumption of unit dry matter intake was similar between the two species. These results clearly established that if the diet and dry matter intake is same, there is no variation in the methane emission between cattle and buffaloes. On the contrary, the number ($\times$107 cells/ml) of total protozoa and Entodiniomorphs were higher in buffaloes as compared to the cattle. However, there was no difference in the number of Holotrichs between the two host species.

Fig. 30: Estimation of enteric methane emission in cattle and buffaloes using the sulfur hexafluoride (SF6) tracer technique.

Indo-German: Contamination of feed and fodders with heavy metals and agro-chemicals and impact on milk composition, rumen microbes and methanogenesis in dairy cattle along the rural-urban Interface of Bengaluru

R Bhatta, P K Malik, A Mech, V Sejian

Milk samples analysis revealed that the milk fat depression is a major issue in the Jigani industrial area. Moreover, about 30% animals were found positive for the internal parasites.

Environmental pollution is a major global problem posing serious risk to humans and animals. The environmental pollutants are spread through different channels and may enter into the food chain. Pesticides, heavy metals and other agro-chemicals are some of the major causes of environmental toxicity in farm animals. Contaminated agricultural land and water are major sources of heavy metals in feeds and fodder grown for animal feeding. The project was initiated to analyse the heavy metals

Fig. 31: Measurement of rectal temperature and body length in field conditions.

(lead, cadmium, arsenic) and pesticide residues concentration in drinking water, milk, feeds & fodder samples and impact of feeding heavy metals/pesticides contaminated feed and fodders on the rumen microbial diversity, and enteric methane emission in dairy animals.

The dairy farms located at the interface of rural-urban in South Bengaluru were identified for the study under this project. The first-hand information on the feeding, management, fodder crops, drinking water, irrigation water, lakes, pastures, milk production, dung collection, manure, fertilizers, pesticides etc. were collected from the 15 dairy farms belonging to 6 villages in Jigani industrial area (Fig. 31). Data for the above parameters by involving 143 animals including dairy cattle, non-lactating cattle, buffaloes, heifers, claves, sheep from the above 15 dairy farms were collected during the reporting period. From the above dairy farms, total 69 feed and fodder samples including wheat bran, semolina, gram husk, groundnut cake, ragi straw, jowar fodder, maize fodder, hybrid napier, KMF concentrate, ragi malt, oat grain and lobia grain. Four lake water samples near to the pasture area in Jigani industries were collected for the heavy metal and pesticides residues analysis.

Technology Translation to Connect Discovery with Application

TTA 6.3 Economics of milk production under different systems of dairy farm management in Karnataka

S Jash, T Chandrappa, G Ravikiran

The estimated cost of milk production (Rs/lit) varied from 23.4 to 25.7 under the semi-intensive system and 21.9 to 23.9 under the extensive system. In contrast, the cost was estimated as 27.3 under the intensive system.

The definitive cost of milk production, based on the rearing systems of bovine husbandry are of paramount importance to commensurate its selling price at farm gate. The study has been envisioned on the quantitative and qualitative requirements of inputs, considering infrastructure in terms of appreciative depreciative functions of capital investments, loans, insurance, as well the operational costs in terms feed, health, labour, power, and ancillary components. The four defined farming systems have been selected across the urban, peri-urban and rural tracts, across the districts of Bengaluru (urban), Bengaluru (rural), Kolar and Tumkur, which forms the heartland milk-shed in Karnataka. An intensive survey was conducted across 92 farmers, under two milk producers' co-operative society in the Bengaluru Urban, Bengaluru Rural, Kolar and Tumkur districts to assess farming systems at three agro-ecological regions, that contributes 30% of milk to Karnataka, of which nearly 70% is procured by the Karnataka Milk Federation (KMF). The study included 24 farmers from intensive system, 38 farmers from Semi-intensive system and 30 farmers practising extensive system. Cost evaluation of infrastructure, feed, health and prophylaxis, the proportional use of water, electricity, farm labour (family inclusive), investment of insurance cover and valuation of dung were estimated to arrive at the input factors for estimating the cost of milk production per litre (Table 14).

Table 14: Cost of milk production (Rs) per litre in different production systems under different zones.

Regions	Intensive	Semi-intensive	Extensive
Central Dry Zone		23.4	21.9
Eastern Dry Zone	27.3	25.7	23.9
Southern Dry Zone		24.8	22.1

The SWOT analysis reflected the strength of the milk production systems in terms of cooperative principles and networking of the milk federation and health monitoring camps of the state animal husbandry department. The weakness of the system identified were power outages and meagre record keepings. The opportunities for improvement identified were mechanisation of dairy-related infrastructures with semi-intensive farmers and market competitiveness. However, the threats identified were productivity and quality assurance and demographic urban migration.

TTA 6.4 Effect of ground water levels on livelihoods of dairy farmers

Letha Devi G, A Mech, G Ravikiran, V Sejian

Secondary data were collected from the Central Ground Water Board, and primary data were collected from 27 farms (13 critical, 7 safe and 6 semi critical and 1 over exploited) located in Chamarajnagar.

Water is an essential component for physiological functions of livestock, milk production and plays a major role in operation of dairy farm. Water availability and quality has a direct impact on health and production performance in dairy cattle. Shrinking water resources warrants judicious use of water since low water availability will lead to adverse effect as animal growth and production. Declining water table coupled with deepening of existing wells and digging of new wells aggravates overexploitation of groundwater and threatens the livelihood security of small and marginal farmers who cannot afford large investments for water abstraction. The project was undertaken with the objectives of to study the effect of different ground water levels on production performance of dairy animals and to study the effect of different ground water levels on livelihood security of farmers

Interview schedule was prepared. Secondary data was collected from the Central Ground Water Board, regarding ground water levels in the study districts and accordingly selected farms were categorised as over- exploited, critical, semi-critical and safe. Primary data were collected from 27 farms (13 critical, 7 safe and 6 semi critical and 1 over exploited) located in Chamarajnagar. Further assessment is on progress.

TTA 6.5: Economics of sheep rearing under different systems of management in Karnataka

T Chandrappa, B Krishnappa, N Ramachandran, RK Veeranna

Parameters to be studied were screened, questionnaire for primary data collection was developed from the sample farmer respondents and validated, and part of secondary data were collected from the line departments on district wise and taluk wise sheep population and sheep developmental programmes.

Sheep are important species of livestock and contribute greatly to the agrarian economy, especially in areas where crop and dairy farming are not economical and play an important role in the livelihood of a large proportion of small, marginal farmers and landless labourers. The improvement in the productivity of sheep rearing by the poor segment of the community in rural areas can be looked up on as a major instrument for attaining social change by improving the income of these people. This will enable them to augment their income and bring them above the poverty line and would also help in reducing the disparities between the per capita income in rural and urban sector. Hence, there is an urgent need to focus on economic aspects such as cost and returns, and strengths, weakness, opportunity and threats (SWOT) under different rearing methods of sheep farming. The sheep population statistics is presented in Table 15. During the reported period, the parameters to be studied were screened, questionnaire for primary data collection was developed from the sample farmer respondents and validated, and part of secondary data were collected from the line departments on district wise and taluk wise sheep population and sheep developmental programmes. Tumkur was selected as the study area with Sira and Koratagere as study taluks. Identified few sample sheep farmers under extensive, semi-intensive and intensive sheep rearing methods, and part of the primary data from sheep farmers were collected (Fig. 32). The study is on progress.

Table 15: District wise sheep population (million) in Karnataka state.

District	Population	District	Population	District	Population
Chitradurga	13.52	Chikaballapur	6.13	Davangere	2.38
Tumkur	12.9	Kolar	4.84	Mysore	2.03
Bellary	12.73	Yadgir	4.37	Hassan	1.99
Belgaum	7.58	Gadag	3.96	Chamarajanagar	1.35
Raichur	6.58	Mandya	3.47	Ramanagara	1.28
Koppal	6.25	Bijapur	3.47	Bengaluru Rural	1.19
Bagalkot	6.23	Haveri	3.13	Other Districts	5.11

Fig. 32: Panel-A: Interaction with the sheep farmer. Panel-B: Housing structure for sheep followed in extensive system.

ICAR-Farmer FIRST: Improving livelihood security of farmers through technological interventions for sustainable livestock farming

Coordinator: R Bhatta

Letha Devi G, DT Pal, K Giridhar, A Arangasamy, A Mech, MA Kataktalware, GB Manjunath Reddy, BN Narayanaswamy, V Gowda

On an average, area under fodder crops increased by 4 times, and 59% of farmers adopted mastitis management protocol, leading to reduction in mastitis incidence by 56%. Technology adoption rate was 69% across different interventions. Area under vegetable crops increased by 3 times, and there was 1.5 times increase in farm income by changing crops. On an average, 11% increase in milk production was reported in the study villages, and 17% gross income increased across different technology interventions as compared to the previous year.

The project under Farmer FIRST is an effort to go beyond the issues of production and address the complex and diverse realities at field level through enhancing farmer-scientist interaction with multi stakeholders' participation. The major aim is to enrich farmer-scientist interface for technology development and application through focus on innovations, multi- stake-holders participation, and technological interventions for sustainable livelihoods. The project is being implemented in 3 villages in Doddaballapura taluk of Rural Bengaluru, covering 500 farm families.

There were 13 technology interventions of FFP under the six modules, covering four villages in a cluster with a total of

550 households. In all the households covered, the interventions either singularly or in combinations were implemented for doubling their income. The total area under direct implementation of crop or horticulture interventions was 204ha. The total area of 869ha was under the FFP directly and indirectly through livestock, poultry, procurement of farm products, outreach programmes through linkages and convergence with FFP team. There was an average 4 times increase in the area under fodder crops and 59% of farmers adopted mastitis management protocols, leading to reduction in mastitis incidence by 56%. There was 69% technology adoption rate across different interventions. Area under vegetable crops increased 3 times and there was 1.5 times increase in farm income by changing crops. An on-site nursery was developed by rural youth for vegetable seedling production, and for distribution of seedlings to other farmers. On an average 11% increase in milk production was reported in the study villages and 17% increase in gross income was estimated across different technology interventions as compared to the previous year. A total of 11capacity development programs and 3 field days were organized. Two "Farmer Field Schools" were organized on the topics "Quality milk production" and "Dry Cow therapy using herbal products" under which 12 sessions were held. Two Scientist-Farmer-Extension interface meetings were organised, and a training program was conducted in collaboration with ICAR-NBAIR on the occasion of celebration of "International Year of Millets". Another training was also organized on soil health in collaboration with ICAR-IIHR and ICAR-NBSS&LUP. Two online workshops were organized to promote ICT tools, "Feed Assist" and "Web Portal on Livestock Advisory System". A technology of "Nutritional Package for Early Attainment of Puberty in Heifers" was developed in participatory technology development (PTD) mode and it was evaluated in 40 animals. Technology feedback was collected for further improvement. Two "Farmer Interest Groups" were developed, one in organic millets and horticultural production and another in mushroom production. Both the groups were given trainings in collaboration with ICAR-NBAIR and ICAR-IIHR and they were facilitated to have forward and backward linkages for procurement of inputs and sales of products.

ICAR-Farmer FIRST: Enriching knowledge and integrating technology and institutions for holistic village development in horticultural based farming systems

D Rajendran

Sheep and goat with extra mineral mixture supplementation and protein supplementation is gained 3.78 kg and 3.96 kg in three months.

Under this program, seven villages were selected in Kanakkapura Taluk of Ramanagara District in Karnataka. Small ruminant like sheep and goat farming is subsidiary in this area. Flock size ranges from two animals to sixty animals. This area known for sericulture farming, rain fed agriculture. Three type of grazing land found in the selected village area viz. road side grazing land, fallow land and hillock area, covering more than 500 acres. In sheep, mineral mixture was supplemented 6-8gm for growing lambs, 10-12gm for adult sheep and 14-16gm for lactating or pregnant sheep. Along with periodic deworming, protein supplement was given in the selected village, and the supplemented animals showed 63g average daily gain and attained 10.6kg at 6 month as compared to 6.84 kg in the unsupplemented group. Income of farmers' was found 36% higher in the supplemented than the unsupplemented group.

Goat population was almost equal to that of sheep population. Goat also were not offered mineral mixture and concentrate supplement, and were reared under housed in three systems, open paddock, in-house rearing system and tied in open field. In goat, mineral mixture was supplemented at the rate of 4-6gm for growing kids, 8-10gm for adult goat and 12-14gm for lactating or pregnant goats. Income of farmers' was found 35% higher in the supplemented than the unsupplemented group.

CHAPTER 3

Publications Awards & Honours

Research Papers

Abhijith A, Sejian V, Ruban W, Krishnan G, Bagath M, Pragna P, Manjunathareddy GB, Bhatta R. 2021. Summer season induced heat stress associated changes on meat production and quality characteristics, myostatin and HSP70 gene expression patterns in indigenous goat. Small Ruminant Research, 203:106490.

Arun AS, Bhat SK, Jose L, Gowda NKS, Pal DT, Swain PS, Sidharth PM. 2021. A comparative study on physiological plasma mineral mapping of sloth bears (Melurus Ursinus) in in-situ vis-a-vis semi captivity conditions. E planet, 19:164-169.

Bagath M, Sejian V, Krishnan G, Devaraj C, Afsal A, Vandana GD, Soren NM, Rajendran D. 2021. Phenotypic and genotypic traits governing adaptive capacity of indigenous Salem Black goats subjected to protein energy alterations in the diet. Small Ruminant Research, 205:106543.

Balamurugan B, Mehrotra S, Veligatla T, Ramamoorthy M, Gopi M, Maurya VP, Singh G, Narayanan K. 2021. Effect of dietary enrichment with high energy diet and additional supplementation of trace minerals, vitamin during the periparturient period in crossbred cows. Haryana Veterinarian, 60:51-54.

Banakar PS, Kulangara A, Soren NM, Dominic G, Terhuja M, Prasad CK. 2021. In vitro evaluation of newer unconventional feedstuffs for livestock. The Indian Journal of Veterinary Sciences and Biotechnology, 17:78–83.

Binsila BK, Archana SS, Ramya L, Swathi D, Selvaraju S, Gowda NKS, Pal DT, Rafay A, Bhatta R. 2021. Elucidating the processes and pathways enriched in buffalo sperm proteome in regulating semen quality. Cell and Tissue Research, 383:881-903.

Carvajal MA, Alaniz AJ, Gutiérrez-Gómez C, Vergara PM, Sejian V, Bozinovic F. 2021. Increasing importance of heat stress for cattle farming under future global climate scenarios. Science of the Total Environment, 801:149661.

Chethan KP, Gowda NKS, Prabhu TM, Giridhar K, Anandan S, Dey DK, Soren NM, Shivakumar MC. 2021. Biomass yield and nutritive value of maize grain sprouts produced with hydroponic technique compared with maize grain and conventional green fodder. Animal Nutrition and Feed Technology, 21:121-133.

De K, Kumar D, Saxena VK, Krishnappa B, Bahire SV, Paul RK, Naqvi SMK. 2021. Effect of nutritional stress on physiological parameters and seminal attributes of native-crossbred ram in semi-arid tropics. Tropical Animal Health and Production, 53:274.

Devapriya A, Sejian V, Ruban W, Devaraj C, Spandan V, Silpa MV, Reshma Nair MR, Nameer PO, Bhatta R. 2021. Analysis of carcass traits and quantitative expression patterns of different meat quality governing genes during heat stress exposure in indigenous goats. Food Chemistry: Molecular Sciences, 3:100052.

Elangovan AV, Udayakumar A, Saravanakumar M, Awachat VB, Mohan M, Mahesh SY, Selvaraj K, Mech A, Rao SBN, Giridhar K, Bhatta R. 2021. Effect of black soldier fly, Hermetia illucens (Linnaeus) prepupae meal on growth performance and gut development in broiler chicken. International Journal of Tropical Insect Science, 41:2077–2082.

Elayadeth-Meethal M, Thazhathu Veettil A, Asaf M, Pramod S, Maloney SK, Martin GB, Rivero MJ, Sejian V, Naseef PP, Kuruniyan MS, Lee MRF. 2021. Comparative expression profiling and sequence characterization of ATP1A1 gene associated with heat tolerance in tropically adapted cattle. Animals, 11:2368.

Gangwar C, Mishra AK, Gururaj K, Kumar A, Kharche SD, Saraswat S, Kumar R, Ramachandran N. 2021. Semen quality and total microbial load: An association study in important Indian goat breeds

during different seasons. Androlgia, 53:e13995.

Geeta ASY, Pradhan S, Rajoria R, Asok Kumar M, Gopi M, Navani NK, Pathania R. 2021. Probiotic attributes of Lactobacillus fermentum NKN51 isolated from Yak cottage cheese and the impact of its feeding on growth, immunity, caecal microbiology and jejunal histology in the starter phase of broiler birds. Indian Journal of Animal Research, 55:451-456.

Giridhar K, Gowda NKS, Pal DT, Krishnamoorthy P, Joseph RF, Dey DK, Shukla AK. 2021. Feeding zinc biofortified sorghum stover decreases zinc deficiency in sheep. Indian Journal of Animal Sciences, 91:299–304.

Giridhar K, Gowda NKS, Pal DT, Krishnamoorthy P, Joseph RF, Dey DK, Shukla AK. 2021. Feeding zinc biofortified zinc sorghum stover decreases zinc deficiency in sheep. Indian Journal of Animal Sciences, 91:299-304.

Gogoi S, Kolluri G, Tyagi JS, Gopi M, Kesavan M, Narayan R. 2021. Impact of heat stress on broilers with varying body weights: Elucidating their interactive role through physiological signatures. Journal of Thermal Biology, 97: 1028-40.

Gupta PSP, Johnson P, Kaushik K, Krishna K, Nandi S, Mondal S, Tej NK, Somoskoi B, Cseh S. 2021. Effect of retinol as antioxidant on the post thaw viability and the expression of apoptosis and developmental competence related genes of vitrified preantral follicles in buffalo (Bubalus bubalis). Reproduction in Domestic Animals, 56:1446-1455.

Gupta PSP, Tej NK, Johnson P, Nandi S, Mondal S, Kaushik K, Krishna K. 2021. Efficiency of different synchronization protocols on oestrous response and rhythmic changes in 17β-estradiol and progesterone hormone concentration in Salem Black goats. Biological Rhythm Research, 52:11-21.

Javvaji PK, Dhali A, Francis JR, Kolte AP, Roy SC, Selvaraju S, Mech A, Sejian V. 2021. IGF-1 treatment during in vitro maturation improves developmental potential of ovine oocytes through the regulation of PI3K/Akt and apoptosis signaling. Animal Biotechnology, 32:798-805.

Kashyap S, Shivakumar N, Sejian V, Deutz NEP, Preston T, Sreeman S, Devi S, Kurpad AV. 2021. Goat milk protein digestibility in relation to intestinal function. American Journal of Clinical Nutrition, 113:845-853.

Kolte AP, Dhali A, Trivedi S, Malik PK, Bhatta R. 2021. Effect of DNA isolation method and host species on the metagenomic DNA recovery and microbial community coverage. Animal Nutrition and Feed Technology, 21:187-98.

Kumar D, Bhatt RS, Balaganur K, De K, Mahla AS, Sahoo A. 2021. Milk replacer and linseed supplementation promotes puberty and semen quality in growing male lambs. Small Ruminant Research, 202:106457.

Kumar R, Kataktalware MA, Senani S, Sivaram M, Letha Devi G, Niketha L, Ramesha KP. 2021. Risk factors associated with the lameness in crossbred dairy cattle maintained under field conditions. Journal of Animal Research, 11:517-525.

Kumar VP, Rao RG, Dhali A, Thammiaha V, Sridhar M. 2021. Evaluation of exogenous laccase enzyme treated finger millet straw on body weight gain, DM intake and nutrient digestibility in heifers. Indian Journal of Animal Research, 55:457-462.

Lavanya M, Archana SS, Swathi D, Ramya L, Arangasamy A, Binsila B, Dhali A, Krishnaswamy N, Singh SK, Kumar H, Sivaram M. 2021. Sperm preparedness and adaptation to osmotic and pH stressors relate to functional competence of sperm in Bos taurus. Scientific Reports, 11:1-13.

Lavanya M, Swathi D, Archana SS, Ramya L, Ranjithkumaran R, Krishnaswamy N, Singh SK, Krishnappa B, Rajendran D, Kumar H, Selvaraju S. 2021. Supraphysiological concentration of urea affects the functional competence of Holstein-Friesian (Bos

taurus) sperm. Theriogenology, 176:104-114.

Letha Devi G, Adhiguru P, Mech A , Kataktalware MA, Chaithra G, Niketha L. 2021. Livelihood vulnerability analysis to climate variability and change risks of livestock farming in Karnataka. Indian Journal of Extension Education, 57:1-5.

Malik PK, Trivedi S, Mohapatra A, Kolte AP, Sejian V, Bhatta R, Rahman H. 2021. Comparison of enteric methane yield and diversity of ruminal methanogens in cattle and buffaloes fed on the same diet. PLoS One, 16:e0256048.

Manimaran A, Wankhade PR, Kumaresan A, Patbandha TK, Sivaram M, Jeyakumar S, Rajendran D. 2021. Peripheral blood concentration of toll-like receptor-4 and its accuracy for prediction of postpartum performances of transition zebu (Bos indicus) cows. Indian Journal of Animal Sciences, 91:628–631.

Mech A, Suganthi RU, Rao SBN, Sejian V, Soren M, David C, Awachat V, Veeranna RK. 2021. Effect of dietary supplementation of linseed oil and natural antioxidants on production performance, fatty acid profile and meat lipid peroxidation in broilers. Asian Journal of Dairy and Food Research, 40:62-68.

Mylostyvyi R, Sejian V, Izhboldina O, Kalinichenko O, Karlova L, Lesnovskay O, Begma N, Marenkov O, Lykhach V, Midyk S. 2021. Changes in the spectrum of free fatty acids in blood serum of dairy cows during a prolonged summer heat wave. Animals, 11:3391.

Mylostyvyi RV, Izhboldina OO, Kalinichenko OO, Orishchuk OS, Pishchan IS, Khramkova OM, Kapshuk NO, Skliarov PM, Sejian V, Hoffmann G. 2021. Seasonal effect on milk productivity and cases of mastitis in Ukrainian Brown Swiss Cows. Theoretical and Applied Veterinary Medicine, 9:66-73.

Nag P, Kumaresan A, Akshaya S, Manimaran A, Rajendran D, Paul N, Sharma A, Karuthadurai T, Saraf K, Jeyakumar S, Ramesha KP. 2021. Sperm phenotypic characteristics and oviduct binding ability are altered in breeding bulls with high sperm DNA fragmentation index. Theriogenology, 172:80-87.

Oso AO, Suganthi RU, Malik PK, Thirumalaisamy G, Awachat VB. 2021. Effect of dietary supplementation of a phyto-supplement on carcass characteristics of broiler chickens. Asian Journal of Dairy and Food Research, 40:440-445.

Patil V, Gupta R, Rajendran D, Patil V. 2021. Dairy cattle nutrition and feed calculator - an android application. Tropical Animal Health and Production, 53:315.

Paul V, Krishnan G, Deori S, Bam J, Chakravarty P, Sarkar M. 2021. Body status and blood metabolites profiles during resumption of postpartum ovarian activity in yak (Poephagus grunniens). Reproduction in Domestic Animals, 56:1377-1386.

Pinto A, May K, Yin T, Reichenbach M, Malik PK, Roessler R, Schlecht E, König S. 2021. Gastrointestinal nematode and Eimeria spp. infections in dairy cattle along a rural-urban gradient. Veterinary Parasitology: Regional Studies and Reports, 25: 100600.

Prabakar G, Gopi M, Kolluri G, Rokade JJ, Khillare G, Beulah PV, Jadhav SE, Tyagi JS, Mohan J. 2021. Effect of supplementation of zinc-methionine on egg production, semen quality, reproductive hormones, and hatchability in broiler breeders. Biological Trace Element Research, 199:4721–4730.

Ramachandran N, Singh SP, Kumar A, Dwivedi D, Kharche SD, Kumar A, Rai B. 2021. Effect of fibre reinforced plastic (FRP) roof on performance of lactating Jakhrana does. Indian Journal of Animal Sciences, 91:744-749.

Ramya L, Swathi D, Archana SS, Lavanya M, Parthipan S, Selvaraju S. 2021. Establishment of bioinformatics pipeline for deciphering the biological complexities of fragmented sperm transcriptome. Analytical Biochemistry, 620:114141.

Reichenbach M, Pinto A, Malik PK, Bhatta R, König S, Schlecht E. 2021. Dairy feed efficiency and urbanization–A system approach in the rural-urban interface of Bengaluru, India. Livestock Science, 253:104718 .

Sampath BK, Nandi S, Mondal S, Gupta PSP, Girish VK. 2021. Influence of Curcumin and Carbazole on ovarian preantral follicle and granulosa cell functions in ovine. Indian Journal of Animal Sciences, 91:540-542.

Saravanakumar M, Elangovan AV, Awachat VB, Pattanaik AK, David CG, Ghosh J. 2021. Effect of peri-natal supplementation of amino acids on post-hatch performance of broiler chicken. Indian Journal of Animal Nutrition, 38:73-80.

Saravanan S, Guleria N, Ranjitha HB, Sreenivasa BP, Hosamani M, Prieto C, Umapathi V, Santosh HK, Behera S, Dhanesh VV, Krishna GS, Gopinath S, Kolte A, Bayry J, Sanyal A, and Basagoudanavar SH. 2021. Induction of antiviral and cell mediated immune responses promote an early viral clearance and mild form of acute foot-and-mouth disease in cattle. Genomics, 113:4254-4266.

Savitha ST, Girish Kumar V, Amitha JP, Sejian V, Bagath M, Krishnan G, Devaraj C, Bhatta R. 2021. Comparative assessment of thermo-tolerance between indigenous Osmanabadi and Salem black goat breeds based on expression patterns of different intracellular toll-like receptor genes during exposure to summer heat stress. Biological Rhythm Research, 52:127-135.

Sekar B, Arangasamy A, Naidu SJ, Reddy IJ, Bhatta R. 2021. Organic mineral supplementation on differential protein profile of Osmanabadi bucks (Capra hircus). Reproductive Biology, 21:100533.

Selvaraju S, Ramya L, Parthipan S, Swathi D, Binsila BK, Kolte AP. 2021. Deciphering the complexity of sperm transcriptome reveals genes governing functional membrane and acrosome integrities potentially influence fertility. Cell and Tissue Research, 385:207-222.

Sikiru AB, Arangasamy A, Egena SS, Veerasamy S, Reddy IJ, Bhatta R. 2021. Elucidation of the liver proteome in response to an antioxidant intake in rabbits. Egyptian Liver Journal, 11:51.

Singh SP, Ramachandran N, Sharma N, Goel AK, Singh MK, Kharche SD. 2021. Assessment of pregnancy-associated glycoprotein profile in milk for early pregnancy diagnosis in goats. Animal Bioscience, 34:26-35.

Suganthi RU, Malik PK, Reddy GBM. 2021. The ussing chamber system: functioning and determination of intestinal transepithelial electrical measurements and intestinal integrity in broiler chickens. Indian Journal of Animal Research, 55:1303-1307.

Swain PS, Rao SBN, Rajendran D, Krishnamoorthy P, Mondal S, Pal DT, Selvaraju S. 2021. Nano zinc supplementation in goat (Capra hircus) ration improves immunity, serum zinc profile and IGF-1 hormones without affecting thyroid hormones. Journal of Animal Physiology Animal Nutrition, 105:621-629.

Tej NK, Johnson P, Krishna K, Kaushik K, Gupta PSP, Nandi S, Mondal S. 2021. Copper and selenium stimulates CYP19A1 expression in caprine ovarian granulosa cells: possible involvement of AKT and WNT signalling pathways. Molecular Biology Reports, 48:3515-3527.

Thirupathaiah Y, Ananthan R, Moorthy SM, Chandrashekar KB, Chandrasekharaiah M, Sivaprasad V, Tewary P. 2021. Silkworm (bombyx mori) pupae proteins: The source of high value amino acids. Sericologia, 61:19-22.

Tripathi SK, Nandi S, Gupta PSP, Mondal S. 2021. Cathepsin b inhibitor improves the developmental competence of grown metabolic stressed ovine oocytes. Indian Journal of Small Ruminants, 27:43-46.

Vijay A, Pal DT, Gowda NKS, Elangovan AV, Dey DK, Nagaraj K, Eknath JS. 2021. Effect of boron supplementation on laying performance of White Leghorn hens fed diet with and without adequate level of calcium. Tropical Animal Health and Production, 53:444 .

Wankhade PR, Manimaran A, Kumaresan A, Patbandha TK, Sivaram M, Jeyakumar S, Rajendran D. 2021. Prediction of postpartum performances of transition Zebu (Bos indicus) cows using receiver operating characteristics analysis. Indian Journal of Animal Sciences, 91:188–195.

Review / Technical Articles

Anandan S, Soren NM, Bhatta R. 2021. ICAR-NIANP introduces milk replacer supplementation for economic meat production in lambs. E Pashupalan, March 2021.

Binsila BK, Selvaraju S, Ranjith kumaran R, Archana SS, Krishnappa B, Ghosh SK, Kumar H, Subharao RB, Arangasamy A, Bhatta R. 2021. Current scenario and challenges ahead in application of spermatogonial stem cell technology in livestock. Journal of Assisted Reproduction and Genetics, 38:3155-3173.

Chauhan SS, Rashamol VP, Bagath M, Sejian V, Dunshea FR. 2021. Impacts of heat stress on immune responses and oxidative stress in farm animals and nutritional strategies for amelioration. International Journal of Biometeorology, 65:1231-1244.

Chethan KP, Gowda NKS, Girish CH, Prabhu TM, Giridhar K, Anandan S. 2021. Grain sprouts as green feed with hydroponic technique. Review of merits and limitations. Indian Journal of Animal Nutrition. 38:109-122.

Kumar SP, Nandeha N, Jat D, Rao SBN, Chandrasekharaiah M, Kumar M, Singh KP. 2020. Puwal baler par urea ghol chidkav pranali ki vayvastha. Krishi Abhiyantriki Darpan (Jan – July 2020, samyuktank-36-37):5-7.

Mayasula VK, Arunachalam A, Babatunde SA, Naidu SJ, Sellappan S, Krishnan BB, Rajendran US, Janardhan RI, Bhatta R. 2021. Trace minerals for improved performance: a review of Zn and Cu supplementation effects on male reproduction in goats. Tropical Animal Health and Production, 53:491.

Ramachandran N, Gopi, M, Rajendran D, Singh R, Pourouchottamane R. 2021. Practical points for safe storage of feed ingredients and finished feeds in commercial goat farms. Livestock and Feed Trends, 19:52-53.

Ramachandran N, Singh RK, Rai B. 2021. Application of plastics in livestock production: An overview. Indian Journal of Animal Sciences, 91:174-181.

Reshma Nair MR, Sejian V, Silpa MV, Fonsêca VFC, de Melo Costa CC, Devaraj C, Krishnan G, Bagath M, Nameer PO, Bhatta R. 2021. Goat as the ideal climate resilient animal model in tropical environment: revisiting advantages over other livestock species. International Journal of Biometeorology, 65:2229-2240.

Sejian V, Silpa MV, Reshma Nair MR, Devaraj C, Krishnan G, Bagath M, Chauhan SS, Suganthi RU, Fonseca VF, König S, Gaughan JB, Dunshea FR, Bhatta R. 2021. Heat stress and goat welfare: adaptation and production considerations. Animals, 11:1021.

Soumya NPP, Mini S, Sivan SK, Mondal S. 2021. Bioactive compounds in functional food and their role as therapeutics. Bioactive Compounds in Health and Disease, 4:24-39.

Suganthi RU, Malik PK. 2021. Benefits of supplementing organic selenium (selenium yeast) to lambs (in Tamil). Kalnadai Kathir, 41:17-20.

Umaya RS, Vijayalakshmi C, Sejian V. 2021. Exploration of plant products and phytochemicals against aflatoxin toxicity in broiler chicken production: present status. Toxicon, 200:55-68.

Vandana GD, Sejian V, Lees AM, Pragna P, Silpa MV, Maloney S. 2021. Heat stress and poultry production: impact and amelioration. International Journal of Biometeorology, 65:163-179.

Lead Papers

Giridhar K. 2021. Integrated farming systems. Brainstorming session on "integrated approaches for livestock management", 16 December 2021, SVVU, Tirupati.

Mondal S, Das, DN, Reddy IJ, Nandi S. Gupta PSP. 2021. Early embryonic loss: an enigma. National e-Conference on Recent Advances in Animal Sciences: Future Challenges and Strategies, 6 January 2021, Sir Sayaad College of Arts, Commerce and Science, Dr Babasaheb Ambedkar University, Aurangabad.

Roy SC, Dhali A, Bhatta R. 2021. Development of next generation species-specific semen extenders for livestock using metabolomics fingerprinting. Kerala Veterinary Science Congress-2021 (virtual mode), 13-14 November 2021, College of Veterinary and Animal Sciences, Mannuthy, Kerala.

Sejian V, Bhatta R. 2021. Heat stress and skin transcriptomics: a novel approach to assess thermotolerance in two indigenous goat breeds of India. XVIII Latin American Congress of Genetics (ALAG 2021), LIV Annual Meeting of the Chilean Society of Genetics, XLIX Argentine Congress of Genetics, VIII Congress of the Uruguayan Society of Genetics, I Paraguayan Congress of Genetics and the V Latin American Congress of Human Genetics, organized by ALAG, Chilean Genetics Society, Sociedad Argentina de Genetica, Sociedad Uruguaya de Genetica and Sociedad Uruguaya de Paraguayan, 5-8 October 2021, Journal of Basic and Applied Genetics, XXXII(1):30.

Sejian V, Silpa MV, Devapriya A, Reshma Nair MR, Devaraj C, Shashank CG, Awachat VB, Bhatta R. 2021. Goat as the ideal climate resilient animal model for food security in tropical regions. III Animal Physiologist Association Conference, 24-25 September 2021, DUVASU, Mathura.

Selvaraju S. 2021. Identification of fertility signatures in sperm-A way forward. International Symposium on "Novel Knowledge, Innovative Practices and Research in Theriogenology" 27-29 December 2021, College of Veterinary and Animal Sciences, Mannuthy, Kerala.

Book

Emerging Issues in Climate Smart Livestock Production - Biological Tools and Techniques. 2021. Mondal S, Singh RL (Eds), Academic Press, Elsevier. ISBN: 978-0-12-822265-2.

Gender and Agriculture: An Indian Perspective. 2021. Anitha Kumari P, Letha Devi G, Ashaletha S, Adhiguru P (Eds), Satish Serial Publishing House, New Delhi. ISBN: 9789390425532.

Gender and Indian Society. 2021. Anitha Kumari P, Letha Devi G, Ashaletha S, Adhiguru P (Eds), Satish Serial Publishing House, New Delhi. ISBN: 9789390660612.

Nutrition and Fertility Management of Dairy Animals in Changing Climate Scenario. 2021. Phand S, Gowda NKS, Selvaraju S, Giridhar K, Krishnappa B, Bhatta R (Eds), MANAGE, Hyderabad. ISBN 978-93-91668-60-0.

Qualitative research in Social Sciences. 2021. Letha Devi G, Adhiguru P, Niketha L (Eds), Satish Serial Publishing House, New Delhi. ISBN: 9789388892872.

Textbook of Agricultural Extension. 2021. Chaithra G J, Letha Devi G, Adhiguru P, Praveen R (Eds), Satish Serial Publishing House, New Delhi. ISBN: 9789390425679.

Book Chapters

Akash, Hooque M, Mondal S, Adusumilli S. 2021. Sustainable livestock production and food security. In: Emerging Issues in Climate Smart Livestock Production

- Biological Tools and Techniques. Mondal S, Singh RL (Eds), Academic Press, Elsevier. pp91-108. ISBN: 978-0-12-822265-2.

Akash, Hooque M, Mondal S, Dipanshu B. 2021. Sustainable livestock production and biodiversity. In: Emerging Issues in Climate Smart Livestock Production - Biological Tools and Techniques. Mondal S, Singh RL (Eds), Academic Press, Elsevier. pp71-90. ISBN:978-0-12-822265-2.

Angadi UB, Animut G, Anandan S, Blümmel M, Moyo S, Rahman H, Jones C. 2021. FeedBase-Ethiopia: the role of database in developing livestock feed. In: India-Africa Partnerships for Food Security and Capacity Building. Modi R, Venkatachalam M (Eds), Springer. pp111-130. ISBN 978-3-030-54112-5.

Bagath M, Devapriya A, Silpa MV, Krishnan G, Devaraj C, Sejian V, Ruban W, Soren, NM, Rajendran D. 2021. Significance of balanced nutrition on immunity and meat parameters under climate change perspectives. In: Climate Smart Technologies for Food Animal Production and Products. Gurunathan K, Phand S, Yogesh PG, Kalpana S, Suresh D, Reddy B, Babji Y. (Eds), ICAR-NRC on Meat, Hyderabad. pp139-148. ISBN 978-93-5473-922-4.

Bijli HK, Letha Devi G, Chaithra GJ. 2021. Gender, technology and nutrition extension in agriculture. In: Gender and Agriculture: An Indian Perspective. Anitha Kumari P, Letha Devi G, Ashaletha S, Adhiguru P (Eds), Satish Serial Publishing House, New Delhi. pp169-226. ISBN: 9789390425532.

Chaithra GJ, Letha Devi G. 2021. Availability and access to extension services: a gender perspective. In: Gender and Agriculture: An Indian Perspective. Anitha Kumari P, Letha Devi G, Ashaletha S, Adhiguru P (Eds), Satish Serial Publishing House, New Delhi. pp121-131. ISBN: 9789390425532.

Pal DT, Gowda NKS, Dey DK. 2021. Mineral nutrition for fertility management in dairy cows. In: Nutrition and Fertility Management of Dairy Animals in Changing Climate Scenario. Phand S, Gowda NKS, Selvaraju S, Giridhar K, Krishnappa B, Bhatta R (Eds), MANAGE, Hyderabad. pp32-39. ISBN 978-93-91668-60-0.

Patil V, Gupta R, Rajendran D, Jain RV. 2021. Cattle feed formulation using modified dual simplex method - an android application. In: Soft Computing for Problem Solving. Advances in Intelligent Systems and Computing. Tiwari A, Ahuja K, Yadav A, Bansal JC, Deep K, Nagar AK (Eds), Springer. pp137-154. ISBN 978-981-16-2708-8.

Pinto A, Yin T, Reichenbach M, Malik PK, Schlecht E, König S. 2021. Dairy farms in an urbanising environment: tradeoffs between productivity and animal welfare. In: The Rural-Urban Interface. Hoffmann E, Buerkert A, Cramon-Taubadel SV, Umesh KB, Shivaraj PP, Vazhacharickal PJ (Eds), Springer. pp103-107. ISBN 978-3-030-79971-7.

Ramachandran N, Gowda NKS, Rajendran D, Gopi M, Dhali A. 2021. Modern practices of feeding and management of goats for commercial production. In: Modern Practices of Plant and Animal Nutrition for Sustainable Development. Biradar N, Kumar V, Kulkarni N, Naik C, Nashine R, Shah RA, Tirlapur L (Eds), Dilpreet Publishers and Distributors, New Delhi. pp137-143. ISBN: 978-81-953726-5-2.

Sejian V, Devapriya A, Silpa MV, Reshma Nair MR, Devaraj C, Krishnan G, Bagath M, Suganthi RU, Awachat VB, Bhatta R. 2021. Climate change and livestock production: current scenario and way forward. In: Climate Smart Technologies for Food Animal Production and Products. Gurunathan K, Phand S, Yogesh PG, Kalpana S, Suresh D, Reddy B, Babji Y. (Eds), ICAR-NRC on Meat, Hyderabad. pp1-17. ISBN 978-93-5473-922-4.

Sejian V, Devapriya A, Silpa MV, Reshma Nair MR, Devaraj C, Krishnan G, Bagath M, Suganthi RU, Awachat VB, Bhatta R. 2021. Carbon foot print and global warming due to livestock production: myths and facts. In: Climate Smart Technologies for Food

Animal Production and Products. Gurunathan K, Phand S, Yogesh PG, Kalpana S, Suresh D, Reddy B, Babji Y. (Eds), ICAR-NRC on Meat, Hyderabad. pp96-106. ISBN 978-93-5473-922-4.

Sejian V, Devapriya A, Silpa MV, Reshma Nair MR, Devaraj C, Krishnan G, Bagath M, Awachat VB, Bhatta R. 2021. Goat as the ideal climate animal model for food security. In: Climate Smart Technologies for Food Animal Production and Products. Gurunathan K, Phand S, Yogesh PG, Kalpana S, Suresh D, Reddy B, Babji Y. (Eds), ICAR-NRC on Meat, Hyderabad. pp107-115. ISBN 978-93-5473-922-4.

Sejian V, Silpa MV, Angela M Lees, Krishnan G, Devaraj C, Bagath M, Anisha JP, Reshma Nair MR, Manimaran A, Bhatta R, Gaughan JB. 2021. Opportunities, challenges and ecological footprint of sustaining small ruminant production in the changing climate scenario. In: Footprints in Agroecosystems. Banerjee A, Meena RS, Jhariya MK, Yadav DK. (Eds), Springer. pp365-396. ISBN 978-981-15-9495-3.

Sejian V, Silpa MV, Chauhan SS, Bagath M, Devaraj C, Krishnan G, Reshma Nair MR, Anisha JP, Manimaran A, Koenig S, Bhatta R, Dunshea FR. 2021. Eco-Intensified breeding strategies for improving climate resilience in goats. In: Eecological Intensification of Natural Resources for Sustainable Agriculture. Jhariya MK, Meena RS, Banerjee A (Eds), Springer. pp627-655. ISBN 978-981-33-4202-6.

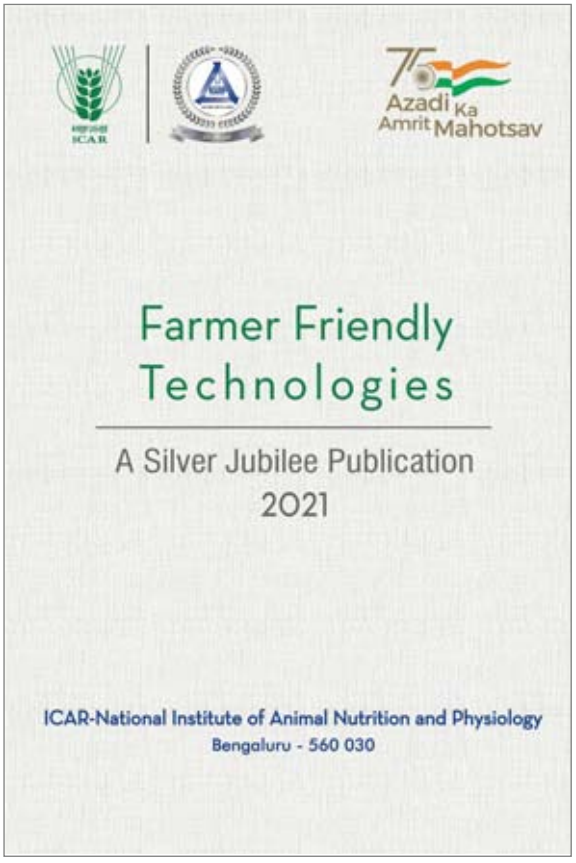
Sejian V, Silpa MV, Reshma Nair MR, Devaraj C, Beena V, Bhatta R. 2021. Climate change and dairy cattle production: emerging concepts and technologies for sustenance. In: Climate Smart Dairying in the Context of Global Warming. Narayanan MK, Phand S, Beena V, Harikumar S, Zarina A (Eds), KVASU and MANAGE, Hyderabad. pp40-48. ISBN 978-81-950446-9-6.

Silpa MV, Reshma Nair MR, Anisha JP, Rashamol VP, Sejian V. 2021. Heat stress amelioration effects of melatonin in goats. In: Melatonin: Production, Functions and Benefits. Martínez AR, Muñoz FL, Egea J (Eds), Nova Science Publishers, New York. pp121-136. ISBN: 978-1-53619-031-1.

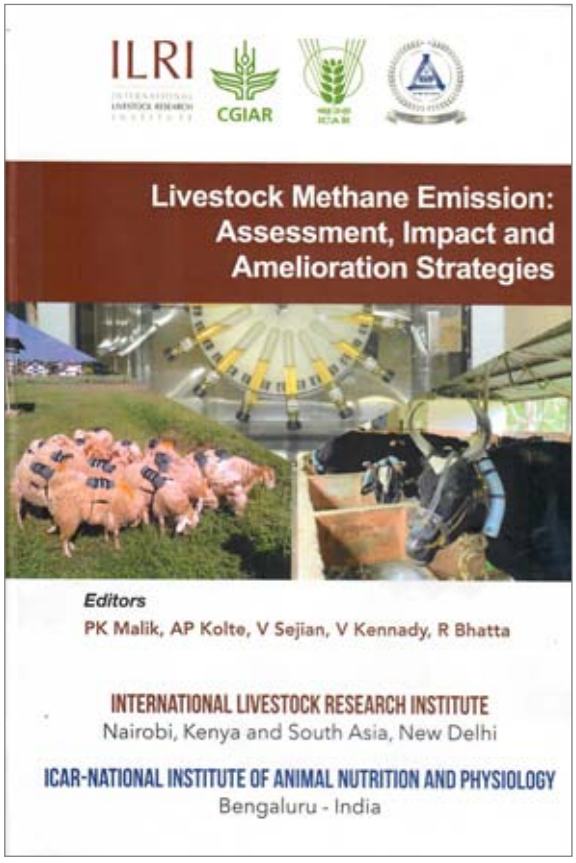
Singh B, Singh KP, Hoque M, Mondal S. 2021. Biotechnology in livestock reproduction. In: Emerging Issues in Climate Smart Livestock Production - Biological Tools and Techniques. Mondal S, Singh RL (Eds), Academic Press, Elsevier. pp371-414. ISBN:978-0-12-822265-2.

Swain PS, Prusty S, Rao SBN, Rajendran D, Patra AK. 2021. Essential nanominerals and other nanomaterials in poultry nutrition and production. In: Advances in Poultry. Patra A (Ed), IntechOpen. pp1-25. ISBN 978-1-83969-001-3.

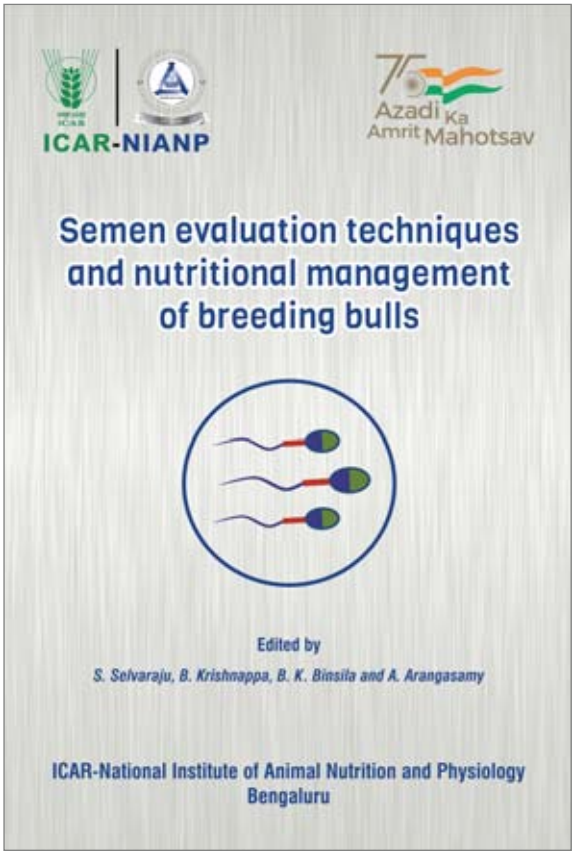
Compilations



Giridhar K, Selvaraju S, Mishra A, Krishnappa B. 2021. Farmer Friendly Technologies. ICAR-NIANP, Bengaluru, India. pp1-43.

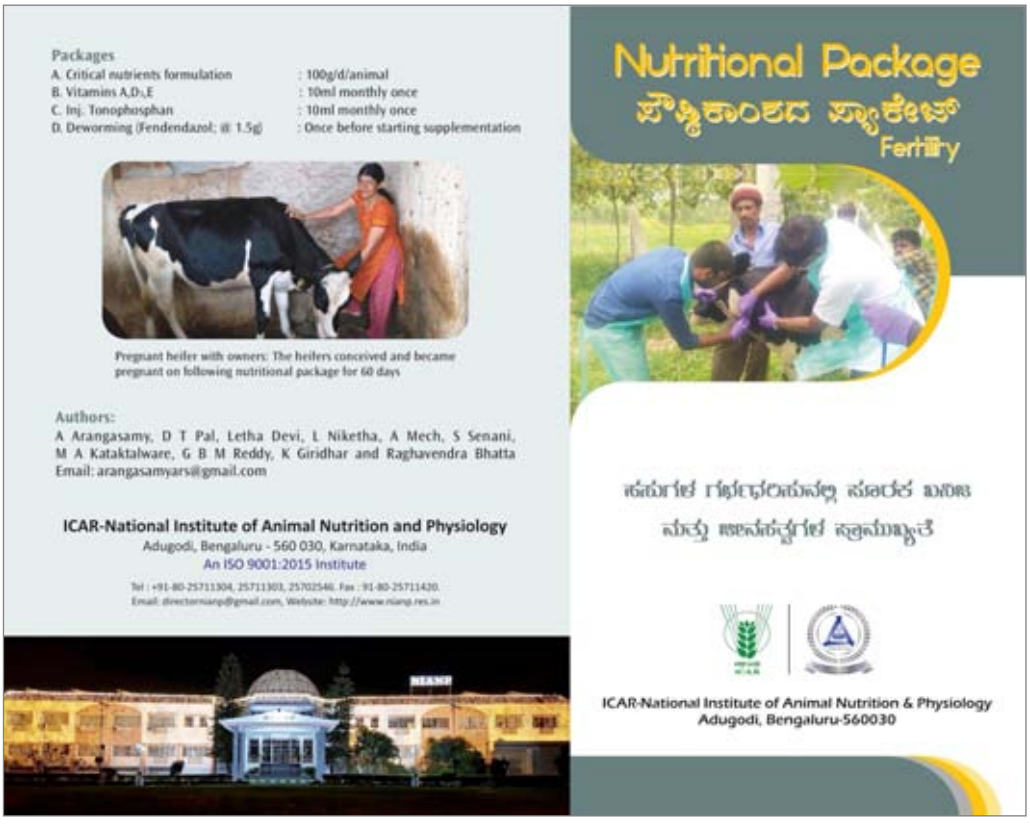


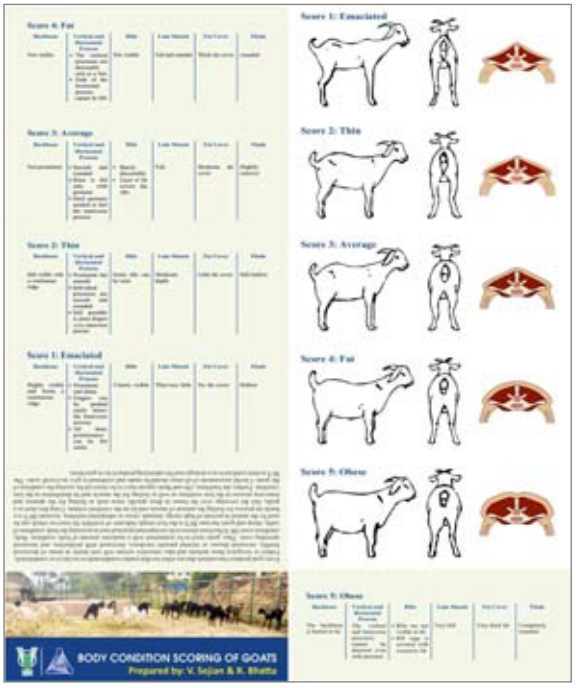
Malik PK, Kolte AP, Sejian V, Kennady V, Bhatta R. 2021. Livestock Methane Emission: Assessment, Impact and Amelioration Strategies. ILRI, New Delhi and ICAR-NIANP, Bengaluru. pp1-94.



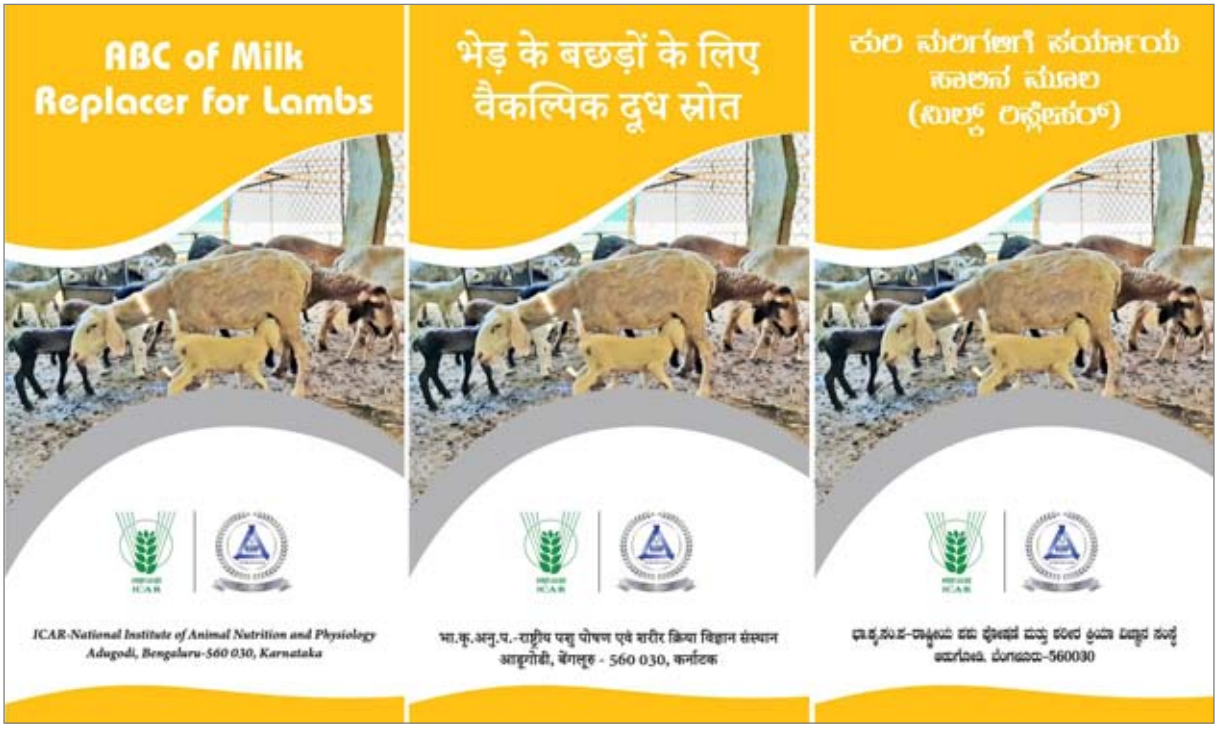
Selvaraju S, Krishnappa B, Binsila BK, Arangasamy A. 2021. Semen Evaluation Techniques and Nutritional Management of Breeding Bulls. ICAR-NIANP, Bengaluru. pp1-48.

Arangasamy A, Pal DT, Letha Devi G, Niketha L, Mech A, Senani S, Kataktalware MA, Reddy GBM, Giridhar K, Bhatta R. 2021. Nutritional Package for Fertility. ICAR-NIANP, Bengaluru. Folder.





Sejian V, Bhatta R. 2021. Body Condition Scoring of Goat. ICAR-NIANP, Bengaluru. Folder.



Anandan S. 2021. ABC of Milk Replacer for Lambs (English, Hindi and Kannada). ICAR-NIANP, Bengaluru. Folder.

Software

Rajendran D, Gopi M, Gowda KNS, Pal DT, Bhatta R. 2021. ICAR-NIANP: Mineral Mixture Formulator.

© ICAR-NIANP, Bengaluru.

Rajendran D, Rao SBN, Gopi M, Ramachandran N, Anandan S, Gowda NKS, Bhatta R. 2021. ICAR-NIANP: Goat Ration Balancing Tool. © ICAR-NIANP, Bengaluru.

Rajendran D, Gowda NKS, Anandan S, Letha Devi G, Prasad KS, Bhatta R. 2021. ICAR-NIANP Feed Chart: An Android Application on Google Play. © ICAR-NIANP, Bengaluru.

Rajendran D, Gowda KNS, Anandan S, Rao SBN, Pal DT, Gopi M, Bhatta R. 2021. ICAR-NIANP Smart Tool: An Android Application on Google Play. © ICAR-NIANP, Bengaluru.

Technology Assessed and Transferred

The anti-methanogenic product "Harit Dhara" was evaluated for its impact on milk composition at a commercial dairy farm. It was established that apart from reducing enteric methane emission, the product at the recommended level minimized the impact of heat load on the milk production by 50%, and increased the content of fat, protein and total solid in milk by 0.5-0.9 units.

A standardized protocol was successfully developed for producing hydroponic fodder in collaboration with the start-up company "Hydro Greens Agri Solutions Pvt. Ltd", who designed the microclimate controlled growing chambers.

NIANP Milk replacer for lambs developed and assessed through field trials in coordination with the State Animal Husbandry department. The milk replacer product is being produced at the Institute and being sold to end users across the states of Karnataka, Tamil Nadu, Andhra Pradesh, Orissa and Uttarakhand.

Technology Commercialised

Protocol for Producing Hydroponic Fodder. Licensed to "M/s Hydro Greens Agri Solutions Pvt. Ltd" for five years for adoption of this protocol for their hydroponic machines.

Area Specific Mineral Mixture for Four Different Regions. Licensed for 10 years to "M/s. Nandi Agrovet" and "M/s Vet Needs Labs" through the AgrInnovate India Ltd, New Delhi.

Patents Filed

Malik PK, Kolte AP, Bhatta R. Enteric methane reduction using biowaste of Padina gymnospora obtained after the supercritical fluid extraction. Application No 202111051271 dated 09.11.2021

Awards & Honours

Dr Raghavendra Bhatta, Director, was conferred the prestigious Fellowship of the "National Academy of Agricultural Sciences, New Delhi".

Dr Raghavendra Bhatta, Director, was conferred the prestigious Fellowship of the "Karnataka Science and Technology Academy, Department of Science and Technology, Government of Karnataka".

Dr V Sejian was listed in world top 2% scientists by Stanford University, USA as per the published report in Elsevier.

Dr V Sejian listed in the top 1% researchers publishing in heat stress research in the last 10 years based on Pubmed ranking.

Dr NKS Gowda, Dr S Selvaraju and Dr A Dhali were conferred the Fellowship of the prestigious "National Academy of Dairy Science (India)".

Dr NKS Gowda became a member of the editorial board of "Indian Journal of Small Ruminants", ICAR-CSWRI, Avikanagar.

Dr S Selvaraju was awarded "Indian Society for the Study of Animal Reproduction Fellowship" for the year 2019-2020.

Dr V Sejian received the Fellowship of the "National Environmental Science Academy" for the year 2021.

Dr S Selvaraju was selected as a member of editorial board of the journal "Systems Biology in Reproductive Medicine", Taylor & Francis.

Dr V Sejian was selected as the Academic Editor of the journal of "PLoS Climate".

Dr KS Roy received First Prize in the "Hindi Technical Writing" in TOLIC (O-1) 2021 Competition.

Dr KS Roy received Second Prize in the "Hindi Quiz Contest" in TOLIC (O-1) 2021 Competition.

Dr BK Binsila received the "Best Research Paper Award of ICAR-NIANP" for the year 2020-2021.

Dr M Gopi received "Mrs Saroj Jakhmola Best PhD Thesis Award 2021" of Animal Nutrition Association, India.

Conference Presentation Awards

Conferences	Awards
XXIX Annual Conference of the Society of Animal Physiologists of India, 25-26 February 2021, Bihar Veterinary College, BASU, Patna.	Best Paper Presentation Award for "Effect of synthetic Kisspeptin analogue (Reprovardhak®) for induction of estrous and optimization of reproductive hormonal profile in sheep" by Roy KS.
V Annual Convention of the Society of Veterinary Biochemists and Biotechnologists of India, 24-25 March 2021, DUVASU, Mathura.	Best Paper Presentation Award for "Determination of intestinal transepithelial electrical measurements and intestinal integrity in broilers: an Indian perspective" by Suganthi RU.
Virtual International Conference on "Promising Genetic and Genomic Technologies-Frontier in Selection and Animal Improvement", 27-28 January 2021, Kerala Veterinary and Animal Sciences University, Pookode.	Best Poster Presentation Award (Second) for "Novel approach of establishing thermo-tolerance in indigenous Kanni Aadu and Kodi Aadu goat breeds based on 16s rRNA sequencing associated changes in skin microbiome" by Silpa MV, Sejian V, Reshma Nair MR, Devaraj C, Bagath M, Krishnan G, Awachat VB, Kolte AP, Malik PK, Schlecht E, König S, Bhatta R
III Animal Physiologist Association Conference, 24-25 September 2021, DUVASU, Mathura.	Best Poster Presentation Award (Third) for "Long term culture of sheep spermatogonial stem cells using three dimentional matrix system" by Binsila BK, Ranjith Kumaran, Selvaraju S, Arangasamy A, Krishnappa B.
4th Zonal (Cenral) Conference-2021 and National Symposium of the Indian Association of Veterinary Pathologists, 05-06 October 2021, College of Veterinary Science and Animal Husbandry, Rewa.	Best Oral Paper Presentation Award (Second) for "Effect of boron supplementation in white leghorn layer birds fed with calcium inadequate diet on humoral immunity and histopathology" by Krishnamoorthy P, Gowda NKS, Pal DT, Shome BR.

ISSAR International Symposium on "Novel Knowledge and Innovative Practices in Animal Reproduction Research and Theriogenology", 27-29 December 2021, College of Veterinary and Animal Sciences, Mannuthy.

Best Oral Presentation Award (Second) for "Influence of three-dimensional matrix system and hypoxia on long-term culture of sheep spermatogonial stem cells" by Binsila BK, Kumaran R, Selvaraju S, Arangasamy A, Krishnappa B.

Best Oral Presentation Award (First) for "Effect of dietary calcium and magnesium supplementation on skewing of sex ratio using New Zealand White Rabbits" by Sharanya JN, Arangasamy A, Babatunde SA, Selvaraju S, Backialakshmi S, Reddy IJ, Bhatta R.

Best Research Paper Presentation Award (Second) for "Sperm expressed X-linked genes influence semen quality and field fertility rate in cattle and buffalo" by Swathi D, Ramya L, Archana SS, Binsila BK, Krishnappa B, Selvaraju S.

GB Singh Memorial Young Scientist Award 2019 for Best Research Paper "Organic Zn and Cu interaction impact on sexual behaviour, semen characteristics, hormones and spermatozoal gene expression in bucks (Capra hircus). Theriogenology, 130:130-139" by Krishnaiah MV, Arangasamy A, Selvaraju S, Guvvala PR, Ramesh K.

CHAPTER 4

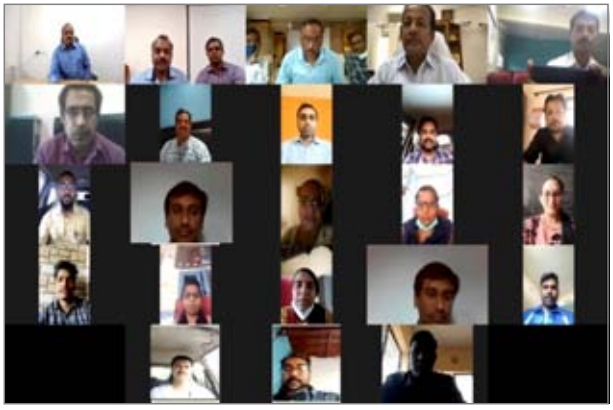
Training & Capacity Building

Training/ Workshop/ Seminar Organized

Hands-on Training Programme on Semen Evaluation Techniques and Nutritional Management of Breeding Bulls, 2-4 December 2021

A short-term hands on training programme on "Semen Evaluation Techniques and Nutritional Management of Breeding Bulls" was organized in association with the "Department of Animal Husbandry and veterinary Services, Karnataka", from 2-4 December 2021. The training was organized as a part of "Azadi Ka Amrit Mahotsav" for the benefit of veterinarians and technicians working in the frozen semen banks. The training was focused on preparation of buffers and stains to evaluate sperm kinematics, viability, morphology, microbial load, functional membrane and acrosomal integrity assessment. The trainees were also apprised of the importance of species-specific semen extender and recent advances in semen evaluation and progress on sexing of semen. Fodder production and nutritional management for breeding bulls were also discussed. Dr RN Sreenivas Gowda, former Vice-chancellor of Karnataka Veterinary and Animal Sciences University, was the chief guest of the valedictory function. He highlighted the current challenges in improving reproductive efficiency of dairy animals in artificial insemination program and producing high quality semen for improving field fertility. Fourteen participants from four frozen semen banks located in Karnataka participated in the training.

Online Training Programme on Feed and Fertility Management, 21 January - 20 February 2021



An online training programme on "Feed and Fertility Management" for field veterinarians was conducted by the Institute from 21 January - 20 February 2021. The training was comprised of six sessions of two lectures in each, covering different aspects of nutritional management of fertility, role micro-nutrients, novel approaches for green fodder production, ration balancing tools, and basics of fertility and reproductive technologies in dairy animals. Android version of ration balancing software was demonstrated and shared to multiple users.

Guest lectures by eminent speakers on aspects of calf management and polyherbal approaches to overcome reproductive disorders were also arranged. Reproductive technologies for small ruminants and fertility improvement were also presented in this programme. The training was attended by 44 Field Veterinary Officers from the Department of Animal Husbandry and Veterinary Services, Govt of Karnataka.

NIANP-MANAGE Online Training Programme on Nutrition and Fertility Management of Dairy Animals in Changing Climate Scenario, 21-23 December 2021

On the occasion of "Azadi Ka Amrit Mahotsav", The Institute in collaboration with MANAGE, Hyderabad, organized a three day online training programme on "Nutrition and Fertility Management of Dairy Animals in Changing Climate Scenario" from 21-23 December 2021. Twelve different technical sessions on different aspects of dairy animal nutrition, climate change, stress, fertility and shelter management, including an online demonstration of ration balancing were conducted. Technical videos on ICAR-NIANP on azolla cultivation, areca sheath as dry fodder, ration balancing and fertility management were also played. Open discussion and feedback sessions were also conducted during the training. A total of 55 Officers from the Animal Husbandry Departments of different States, Krishi Vigyana Kendras and State Veterinary Universities participated in the programme.

ILRI-NIANP Hands-on Training on Livestock Methane Emission: Assessment, Impact and Amelioration Strategies, 26-28 October 2021

A training program on "Livestock Methane Emission: Assessment, Impact and Amelioration Strategies" was organized by the Institute in collaboration with International Livestock Research Institute (ILRI), Nairobi from 26-28 October 2021. The training offered virtual lecture series and hands-on training on methane emission from livestock production systems and its amelioration. The various topics covered in the training were on various aspects of rumen methanogenesis including methane quantification, methane modelling, ameliorative strategies, hydrogenotrohy, thermodynamics, molecular techniques and bioinformatics. A total of 22 participants from 10 States participated in the training programme.

Technical Seminar on Feeding and Semen Quality Management in Breeding Bulls, 21-23 September 2021

On the occasion of "Azadi Ka Amrit Mahotsav", the Institute organized a three day technical seminar on the theme "Feeding and Semen Quality Management in Breeding Bulls" for the officers of "Nandini Sperm Station, Karnataka Milk Federation" from 21-23 September 2021. The seminar comprised of technical presentations on nutrition and balanced feeding of breeding bulls, newer green fodder varieties and improved cultivation practices, semen quality assessment techniques, semen freezing, common problems encountered in semen processing and ameliorative measures. The seminar was attended by 17 officers of the of Nandini sperm station.

Australia-India Council workshop on Transfer of Mitigation Technologies for Heat Stress in Farm Animals, 18-19 February 2021

The second Australia-India Council workshop on "Transfer of Mitigation Technologies for Heat Stress in Farm Animals" was organized virtually by the Institute in collaboration with the University of Melbourne, Australia for two days on 18-19 February 2021. During the workshop, Prof. T Reeves, Prof. R Eckard, Prof. F Dunshea and Dr J Cottrell from the University of Melbourne, Prof. J Gaughan from the University of Queensland, Dr T Nguyen from DATAGENE, AG VIC, Australia, Prof. C Clark from the University of Sydney and Dr F Liu from Rivalea Australia Pvt Ltd shared their research experiences with the participants in the area of mitigation technologies for heat stress and enteric methane emission in farm animals. The workshop was attended by 25 participants from India and 25 participants from Australian.

Technical Workshop on Livestock Feeding Management and Production, 6 September 2021

On the occasion of "Azadi Ka Amrit Mahotsav", the Institute organized a technical workshop for livestock farmers on the theme "Livestock Feeding Management and Production" at KVK-Ramanagar on 6 September 2021. Various technical presentations and interactive session were organised on feeding of dairy animals and small ruminants including the health care aspects. Special thrust was given on green fodder production and area specific mineral mixture supplementation. More than 50 farmers participated in the event.

Technical Workshop on Improved Methods of Small Ruminant Farming for Higher Income, 27 July 2021

The Institute in association with the "Department of Animal Husbandry, Govt of Karnataka and KVK Hadonahalli, organized a one day technical workshop for progressive sheep and goat farmers on "Improved Methods of Small Ruminant Farming for Higher Income" at KVK Hadonahalli on 27 July 2021. Various lectures were delivered on guidelines for feeding of sheep and goat, use of milk replacer for reducing mortality, better growth of lambs and kids, breeding and management of small ruminants, Government initiatives for hygienic meat production and importance of cultivating climate resilient green fodder varieties and fodder trees. The workshop was attended by more than 125 progressive farmers.

Technical Webinar on Fodder and Farming, 14 July 2021

On the occasion of "Azadi Ka Amrit Mahotsav", the Institute organised a technical webinar on "Fodder and Farming" for the benefit of the field officers of Animal Husbandry Department, KVKs and Milk Unions in Karnataka. Technical presentations were made on improved green fodder production and effective use of dry fodder for feeding of livestock. The event was attended by 103 participants.

Technical Seminar on Sustainability of Dairy Production, 29 November 2021

On the occasion of "Azadi Ka Amrit Mahotsav", the Institute in collaboration with the Indian Dairy Association-South Zone and Veterinary college, Hassan organized a technical seminar for the field officers of Hassan Milk Union and Hassan District Animal Husbandry Department on "Sustainability of Dairy Production" at the Veterinary college, Hassan on 29 November 2021. Technical presentations and interactive session on feeding of dairy animals, green fodder production and fertility management were organised during the event. The seminar was attended by 150 participants.

Hosting Scholars with External Grant for Conducting Research

Scholar	Title of the Research Project	Grant	Mentor
J Sharanya	Effect of dietary calcium and magnesium on sex ratio and placental genes expression in New Zealand white rabbit	CSIR Fellow	A Arangasamy
K Kavya	Effect of novel peptide isolated from buffalo ovarian follicular fluid on in vitro maturation, fertilization and embryo development of oocytes retrieved from vitrified preantral follicles	DST, Women Scientist Scheme -A	PSP Gupta

K Kalpana	Effect of cryopreservation of preantral follicles on estradio l synthesis pathways and oocyte development in ruminant	DBT Category I Scheme	PSP Gupta
PK Singh	Endocrine disruptions and ovarian functions: genomics, epigenomics and ovarian steroidogenic pathways	UGC JRF	S Nandi
MV Krishnaiah	Supplementation of organic zinc and copper on spermatozoal gene and protein expression pattern in male goat (*Capra hircus*)	CSIR Fellow	A Arangasamy
SS Archana	Immuno -modulatory molecular signature in relation to semen fertility	DST, Women Scientist Scheme -A	S Selvaraju
S Roy	Bioconversion of D -galactose into D - tagatose for evaluation as nutraceutical	DST KSTePS	AK Samanta

Training Undergone by Staff

Scientist

Particulars	Participants
Online training programme on "Climate Smart Technologies for Food Animal Production and Products", 19 -23 April 2021, ICAR -NRC on Meat and MANAGE, Hyderabad.	C Devaraj
Internal Auditor's Training for the certification of ISO 9001:2015, 10 -11August 2021, ICAR -NIANP, Bengaluru.	N Ramachandran, C Devaraj
Online training programme on "SNP Data Analysis for Detecting Parentage in Animals", 23 September 2021, GADVASU, Ludhiana.	C Devaraj
Hands-on training and workshop on 'Livestock Methane Emission: Assessment, Impact, and Amelioration Strategies", 26 -28 October 2021, ILRI and ICAR - NIANP, Bengaluru.	C Devaraj, M Gopi
Online management development programme on "Leadership Development (a pre -RMP Programme)", 13 -24 December 2021, ICAR - NAARM, Hyderabad.	KVH Sastry, S Mondal, A Dhali
Online CCE -proficience programme on "Laboratory Animal Management", 5 January - 4 May 2021, IISc, Bengaluru.	K S Roy, A Dhali, A Mishra, N Ramachandran
Online training program on "Emotional I ntelligence at Workplace for Scientists/Technologists", 15 -19 February 2021, DST, New Delhi.	N Ramachandran
Online training programme on "Application of Bioinformatics in Agricultural Research and Education", 20 -24 September 2021, ICAR -NAARM, Hyderabad.	G Krishnan, M Gopi
Online training programme on "Proteomics Data Analysis", 24 -26 November 2021, ICAR -IASRI, New Delhi.	B Krishnappa
Training on "Handling and Management of Immuno -compromised Mice", 27 December 2021, ACRC, GKVK, Bangalore.	BK Binsila
Online Training Programme on "Application of Intellectual Property Rights for Different Aspects of Animal Genetic Resources in India", 10 -20 September 2021, College of Veterinary Science and Animal Husbandry, Mhow.	G Letha Devi
Online Short course on " Poultry Management " organized by US Soybean Export Council from 24 -25th September, 2021.	M. Gopi
Generic Online Training in Cyber Security for Central Government Ministries Departments on 09 June, 2021.	SBN. Rao

Technical and Administrative Personnel

Particulars	Participants
Online training programme on "Recent Advances in Disease Diagnosis", Veterinary Science University, Jabalpur, 27 July -16 August 2021.	VB Awachat

Online training programme on "Motivation, Positive Thinking, Communication and Behavioral Skills", ICAR -NAARM, Hyderabad, 25-30 November 2021.	VB Awachat
Online training programme on "Pension and Retirement Benefits", ISTM, New Delhi, 18 -21 January 2021.	PP Sheeja
Online workshop on "e Office", ISTM, New Delhi, 25 -26 February 2021.	YC Vijayalakshmi, A Murthy
Online training programme on "Making a Secure and Resilient Workplace", ICAR -CPRI, Shimla, 1 -3 September 2021.	JV Jyothi, A Murthy
Online training program on "e Governance", ICAR -IASRI, New Delhi, 6-10 September 2021.	YC Vijayalakshmi

Workshop/ Conference/ Seminar/ Symposium/ Krishi Mela/ Expo/ Meeting Attended by Scientists and Technical Officers

Particulars	Participants
III Annual Conference of APA and National Symposium On "Physiological Interventions for the Augmentation of Sustainable Animal Production (Online)", 24 -25 September 2021, College of Veterinary Science, Mathura.	AV Elangovan, KS Roy, RK Gorti, A Dhali, C Devaraj, IJ Reddy, S Nandi, CG David, V Sejian, Ashish Mishra, G Krishnan, BK Binsila, M Bagath
XXIX Annual Conference of SAPI on "Recent Approach to Escalate Livestock Productivity under Current Socio -economic Scenario, (Online)", 25-26 February 2021, Bihar Veterinary College, Patna.	KS Roy, PSP Gupta, S Mondal, S Nandi, A Mishra
International Symposium of ISSAR on "Novel Knowledge, Innovative Practices and Research in Theriogenology", 27 -29 December 2021, College of Veterinary and Animal Sciences, Thrissur.	S Selvaraju, A Arangasamy, BK Binsila, B Krishnappa
31st Annual Meeting of ISSRF and International Conference on "Challenges and Strategies in Reproductive and Environmental Health with Special Reference to Covid -19 Pandemic", 19 -21 February 2021, University of Delhi, New Delhi.	SC Roy
XV Agricultural Science Congress on "Energy and Agriculture: Challenges in 21st Century", 13 -16 November 2021, Banaras Hindu University, Varanasi.	M Gopi
XVIII Annual Convention of SOCDAB on "Harnessing Potential of Indigenous Animal Genetic Resources for Enhancement of Productivity and Profitability (Online)", 11 -12 February 2021, ICAR - NBAGR, Karnal.	C Devaraj

International Conference on "Convergence of Technology and Policy for Sustainable Meat Production", 25 -28 October 2021, KVASU, Mannuthy.	C Devaraj, M Bagath
International Conference on "Connecting Our World: Biometeorology 2021", 21 -22 September 2021, International Society of Biometeorology, USA.	V Sejian
"XVIII Latin American Congress of Genetics, LIV Annual Meeting of the Chilean Society of Genetics, XLIX Argentine Congress of Genetics, VIII Congress of the Uruguayan Society of Genetics, I Paraguayan Congress of Genetics and the V Latin American Congress of Human Genetics (Online)", 5 to 8 October 2021, Valdivia, Chile.	V Sejian
International e-Conference on "Water Management in Dairy Sector", 12 October 2021, IRMA, Anand.	G Letha Devi
National e-Conference on "Recent Advances in Animal Sciences: Future Challenges and Strategies", 6 January 2021, SS College of Arts, Commerce and Science, Aurangabad.	S Mondal
International Virtual Conference (IVACON -2021) on "Emerging Challenges to Veterinary Profession". 19 -20 June 2021, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana.	NM Soren
4th Annual Asian Conference on "Science, Technology and Medicine" 20-21 November 2021, Asian Council of Scientific Editors, Dubai.	M Gopi
International Symposium on "Harnessing the Potentials of Genome Editing Tools to Augment the Productivity and Health of Farm Animals", 19-20 July 2021, ICAR-NDRI, Karnal.	A Dhali, A Mishra
Animal Nutrition Association Centennial Symposium on "100 Years of Animal Nutrition Research in India", 11 -12 March 2021, ICAR-IVRI, Izatnagar.	DT Pal, S Anandan, M Chandrasekharaiah

Australia-India Council Sponsored Virtual International Workshop on "Transfer of Mitigation Technologies for Heat Stress in Farm Animals ", 18-19 February 2021, ICAR -NIANP, Bengaluru and University of Melbourne.	KS Roy, C Devaraj, V Sejian, G Krishnan
Online Animal Biotechnology Workshop for the Asia Oceania Region on "The Impact of Gene Technology in Animal Agriculture and Food Production", 31 August - 1 September 2021, ISAAA, BICA, USDA, IAICA and Virginia Tech, USA.	C Devaraj, S Nandi, M Chandrasekharaiah
Australia-India Council Sponsored Workshop on "Sustainable Farm Animal Production in Changing Climatic Scenario", 22-24 September 2021, Bihar Animal Sciences University, Patna.	V Sejian
Virtual Workshop on "Impac t of Climate Change on Livestock Production", 8 December 2021, Uva Wellassa University of Sri Lanka, Sri Lanka.	V Sejian
UNESCO Sponsored Virtual Workshop on "Mass Spectrometry-based Proteomics", 12-13 October 2021, Regional Centre for Biotechnology (DB T), Faridabad.	SC Roy
Virtual Interactive RTI Workshop, 2 January 2021, Citizens Forum India.	KS Roy
Online Workshop of TOLIC -1 on "Karyalayeen Paridrishya aur Saral Bodhgamya Hindi Ka Prayog", 18 March 2021, ISRO, Bengaluru.	A Mech
Virtual Sensitization Workshop on "Agricultural Research Management System (ARMS) and Monthly Reporting in ICAR-Institutions", 18 October 2021, ICAR -IISW, Dehradun	C Devaraj, DT Pal
Krishi Mela, 11-14 November 2021, UAS, Bengaluru.	K Giridhar, KS Roy , N Ramachandran, G Letha Devi, C Devaraj, A Arangasamy, D Rajendran, NKS Gowda

National Horticultural Fair - 2021, 8-12 February 2021, ICAR - IIHR, Bengaluru.	N Ramachandran, C Devaraj, A Arangasamy, G Krishnan, NKS Gowda
First and Second Virtual Review Meeting of TOLIC -1 for the year 2021, 18 October and 13 December 2021, ISRO, Bengaluru.	A Mech
Annual Review Meeting of CGIAR Centres, 3 -4 February 2021, ICAR, New Delhi.	PK Malik
Annual Review Meeting of ICAR -NASF, 28 Ja nuary 2021, ICAR, New Delhi.	S Mondal
DBT Project Review Meeting, 5 March 2021, New Delhi.	A Arangasamy
SERB NPDF-ECRA Expert Committee Meeting, 15 -17 September and 11 -13 November 2021, New Delhi	S Selvaraju
Annual Review Meeting of ICAR-Outreach Programme on "Monitoring of drug residues and environmental pollutants" 23 November 2021 , New Delhi .	SBN Rao
Annual Review Meeting of ICAR -CRP on Bio-fortification, 05 July and 30 November 2021, IIRR, Hyderabad.	SBN Rao , M Chandrasekharaiah, NM Soren
CPGRAMS Meeting, 25 November 2021, ICAR, Krishi Bhavan, New Delhi .	DT Pal
Annual Review Meeting of ICAR-AICRP on "Nutritional and Physiological Interventions for Improving Reproductive Performance in Animals", 18 January 2021 , ICAR-NIANP, Bengaluru.	NKS Gowda , DT Pal, SC Roy, S Selvaraju, A Dhali, BK Binsila

List of Other Training/ Workshop Conducted for Stakeholders

Particulars	Date	Venue
Training Programme on "Cattle Feed Management and Quality Milk Production"	16 March 2021	Hoskote, Bengaluru Rural
Workshop on "Food and Nutrition of Farmers"	26 August 2021	Ragihalli, Karnataka
Workshop on "Role of Millets in Healthy Nutrition"	17 September 2021	M.G.palya, Karnataka
Training Programme on "Climate Resilient Livestock Production"	28 September 2021	Gangasandra village, Karnataka
Workshop on "Sustainability in Dairy Sector with a Message on Nutrition"	30 November 2021	Veterinary college, Hassan, Karnataka

Allocation and Utilization of HRD Fund, April-December 2021

HRD fund allocation (lakh)	Actual expenditure (lakh)	Utilization (%)
63,400	63,400	100

CHAPTER 5

Other Activities

Research Advisory Committee

The 26th meeting of the "Research Advisory Committee (RAC)" of the Institute was held in virtual mode on 29-30 July 2021, with the following members.

Name	Designation
Dr K Pradhan, Chancellor, SOA University Bhubaneswar	Chairman
Dr KK Baruah, Former Director, ICAR -NRC on Yak, Dirang	Member
Dr RC Upadhyay, Former Head, Animal Physiology Division, ICAR-NDRI, Karnal	Member
Dr AK Tyagi, ADG (AN&P), ICAR, New Delhi	Member
Dr G Gopal Reddy, Lexington Enterprises Pvt. Ltd., Bengaluru	Member
Dr Raghavendra Bhatta, Director, ICAR -NIANP, Bengaluru	Member
Dr DT Pal, Principal Scientist, ICAR -NIANP, Bengaluru	Member Secretary

The Chairman of the committee expressed his satisfaction that the institute received international reputation and conducted excellent research works in the fields of animal nutrition and physiology. He mentioned that the institute made commendable impact on transfer of technologies that resulted socio-economic upliftment of the livestock farmers. He complimented to the Director, scientists, and all staff of the institute for their efforts towards smooth functioning of the institute. The major recommendations of the 26th RAC meeting are given below.

- The Institute should emphasize on the strategic and fundamental research for delivering farmers friendly and industry oriented technologies, looking into the overall growth of livestock sector.
- The institute should have technology incubation facilities to promote and encourage the youth for start-up business.
- Impact of developed and commercialized or widespread technologies may be assessed and efforts may be made to commercialize the technologies which have got patented.
- The newly developed laboratory animal house facility could be used judiciously and effectively by maintaining all GLP compliances.
- The works on gut microbes and minerals bioavailability may be continued to a logical end.

Institute Research Committee

The Annual "Institute Research Committee (IRC)" meeting for the period January 2021 to December 2021 was held on 17-18 December 2021 in the Institute Auditorium, under the Chairmanship of Dr Raghavendra Bhatta, Director of the Institute. A total of 40 members participated in the IRC meeting and 51 projects (30 IRC approved Institute projects and 21 externally funded projects) were reviewed during the meeting. The Director and Chairman of IRC made his remarks in the meeting mentioning that all the projects should have deliverables, good publications and anticipated products, protocols or methods. Further, he suggested that following completion of a project, scientist should indicate any further works needed to be carried out in the particular area. He complimented all scientists of the institute for their good progress and achievements under the projects during the reported period.

Institute Management Committee

Members	Designation
Dr Raghavendra Bhatta, Director, ICAR -NIANP, Bengaluru	Chairman
Dr Manjunath S Palegar , Director , DAHVS, Hebbal, Bengaluru	Member
Shri S Krishnareddy, Kolar District, Karnataka	Member
Dr Divakar Hemadri, Principal Scientist, ICAR -NIVEDI, Bengaluru	Member
Dr Rajendra Hegde, Head, ICAR -NBSSLUP, Bengaluru.	Member
Dr PV Rami Reddy, Principal Scientist, ICAR-IIHR, Bengaluru	Member
Dr SD Kharche, Principal Scientist, ICAR -CIRG, Makhdoom	Member
Dr AK Tyagi, ADG (AN&P), ICAR, New Delhi	Member
Shri Vijay Kumar, AF&AO, ICAR -NIVEDI, Bengaluru	Member
Mrs S Shashikala, Administrative Officer, ICAR -NIANP, Bengaluru	Member Secretary
Mrs Sheeja PP , AF&AO , ICAR-NIANP, Bengaluru	Special Invitee

The 42nd and 43rd Institute Management Committee (IMC) meetings were held on 22 February and 5 August 2021 respectively, under the chairmanship of Dr Raghavendra Bhatta, Director, ICAR-NIANP. During the meetings, the chairman briefed the various activities of the Institute including various research activities and, the action taken for the recommendations of the preceding meeting held was confirmed and agreed by the IMC. Different agenda items such as procurement of equipment, manpower and infrastructure development were discussed in the meetings and the proposals were recommended by the IMC.

Institute Technology Management Unit

The "Institute Technology Management Unit (ITMU)" maintains intellectual property (IP) portfolio, contract research and commercialization of the technologies developed. The unit is guided by the Assistant Director General (IP&TM), New Delhi and ZTMC, ICAR-IVRI, Bareilly, UP. The ITMU is headed by the Director, ICAR-NIANP and members are drawn from different divisions/ section with an external intellectual property expert. The unit is mandated to create awareness among the Institute scientists for developing technologies with potential of IP and guiding them for patent ling process. During the reported period, one patent applications was led. A standardized protocol developed for producing hydroponic fodder in collaboration with the start-up company M/s Hydro Greens Agri solutions Pvt. Ltd, Bengaluru was licensed to the company. The Area Specific Mineral Mixture for Karnataka was licensed to M/s. Nandi Agrovet, Bengaluru and M/s Vet Needs Labs, Bengaluru on a non-exclusive basis through the AgrInnovate India Limited, New Delhi. The Institute has entered into a functional-industry-linkage through MoU for undertaking collaborative research to develop anti-methanogenic products using industrially available tannins with M/s Radiant Chem Industries, Chennai.

Sample Analysis Services Section

The "Sample Analysis Services Section" of the institute offers various paid services to different stakeholders. The section majorly provides analytical services like proximate analysis, estimation of different fibre fractions, minerals, metabolizable energy and urea in feed ingredients as well as in compounded feeds to different stakeholders like State Government Animal Husbandry Department, Research Institutes, Milk Federations, Private firms, etc. Other analytical services provide by the section are estimations of aflatoxins in feed samples, total microbial counts and probiotic organism count in rumen liquor samples, estimation of osmolality, analysis of long-chain fatty acids in feed, milk and meat samples, volatile fatty acids in rumen liquor samples, and estimation of different hormones such as oestradiol, progesterone, testosterone, cortisol, IGF1, androstenedione, total and free T3 and T4, FSH and LH.

Official Language Implementation Cell

The main objective of the "Official Implementation Cell" is enhancing usage of Hindi as Official Language in the institute. The Official Language Implementation Committee (OLIC) is consisted of Heads and In Charges of all the

Divisions and Sections with Director as the Chairman and In Charge Official Language (OL) as the member secretary. Quarterly meetings of OLIC were held at regular intervals to review the progress in implementation of OL in different Divisions and Sections. The decisions taken in the OLIC meetings were implemented in the day to day office work and the minutes of the meetings were sent to the ICAR headquarter, New-Delhi, Town Official Language Implementation Committee (TOLIC-1), Bengaluru and Regional Implementation Office (South) for future observations and recommendations. Hindi workshops were conducted regularly, once in every quarter, to promote correspondence and usage of OL in the day-to-day work. The different topics that were discussed in the workshops were the use of scientific and technical words in Hindi, progressive usage of Hindi in office work and promotion plans in Hindi. During the reported period the first virtual workshop was conducted on "E-Office and Official Language Implementation" on 23 March 2021 and the speaker of the session was Mr Damodaran, Assistant Director, HTS, Central Training Institute, Bengaluru. The second workshop on "E-tools for effective implementation of Rajbhasha" was conducted on 07 August 2021 and the speaker of the session was Dr GR Choudhary, Assistant Director, OL, DRDO, Bengaluru. The third workshop was conducted on 14 December 2021 on "Noting and Drafting in Hindi" at the Institute auditorium and the speaker of the session was Mr Damodaran, Assistant Director, HTS, Central Training Institute, Bengaluru. The institute also observed "Hindi Diwas" on 14 September 2021 and on this occasion Hindi week was observed from 14-21 September 2021. Various competitions such as Hindi song, quiz, translation, antakshari, poem recitation, etc. were organized during this one week period. The valedictory function was conducted on 21 September 2021, and prizes were distributed to the winners by the Director of the institute.

Institutional Animal Ethics Committee

The "Institutional Animals Ethics Committee (IAEC)" is registered by the CPCSEA, New Delhi for the purpose of control and supervision of experiments on animals performed in ICAR-NIANP for assuring quality and consistent ethical mechanism to use animals for research. The main objective of IAEC is to supervise the experiments on animals to be performed with due care and humanity, so that animals are properly looked after before, during and after experiments. The IAEC reviews and approves the research proposals involving small animal experimentation before the start of the study. Whereas, for experimentation on large animals, the case is forwarded to the CPCSEA with recommendation of IAEC. In the reported period, three proposals were submitted to IAEC for approval. Out of those proposals, 2 proposals were recommended to the CPCSEA for the consideration of approval and 1 proposal was approved by IAEC.

Women's Cell

The Women's Cell of the institute is involved in the welfare of all the women employees of all categories. The facilities in Women cell are continuously upgraded for the benefit of the women employees. Efforts were made to create awareness among women contractual staff about COVID and staff were briefed about the safety and precautions to be taken during COVID pandemic. The International Women's Day was celebrated in the institute on 8 March 2021. As a part of the celebrations, successful women farmers were identified from Ragihalli village, Bannerghatta, Bengaluru, inputs were distributed to them. A virtual guest lecture by Dr GC Anupama, Senior Professor and Dean, Indian Institute of Astrophysics, Bengaluru was organized on 15 March 2021, for the benefits of the women staff of the Institute.

Linkage and Collaboration

The Institute has been working as a partner of the Indo-German (DBT-DFG) collaborative research project on "Contamination of feed and fodders and its impact on milk composition, rumen microbes and methanogenesis in dairy cattle along the rural-urban interface of Bangalore" for the period of 19 March 2021 to 18 March 2024. The participating Institutions in this project are ICAR-NIANP, Bengaluru, University of Gottingen, Germany and University of Kassel, Germany.

The Institute has been working as a partner of the ILRI-ICAR collaborative research project on "Methane emission and its mitigation" for the period of January 2019 to December 2022. The participating Institutions in this project are ICAR-NIANP, Bengaluru, ICAR-IVRI, Barielly and ILRI, Nairobi, Kenya (CGIAR).

The Institute in collaboration with the University of Melbourne, Australia has been working on the project "Transfer of mitigation technologies for heat stress in farm animals", sanctioned by the Australia India Council, Department of Foreign Affairs and Trade, Government of Australia.

The Institute in collaboration with the CIRAD (Centre De Cooperation Internationale en Recherche Agronomique pour le Developpement), France is working on the project "Assessing the productive and adaptive capability of two different goat breeds to heat stress based on differences in the phenotypic and genotypic traits", sanctioned by European Union, Government of France.

To ensure the widespread availability of anti-methanogenic supplement across different parts of the country and seasons, the ICAR-NIANP and M/s Radiant Chem Industries, Chennai entered into a functional-industry-linkage through MoU for undertaking collaborative research to develop anti-methanogenic products using industrially available tannins.

Laying of Foundation Stone of Farmers Training cum Student's Hostel and Community Hall

The Honourable, Deputy Director General (Animal Science), ICAR, Dr Bhupendra Nath Tripathi laid the foundation stone of the Farmers Training cum Student's Hostel and Community Hall at the Institute on 23 January 2021 in the presence of Dr Raghavendra Bhatta, Director, ICAR-NIANP and all the staff members of the Institute.

Celebration of Institute Foundation Day

The Honourable, Deputy Director General (Animal Science), ICAR, Dr Bhupendra Nath Tripathi laid the foundation stone of the Farmers Training cum Student's Hostel and Community Hall at the Institute on 23 January 2021 in the presence of Dr Raghavendra Bhatta, Director, ICAR-NIANP and all the staff members of the Institute.

Implementation of हर मेड़ पर पेड़

As per the guidelines received from ICAR, the Institute conducted a tree plantation drive under the campaign "हर मेड़ पर पेड़" on 16 July 2021. During the occasion, the saplings of golden melaleuca (Melaleuca bracteata) were planted in the Institute premises.

Staff Welfare Club

The Staff Welfare Club (SWC) of the Institute organizes various programme for the staff throughout the year. However, the activities of SWC were restricted during the reported period due to COVID pandemic. The SWC organized the celebration of Republic Day, Independence Day, Ganesh Chaturthi, Ayudh Puja, Kannada Rajyotsava and Institute's Foundation day. The club also recognized the children of permanent staff, who have passed the 10th and 12th board examinations with outstanding grades, awarded the outstanding contractual employees for their contribution, and organised farewell of the retired employees.

Development of New Infrastructure

During the reported period, the construction of "Community Hall" began. This 216 m2 facility is being created for welfare activities of the Institute staff for the purposes of hosting of family functions and playing indoor games. Similarly, the construction of "Farmers/Students Hostel" started too. The built-up area of this facility is 312 m2 , and it consists of six double-occupancy rooms. Both the facilities are being constructed by CPWD and will be handed over to the Institute soon.

Swachh Bharat

Institute implemented the Swachh Bharat Abhiyan programme in accordance with instruction of Govt of India and ICAR and actively adopted the Campaign. Several Swachhata Awareness programmes were organised under the campaign. As per the guidelines of ICAR, Swachhata programme was arranged at the Institute campus from 16th Dec 2021 to 31st Dec2021. The Swachhata programs like Swachhta pledge, display of banner, tree plantation drive, solid waste management and Essay and drawing competition for school children of staff etc. were organised to create awareness about campaign. The Institute implemented digitalization of office records through e-office, GeM, PFMS, FMS etc. The various cleaning and maintenance activities were organised in the Institute such as cleanliness drives at Institute campus, cleaning of storm water drainage, disposal of old and obsolete furniture and junk items through auction, vermicomposting of organic waste for generation of wealth from waste, levelling the uneven areas of the Institute campus, and creation of lawn and sitting area near the Nandini Milk Parlour.

Mera Gaon Mera Gaurav Programme

Under the "Mera Gaon Mera Gaurav" program, the Institute constituted several teams of scientists and technical staff. Each team adopted different villages within 100 km distance from Bengaluru. These teams regularly visited the villages and interacted with farmers to appraise about scientific feeding, production, fodder cultivation, clean milk production and management of livestock. Literatures and calendar containing various technical information were printed in local language and distributed to farmers. Technical information were also provided through workshops and seedlings and seeds of various fodder crops were distributed among the beneficiaries.

In House Seminar

Date	Talk Delivered	Speaker
12 September 2021	Activities carried out at "SAARC Agriculture Centre, Bangladesh" as Senior Program Specialist (Livestock)	Dr AK Samanta, Principal Scientist, ICAR -NIANP, Bengaluru.
16 December 2021	NABL Accreditation	Dr K Ashok Kumar, Head and Principal Scientist, Fish Processing Division, ICAR -CIFT, Cochin

Students' Research

Name of the student	Degree	University registered	Dissertation title
S Roy	PhD	Jain (Deemed -to-be University)	Biotransforamtion of D -Galactose into D -tagatose and its evaluation as nutraceuticals
K Kalpana	PhD	Jain (Deemed -to-be University)	Effect of cryopreservation of preantral follicles on estradiol synthesis pathways and oocyte development in ruminant.
SS Archana	PhD	Jain (Deemed -to-be University)	Identification of sperm immune regulatory proteins influencing semen quality in HF bulls
L Ramya	PhD	Jain (Deemed -to-be University)	Identification of sperm novel transcripts and RNA elements influencing semen quality and fertility in Murrah buffalo
D Swathi	PhD	Jain (Deemed -to-be University)	Elucidation of sperm -enriched biological processes and the ir candidate genes regulating fertility in Murrah buffalo
J Sharanya	PhD	Jain (Deemed -to-be University)	Effect of dietary calcium and magnesium on sex ratio and placental genes expression in New Zealand white rabbit
S Backialakshmi	PhD	Jain (Deemed -to-be University)	Molecular studies on sperm functional gene expression and seminal plasma protein profiling in Osmanabadi bucks (*Capra hircus*) supplemented with organic zinc and copper

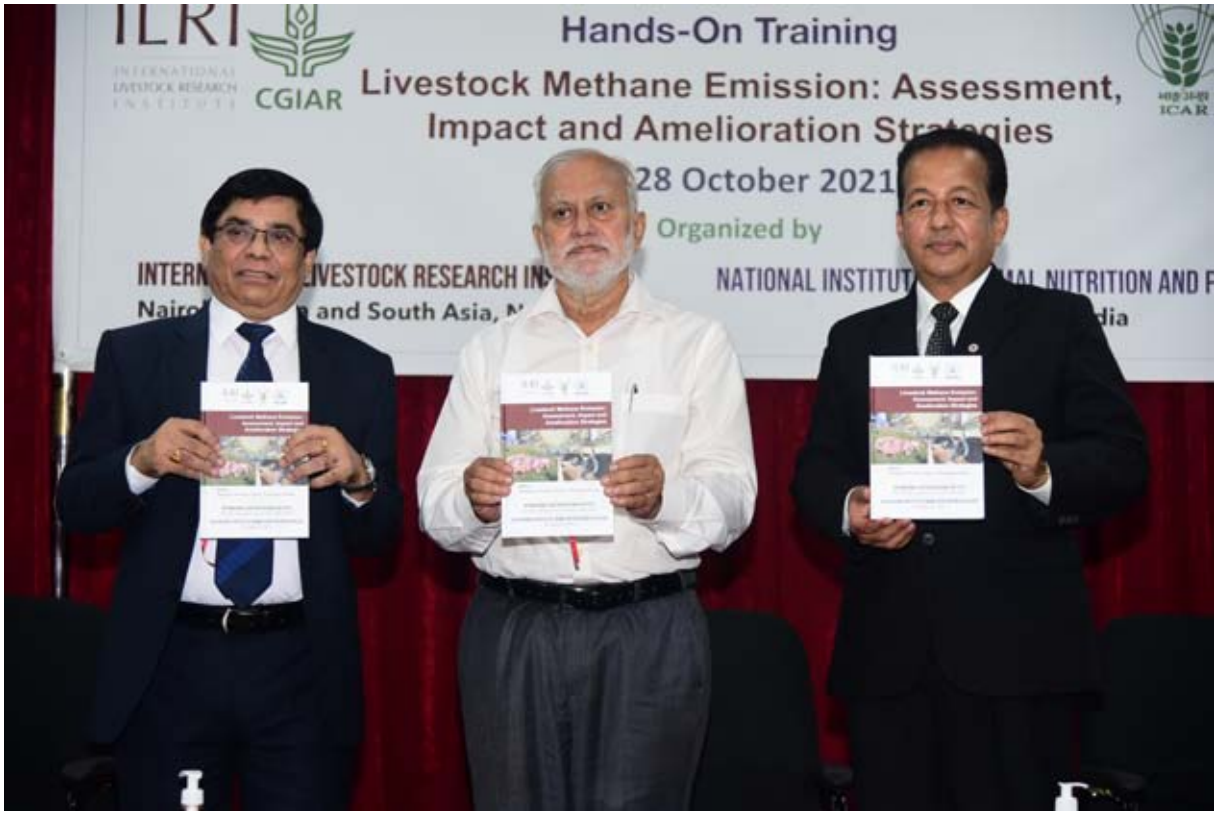
VM Krishnaiah	PhD	Jain (Deemed -to-be University)	Supplementation of organic zinc and copper on spermatozoal gene and protein expression pattern in male goat (*Capra hircus*).
R Ranjith Kumaran	PhD	Jain (Deemed -to-be University)	Establishment of cryopreservation of sheep spermatogonial stem cells
P Hemanth Kumar	MVSc	ICAR-IVRI	Effect of milk and its components on cryosurvival and signaling in buffalo (*Bubalus bubalis*) sperm

Right to Information

During the reported period (January-December 2021), a total of 14 RTI queries/applications received. Requisite information was provided to all as per the provision of RTI Act 2005.

Distinguished Visitors

Dr BN Tripathi, Honourable DDG (Animal Science), ICAR, visited the Institute on 23rd January 2021



Dr S Ayyappan, Honourable Chairman, Karnataka Science and Technology Academy and Former Secretary (DARE) and DG (ICAR), and Dr H Rahman, Regional Representative for South Asia, ILRI, visited the Institute on 26th October 2021.

Dr Praveen Malik, Animal Husbandry Commissioner, Ministry of Fisheries, Animal Husbandry and Dairying, Govt of India, visited the Institute on 28th October 2021

Dr Rameshwar Singh, Honourable Vice Chancellor, Bihar Animal Sciences University, Patna, and Dr Jagadeesh Bayry, Professor, IIT, Palakkad visited the Institute on 24th November 2021

CHAPTER 6

Infrastructure & Facilities

Research Laboratories

The Institute maintains 17 advanced research laboratories with specialized analytical facilities. The "Micro Nutrient Laboratory" is mandated for conducting research on micronutrients for animal production and reproduction. The laboratory is equipped with high throughput instruments such as ICP and equipment for analysing macro and micro minerals as well as toxic heavy metals in feeds and fodders, soil, water and, animal products like meat, milk, egg, hair and skin. The "Toxicology Laboratory" is well equipped with all modern equipment for estimation of toxic elements in feeds, fodder water, soil and biological materials. The "Feed Analysis Laboratory" is having all the facilities for estimation of proximate principles in feed and fodder samples, and in vitro digestibility studies. This laboratory also extends commercial analytical services to outside agencies such as milk federations, commercial firms, other institutions and farmers. The "Rumen Microbiology Laboratory" and "Gut Microbiology Laboratory" are well equipped with modern facilities for isolating and characterizing the rumen microbes such as bacteria, protozoa and methanogens. The "Energy Metabolism Laboratory" is primarily involved in quantifying greenhouse gas emissions from livestock, understanding the underlying mechanisms of enteric methane emission and devising cost effective and farmers' friendly amelioration strategies for reducing enteric methane emissions. The laboratory has international collaborations with Japan, Germany, Australia and Kenya. The "Feed Quality and Safety Laboratory" is involved in assessing the quality and safety of animal feeds and related biological samples. This laboratory also provides commercial analytical services to milk federations, government agencies and Feed factories. The "Feed Additives and Nutraceuticals Laboratory" is mandated to conduct research on nutraceuticals, particularly prebiotics and probiotics. The laboratory focuses on the process for extraction and production of prebiotics from agricultural wastes and byproducts, and evaluation of prebiotics and probiotics as nutraceuticals in different animal models. The "Feed Resources and Informatics Laboratory" explores newer feed resources for adding to the feed basket and develops farmers' friendly smart tools.

The "Omics Laboratory" is equipped to handle transcriptomics, metagenomics and proteomics protocols and bioinformatics. It focuses on unravelling determinants of oocyte and embryo developmental competence, production of recombinant proteins in bacteria and yeast systems, microbial community analysis based on TRFLP and amplicon sequencing, metagenome sequencing of rumen microbes in domestic livestock species and metabolome characterization of the rumen environment. The "Radioisotope and Endocrinology Laboratory" is a certified RIA Type II Laboratory and licensed by AERB (BARC). This laboratory caters to the application of radioisotopes and molecular

endocrinological tools for various research applications and, focuses to conduct the basic endocrine and neuroendocrine hormone dependent productive status and wellbeing in farm animals and poultry. The "Reproductive Physiology Laboratory" focuses on improving fertility in farm animals by working on novel areas such as, profiling of sperm transcripts for predicting/screening male fertility, sperm sexing by proteomic approaches, molecular markers for assessment of semen quality and cryo-susceptibility, and spermatogonial stem cells. The

"Animal Biotechnology Laboratory" focuses on culturing and cryopreservation of preantral follicles, in vitro production of sex specific embryos, sex specific differences in embryo development, endocrine disruptors and gamete functions and identification of biomarkers of developmental competence of preantral follicle, oocyte and embryos under environmental, nutritional and metabolic stress. The "Molecular Biology Laboratory" primarily focuses on early pregnancy biomarkers and diagnostic assay in buffalo, characterizing protein, peptides and microRNA functions and expression, stem cell biology, development of novel semen extender for buffalo and production of recombinant buffalo bull fertility and sperm motility associated proteins. The "Nutrient Kinetics and Integrative Physiology Laboratory" focuses on elucidating cellular and molecular mechanisms for livestock adaptation and thermo-tolerance, regulation, integration and modulation of gastrointestinal functions in livestock, nutrient-gene interactions and nutrition-immune system interaction in livestock and, screening of indigenous goat breeds with extreme climate resilience capability.

Centre for Climate Resilient Animal Adaptation Studies

The "Centre for Climate Resilient Animal Adaptation Studies" is a newly added facility. The centre is the first of its kind in Asia. The centre has two climate chambers, thermo-neutral zone chambers and heating/cooling chambers. The chambers are primarily for small ruminants and are extendable for pig and poultry. Each chamber has the holding capacity of twelve small ruminants with provision for individual feeding and watering and, collection of urine and faeces.

The unique features of this facility are 24 microclimate-controlled chambers, thermo-neutral zone chambers with four temperature (22-28^{o}C) regulating sensors and one relative humidity (55-60%) regulating sensor, heating/ cooling chambers with six temperature (5-50^{o}C) regulating sensors and one relative humidity (45-95%) regulating sensor, regulations of weather variables (temperature, relative humidity and light intensity), provision to induce accurate thermo-neutral zone for small ruminants, provision of conducting both heat stress and cold stress studies, provision to simulate any weather condition across the world, no socialization stress as animals can see and communicate with each other, no restraining stress as animals can be maintained in individual cabins ensuring free movements, data logger to record weather variables of microenvironment within the climate chambers as well as both within and outside the climate chamber building and, provision to conduct experiments throughout the year.

Centre for Laboratory Animal Research

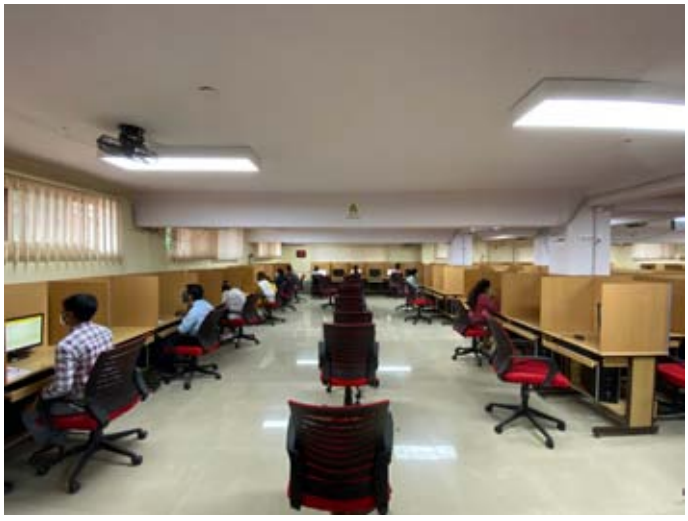
The state-of-the-art facility "Centre for Laboratory Animal Research" has been established at the Institute. This 846m^2 facility offers provisions for housing and breeding of rat, mice, rabbits, guinea pigs and hamsters, as well as conducting experiments on them. The facility includes animal rooms, holding and quarantine room, surgery/dissection theatre, two modern research laboratories and auxiliary rooms under one roof.

It is an integrated BSL-II facility with double corridor movement through clean and dirty alleys. The animal rooms are centrally air-conditioned with directional air movement with pressure difference between corridors and animal rooms. Designated animal rooms for mice and rats with individually ventilated cage system (IVC) are available in the facility. The facility also includes service rooms for washing and autoclaving, storage for clean and non-clean materials dedicated laboratories for conducting experiments on laboratory animals with facilities for molecular biology and proteomic work, culturing of oocytes, embryos and cells, genetic manipulation of oocytes, embryos and cells and production of recombinant proteins and antibodies.

The facility is mandated to conduct experiments on laboratory animals in the area of bioavailability of nutrients, developmental biology, production of genetically modified animals, stress-induced alterations in reproductive and immune functions, developing metabolic disease models and association of gut microflora with reproductive and immune functions. Further the facility will also be used for breeding of mouse/rat strains and inhouse production of important antibodies in laboratory animals and imparting trainings on the breeding and management of laboratory animals.

ARIS Cell and ICAR-ASRB Online Examination Centre

The "Agricultural Research Information Systems (ARIS) Cell" was set up in 1998. The ARIS cell felicitates maintenance of computer systems along with printers and scanners. The ARIS cell is also responsible for the information security of the Institute through a centralized network-based security system. Internet facility is provided by the "National Knowledge Network (NKN)" initiative of the Govt of India. As a hub of the NKN, the institute is provided with 100mbps link. The cell also maintains the website of the Institute with regular updates about recruitments, tenders, training courses etc. The



software "Feed Base" and web portals such as "Feed Chart" and "Indian Livestock Feed Portal" have been developed and are being hosted on the Institute website.

The "ICAR-ASRB Online Examination Centre" for Karnataka was established at the Institute for conducting ICAR NET/ARS examinations. The centre is equipped with 100 examination PC terminals supported by two servers and UPS backup for conducting the examinations. Online monitoring of the entire examination process is done through IP based CCTV surveillance system. Online examinations are regularly being conducted at the centre.

Library

The Institute has a highly spacious and well organised Library for its staff and readers. The library subscribes Indian and foreign scientific journals (online), general magazines and newspapers regularly for keeping its readers abreast with the current developments. Until now, the library has archived 3506 numbers of back volumes (hard copies) of Indian and foreign scientific research journals, procured 1329 numbers of scientific and administrative reference books, and 26 numbers of masters and PhD thesis. To promote Rajbhasha (Hindi), the library has procured 447 numbers of Hindi books. For the year 2021, the library has received 136 gratis publications from India and abroad. The library provides access to more than 2500 online national and international scientific research journals and 1174 e-books though Consortium of e-resources in Agriculture (CeRa)/ J-Gate Plus platform subscribed by ICAR, New Delhi. In addition, currently, the library subscribes 12 general magazines and 7 newspapers in English, Hindi and Kannada for the readers. The Library facilities of the institute are also offered to the students, researchers and staff of the other ICAR institutes, state agricultural universities (SAUs) for their reference work. The library maintains computer terminals for the readers for browsing of scientific literature and references. The library renders various reprographic services to the researchers, students, trainees and staff of the institute as well. Presently, all the accessions and majority of the operations of the library including issue of books/ journals/ reading materials and its records have been made digitalized.

Experimental Livestock Unit

The Experimental Livestock Unit (ELU) has the facilities for housing experimental animals such as large and small ruminants and poultry birds. The unit also possesses a small scale feed processing and storage facility. During the reported period 23 cattle, 16 buffaloes, 140 sheep/goats, 750 poultry were maintained for various experiments for 12 different research projects. Revenue was also generated from the unit by selling of farm produce (meat, eggs, live birds and animals) on completion of experiments under various projects.

Fodder Production Unit

This unit is ensuring regular supply of green fodder to the experimental livestock unit of the Institute. Demonstration plots of cowpea and marvel grass were established. The stem cuttings of Erythrina fodder tree were planted. Various forage crops like Bajra, Marvel Grass, Guinea Grass, perennial Sorghum, Hybrid Napier Bajra, Maize and Para Grass were cultivated. The top feeds were supplied from fodder trees like Melia, Sesbania, Moringa and Gliricidia. Silage from various forage crops was prepared in plastic drums to ensure adequate green fodder during the lean months. Azolla cultivation continued in the ponds for its use as supplemental feed. The stem cuttings of Hybrid Napier Bajra, root slips of Guinea Grass and Marvel Grass, seedlings of Sesbania, and Azolla culture were supplied to several farmers. Method demonstrations were conducted on silage making in plastic drums, production of grain sprouts on straw bedding, Azolla cultivation in ready to use PVC ponds and preparation of shade dried Azolla for popularization of these technologies to the trainees and farmers.

Guest House

The Institute has a picturesque guest house within the campus. It is furnished with AC suites and rooms. Television with DTH connection and internet connectivity are available in each room apart from the basic amenities. VIPs, Institute guests and invited guests are accommodated at this guest house. Other facilities at the Guest House includes dining hall with kitchen and food is available for all the residing guests on prior request.

Agricultural Technology Information Centre

Agricultural Technology Information Centre (ATIC) acts as a single window to provide information and advisory services on livestock production, sale of institute publications and as a location contact point for farmers and other visitors of the Institute. The centre facilitates information-based decision-making among the farmers by providing technology information in a customized manner. ATIC provides advisory services on livestock farming, suitable species, breeds, feeding and management practices etc., which are critical for the farmers. Information dissemination is carried out through personal interaction with visitors, interaction through telephone, information through reply of letters and participation in various exhibitions, fairs and farmers' meets. During the reported period, various livestock advisories were prepared by the Centre in English and Kannada languages for dairy farming, fodder production, goat and sheep rearing, and backyard poultry farming.

Conference Facilities

The institute has state of the art, fully airconditioned auditorium with a seating capacity of 250. The auditorium is complete with all audio-visual facilities and acoustics for conducting scientific meetings. In addition, the institute also has a committee room, a lecture hall and seminal hall which are fully equipped.

Playground and Children's Park

A 13000 m2 playground and a 1800 m^2 children's park are maintained for the benefits of the staff and their children, who are residing in the campus. Various joy rides are installed at the children's park. Similarly, a cricket pitch is maintained at the playground. Weeding, mowing and watering are regularly done at the playground and children's park. These facilities are extensively used for various physical and sports activities by the staff and children.

CHAPTER 7

Personnel

List of Employees

Scientific personnel

Name	Designation
Dr Raghavendra Bhatta	Director
Animal Nutrition Division	
Dr SBN Rao	Principal Scientist, I/C
Dr M Chandrasekharaiah	Principal Scientist
Dr AK Samanta	Principal Scientist
Dr S Anandan	Principal Scientist
Dr NKS Gowda	Principal Scientist
Dr DT Pal	Principal Scientist
Dr D Rajendran	Principal Scientist
Dr NM Soren	Principal Scientist
Dr M Bagath	Senior Scientist
Dr AP Kolte	Scientist
Dr S Jash	Scientist
Dr T Chandrappa	Scientist
Dr M Gopi	Scientist
Animal Physiology Division	
Dr JR Ippala	Principal Scientist, I/C
Dr PSP Gupta	Principal Scientist
Dr S Mondal	Principal Scientist
Dr SC Roy	Principal Scientist
Dr S Nandi	Principal Scientist
Dr J Ghosh	Principal Scientist
Dr ICG David	Principal Scientist
Dr S Selvaraju	Principal Scientist and National Fellow
Dr V Sejian	Principal Scientist
Dr A Arangasamy	Principal Scientist
Dr A Mishra	Principal Scientist
Dr G Krishnan	Senior Scientist
Dr BK Binsila	Scientist
Dr B Krishnappa	Scientist
Bioenergetics and Environmental Sciences Division	
Dr AV Elangovan	Principal Scientist, I/C
Dr K Giridhar	Principal Scientist
Dr KVH Sastry	Principal Scientist
Dr KS Roy	Principal Scientist

Dr G Ravikiran	Principal Scientist
Dr A Dhali	Principal Scientist
Dr (Mrs) RU Suganthi	Principal Scientist
Dr PK Malik	Principal Scientist
Dr N Ramachandran	Principal Scientist
Dr (Mrs) A Mech	Principal Scientist
Dr (Mrs) G Letha Devi	Senior Scientist
Dr C Devaraj	Scientist

Technical Officers / Technicians

Name	Designation
Shri V Ramesh	Chief Technical Officer, T-9 (Maintenance)
Dr VB AwachatAssistant	Chief Technical Officer, T-7/8 (ELU)
Shri VR Kadakol	Technical Officer, T-5 (APD)
Shri DR Govinda	Senior Technical Assistant, T-4 (Estate and Maintenance)
Mrs G Maya	Senior Technical Assistant, T-4 (BEES)
Shri KM Kamalesh	Senior Technical Assistant, T-4 (Maintenance)
Mrs YC Vijayalakshmi	Technical Assistant, T-3 (Establishment)
Mrs K Bharathi	Technical Assistant, T-3 (AND)
Shri M Shivarama	Technical Assistant, T-3 (Maintenance)

Administrative Personnel

Name	Designation
Mrs S Shashikala	AO
Shri SR Sreenivasa	AAO
Shri R Suresh Babu	Assistant
Mrs JV Jyothi	Assistant
Mrs Geetha B	Assistant
Shri Ajayan P	PS (on deputation)
Shri L Gowda	UDC (retired on 31-05-2021)
Shri A Murthy	UDC
Shri N Vinod Kumar	UDC (on deputation)
Mrs PP Sheeja	AFAO
Mrs MP Mridula	Assistant
Mrs P Nagaraju	UDC

Supporting Staff

Name	Designation
Shri K Narayana	SSSI
Mrs J Lakshmi	SSSI

CHAPTER 8

List of Research Projects

Biogeography of Gut Microbes in Animals

Funding	Project Title	Duration	
		Start	End
Institute	BGM 2.4. Isolation and characterization of lipolytic/lipid biohydrogenation bacteria from the rumen of sheep supplemented with different fat sources	Apr, 2017	Mar, 2022
Institute	BGM 2.5. In ovo manipulation of gut microbes in broiler chicken	Jun, 2020	Mar, 2023
Institute	BGM 2.6. Production and evaluation of nutraceutical potential of Post and Parabiotics in lab animals	Apr, 2021	Mar, 2024
ICAR-Network	Veterinary type culture – rumen microbes	Oct, 2009	Mar, 2022

Novel Approaches for Assessing and Improving Nutrient Bioavailability, Animal Reproduction and Productivity

Funding	Project Title	Duration	
		Start	End
Institute	APR 3.14. Comparative assessment of the resilience capacity of indigenous goat breeds to summer heat stress based on selective thermo-tolerant gene expression pattern	Apr, 2017	Mar, 2021
Institute	APR 3.15. Modulation of sexual differentiation in embryos altering oxidative status ofin vitro culture system	Apr, 2017	Mar, 2022
Institute	APR 3.16. G-Protein coupled receptors and gut hormones in gut chemosensing and regulation of fat digestion and absorption in sheep	Apr, 2017	Mar, 2022
Institute	APR 3.18. Role of uric acid in alleviating oxidative stress induced mitochondrial dysfunction during different production cycles in poultry: Regulation by organosulphur compounds	Apr, 2017	Mar, 2022
Institute	APR 3.19. Studies on metal carnitine chelates for improving bioavailability and tissue utilization of trace minerals and production performance in animals	Apr, 2017	Mar, 2022
Institute	APR 3.20. Evaluation of grain sprouts as fodder for livestock	Apr, 2017	Mar, 2021
Institute	APR 3.21. Influence of administration of prostaglandin modulators on embryo survivality in sheep	Nov, 2017	Oct, 2021

Institute	APR 3.22. Development of nutritional modules for commercial broiler sheep production	Apr, 2017	Mar, 2021
Institute	APR 3.23. Unravelling the physiological role of adiponectin in regulation of energy metabolism in goats	Apr, 2018	Mar, 2022
Institute	APR 3.24. Modulation of GnRH system through novel neuropeptides during embryogenesis and responses in post hatch broiler chickens	Apr, 2018	Mar, 2022
Institute	APR 3.25. Development of precise delivery system for improved bioavailability of zinc for poultry	Apr, 2018	Mar, 2022
Institute	APR 3.26. Biological activities of rare earth elements in relationship to production performance of egg and egg and meat type chicken	Apr, 2018	Mar, 2022
Institute	APR 3.28. Elucidation of cryo-tolerance and its mechanism in buffalo spermatozoa	Jun, 2020	May, 2023
Institute	APR 3.29. Development of a synthetic semen extender for cryopreservation of buffalo semen	Jul, 2020	Jun, 2024
Institute	APR 3.30. Studies on Complementary Physiological and Molecular Mechanisms and Finetuning Research Tools for Holistic Poultry Production	Dec, 2021	Nov, 2024
ICAR-National Fellow	Development of buffalo bull fertility diagnostic chip based on sperm transcripts signatures	May, 2017	May, 2022
Inter-institutional	Ethno-Veterinary study for enhancement of reproductive performance in livestock	Mar, 2019	Mar, 2022
Inter-institutional	Biosynthesis of different nano mineral particles using plant extracts and evaluation of their potential as feed supplement in poultry	Jun, 2020	May ,2023
AICRP	Nutritional and physiological interventions for enhancing reproductive performance in animals	Apr, 2014	Mar, 2026
DST (Indo-Iran)	Identification of potential biomarkers in donor cows for in vitro embryo production by integrative genomic and system biology approaches	Jan, 2020	Jan, 2023
DBT-Twinning	Biotechnological interventions to augment productive performance of pigs on horticultural by-product based diet	Mar, 2018	Mar, 2022
NASF	CRISPR/CAS9 guided functional analysis of genes regulating early embryonic survival in buffalo	Aug, 2018	Jul, 2022
NASF	Targeted immobilization of Y- bearing spermatozoa and modulation of oviduct 1ilieu for skewing the sex ratio towards female offspring in dairy cattle	Aug, 2018	Jan, 2022

ICAR-Extramural	Efficacy of Kisspeptin and its analogues in the existing estrus synchronization protocols to augment fertility in small and large ruminants	Nov, 2018	Mar, 2023
DST-SERB	Establishment of the 3D in vitro culture conditions for maintaining long-term stemness in sheep spermatogonial stem cells	May, 2019	Aug, 2022
ECLIPSE	Assessing the productive and adaptive capability of two different goat breeds to heat stress based on differences in the phenotypic and genotypic traits	Jul, 2018	Jun, 2021

Feed Informatics, Feed Quality and Safety and Value Addition

Funding	Project Title	Duration	
		Start	End
Institute	FQS 4.3. Development of a novel phytogenic blend to replace antibiotic growth promoters in broiler production	Dec, 2017	Mar, 2022
Institute	FQS 4.4. Assessment and characterization of antimicrobial resistance (AMR) genes in poultry production environment	Apr, 2019	Mar, 2022
Institute	FQS 4.5. Assessment and forecasting of feed resources at regional and national level for different production scenarios	Oct, 2020	Mar, 2024
ICAR-CRP	Bio-fortification of cereals- evaluation of value addition cereals (VAC) and cereal by-products for animal feeding	Jan, 2015	Mar, 2022
AICRP	Micro and secondary nutrients and pollutant elements in soil and plants: Effect of zinc fortification of soil on zinc status in fodder and livestock	Jan, 2016	Mar, 2023
ICAR-Outreach	Monitoring of drug residues and environmental pollutants	Nov, 2009	Mar, 2022

Climate Change Impact on Livestock

Funding	Project Title	Duration	
		Start	End
Institute	CCL 5.2. Life cycle assessment of sheep farming in Bengaluru rural	Feb, 2020	Feb, 2023
ICAR-Outreach	Estimation of methane emission under different feeding systems and development of mitigation strategies	Apr, 2008	Mar, 2026
ILRI-ICAR	Methane emission and its mitigation	Jan, 2019	Jan, 2022

Indo-German	Contamination of feed and fodders with heavy metals and agro-chemicals and impact on milk composition, rumen microbes and methanogenesis in dairy cattle along the rural-urban Interface of Bengaluru	Mar, 2021	Mar, 2024

Feed Informatics, Feed Quality and Safety and Value Addition

Funding	Project Title	Duration	
		Start	End
Institute	TTA 6.3. Economics of milk production under different systems of dairy farm management in Karnataka	Apr, 2017	Dec, 2021
Institute	TTA 6.4. Effect of ground water levels on livelihoods of dairy farmers	Apr, 2021	Mar, 2023
Institute	TTA 6.5. Economics of sheep rearing under different systems of management in Karnataka	Apr, 2021	Mar, 2023
ICAR-Farmer FIRST	Improving livelihood security of farmers through technological interventions for sustainable livestock farming	Nov, 2016	Mar, 2026
ICAR-Farmer FIRST	Enriching knowledge and integrating technology and institutions for holistic village development in horticultural based farming systems	Nov, 2016	Mar, 2026

ICAR - National Institute of Animal Nutrition and Physiology
Adugodi, Bengaluru – 560 030, Karnataka, India
An ISO 9001:2015 Institute
Tel: +91-80-25711304, 25711303, 25702546; Fax: +91-80-25711420
Email: directornianp@gmail.com, Website: http://www.nianp.res.in

ISBN 9788195420117