ICAR-CIRB

Annual Report
2015-16

भाकृअनुप
ICAR

ICAR-Central Institute for Research on Buffaloes
Hisar - 125 001 (Haryana) India

Citation
ICAR-CIRB Annual Report 2015-16
ICAR-Central Institute for Research on Buffaloes
Hisar, Haryana, India - 125 001

Published by
Dr. Inderjeet Singh
Director, ICAR-CIRB

Compiled, Design and Edited by
Dr. Hema Tripathi
Dr. Avijit Dey
Dr. Varij Nayan
Dr. Selokar Naresh Lalaji

ICAR-Central Institute for Research on Buffaloes
Hisar - 125 001, Haryana, India
Tel. No. : +91 1662 - 281602
Fax : +91 - 1662-275004
Toll Free : 1800-180-1043
Website : http://www.cirb.res.in
e-mail : director.cirb@icar.gov.in

Date of Printing : 03.07.2016

Printed at
Dorex Offset Printers
Near Swastik Gas Godown, Satya Nagar, Hisar
Ph. No. 9896011117

Contents

Preface

Annual Report 2015-16 of ICAR-Central Institute for Research on Buffalo (CIRB) is being presented as a comprehensive treatise highlighting the significant achievements of the Institute in the areas of buffalo production during the last one year which provides a holistic view of this premier Institute of the country and its functioning. The research and development programme of CIRB got momentum through mandate oriented and well-structured research programmes comprising 12 in-house and 14 externally funded research projects. The primary focus of the Institute involves genetic up gradation and multiplication of pure breeds of buffaloes and improvement of production performance using scientific interventions. The Institute is also endeavoring to undertake research in genomic, physiological-nutritional interventions, advance reproduction and management strategies for augmenting buffalo production under farm and field conditions. Supply of quality semen and application of cloning, embryos transfer, nanotechnology and genomic based selection are explored for increasing the productivity and economic utility of buffalo. The institute will also be a key player in the socio-economic upliftment of buffalo rearing farmers by infusing superior germplasm in the farmer's herd by providing quality semen, and disseminating knowledge on effective buffalo husbandry practices through on and off campus trainings.

The most remarkable breakthrough during 2015 was the birth of cloned buffalo calf, named 'Hisar-Gaurav' using somatic cell isolated from tail, this way Institute becomes India's second institute to produce cloned buffalo. The Institute is expecting more clones in near future both in Institute herd as well as in the field at farmer's doorstep. This research achievement received an overwhelming recognition in the country and put CIRB on world map.

For dissemination of quality germplasm, 74 Murrah breeding bulls were sold to various developmental agencies, breeders, panchayats and farmers, while 25 Nili-Ravi bulls were sold primarily to Punjab State Animal Husbandry Department for frozen semen production and natural mating in breeding tract of the breed and under tribal sub-plan. Under Murrah progeny testing programme, bull no. 3267 and 3591 from CIRB Hisar ranked 1 and 2 with sire index value of 2177.81 and 2176.56 kg, respectively and are used for nominated mating in elite buffaloes. Nili-Ravi

herd performance exceptionally well for all production parameters, which were all-time best, reimposing the superiority of this breed and reasonability of using it as an improver breed for nondescript population across the country. For improving buffalo reproduction in field various estrus induction and synchronization protocols such as Ovsynch, Ovsynch-plus, Heat synch and Progesterone implant were tested. Mx2 was identified as a biomarker during early pregnancy and seminal plasma level of OPN, TAC and MDA could be a discriminative tool to predict fertility in breeding bulls. For SCNT studies, 11 primary somatic cell lines elite buffaloes including field champions were established and cryopreserved. In the area of buffalo nutrition management, various feeding modules were optimized for improving reproductive performance and production. Garlic oil has positive effects on rumen fermentation and significantly reduces methane production without affecting dry matter digestibility. Combination of herbal feed additive for controlling gastro-intestinal parasites in buffaloes was developed.

Besides the research, many extension activities were executed includes buffalo Mela cum exhibition in Institute premises on the occasion of main and sub-campus foundation days. Infertility treatment camps and calf rallies were organized for buffalo husbandry promotion. Under new initiative, Mera Gaon Mera Gaurav scheme, total 32 villages from the states of Haryana, Rajasthan and Punjab were adopted for scientific awareness of farmers. Various events such as ICAR Foundation Day, World Food Day and Jai Kisan Jai Vigyan Week were celebrated with enthusiasm. In human resource development, graduate research students from deemed universities, ICAR-NDRI and ICAR-IVRI completed their research thesis work, and currently 14 students are perusing M.V.Sc. /Ph.D. research work at CIRB. Institute scientists and administrative staff were trained at various institutions. More than 100 field veterinarians from states of Uttar Pradesh, Rajasthan, Haryana, Punjab, Gujarat, West Bengal, Karnataka and Chandigarh were trained in ultrasonography in large animal. On and off campus trainings were organized on buffalo husbandry practices for rural youths and farm women.

I would like to express my sincere gratitude and acknowledgement for the valuable guidance and support given by the Secretary, DARE and Director General, ICAR, the Deputy Director General (Animal Science) and their team at the ICAR HQ. I record my sincere acknowledgment to the Heads of division, scientists, administrative and technical staff of the Institute for their contribution towards the progress of this Institute. I am sure that with their persistent support and efforts, I would be able to march ahead in fulfilling the mandate and objectives of CIRB with earnest zeal and responsibility and bring success and glory to the Institute in the years to come.

Thanks

Dr. Inderjeet Singh

Executive Summary

- Achieved continuation of ISO 9001:2008 certification (BN8192/7295:0913) for third year under the scope 'Improved Buffalo Germplasm Production' for institute.
- 152 calves of high genetic merit were born during the period. A total of 74 breeding Murrah bulls were sold to various developmental agencies, breeders, panchayats and farmers, while 25 Nili-Ravi bulls were sold primarily to Punjab State Animal Husbandry Department for frozen semen production and natural mating in breeding tract and under tribal sub-plan.The reproductive traits *viz*. service period (138 days), calving interval (449 days) and dry period (141 days) were the best (lowest) in last ten years.
- In XI set of Murrah progeny testing programme, bull no. 3267 and 3591 from CIRB Hisar, ranked 1st and 2nd with sire index value of 2177.81 and 2176.56 kg, respectively followed by bull no. 2133 from GADVASU, Ludhiana having sire index of 2175.40 kg.
- 95426 frozen semen doses were produced, 24114 doses supplied and 34838 doses sold for Murrah and in case of Nili-Ravi, 16460 semen straws were produced and 2350 straws were sold.
- 4434 A.I. using 15 test bulls of XV set and 9 test bulls of XVI set were performed in ten adopted villages. The conception rate in the field was 53%. In this period, 2486 pregnancies were confirmed and 1718 calvings (900 males, 818 females) were recorded. The average age at first calving for 119 progenies was 41.52 months.
- A total of 1345 female Murrah progenies of XII to XV set are standing in the field for future recordings, out of which 577, 578 and 190 daughters were <1 year, 1-3 years and >3 years, respectively. The physical identification using injectable microchips/ear tagging has been done in all female progenies born in the field till December 2015.
- The overall wet average (8.04 kg), herd average (5.21 kg), 305 days lactation milk yield (2336.06 kg), total lactation milk yield (2483.11 kg), peak yield (11.17 kg), and lactation length (322.19 days) were achieved in Murrah herd.
- In Nili-Ravi buffaloes, the overall wet average, herd average, 305 days milk yield, and total lactation milk yield reported were 8.51 kg, 6.22 kg, 2471 kg and 2564 kg, respectively. These were all time best. The reproductive traits such as service period, calving interval and age at first calving were 145 days, 453 days and 40 months, respectively.
- 456 DNA samples from Murrah (76), Nili-Ravi (116), Jaffarabadi (116), Pandharpuri (77), Bhadawari (36) and Surti (35) were deposited in DNA repository.
- Cloned calf, 'Hisar-Gaurav' was born at ICAR-CIRB which was made from somatic cell isolated from tail. With this achievement, the institute became India's second institute to produce a cloned buffalo using hand guided cloning technology.
- 14 primary somatic cell lines from fetus, new-born, elite bulls and superior buffaloes were established and cryopreserved. Somatic cells were also isolated from fresh semen stored at 4°C for 6 days.
- The buffalo fibroblasts electroporated with GFP construct resulted in approximately 30-40% cells integrating with GFP construct and showing green fluorescence.
- Application of estrus induction and synchronization protocol was made under field conditions using four protocols *viz*. Ovsynch, Ovsynch-plus, Heat synch and Progesterone implant. Animal infertility treatment camps were organized in different villages to meet the objectives.
- Seminal leptin concentration was found to be positively correlated with sperm abnormalities, MDA concentration and negatively correlated with sperm concentration.
- *Gub Doka* cases had lower serum albumin and

phosphorus levels as compared to *Doka* cases.

- Buffalo Mx2 was targeted for sensing applications as it has shown promise as a biomarker during early pregnancy. Oligopeptides were deduced and designed from the buffalo Mx2 protein for production of polyclonal antibodies. A homology model of buffalo Mx2 protein was also developed.
- Measurements of OPN, TAC and MDA in seminal plasma have shown potential as a discriminative tool to predict fertility in breeding bulls.
- Reproductive parameters for resumption of cyclicity and pregnancy rate were not affected by feeding of protected nutrients (bypass fat and protein either alone or in combination) over and above the ICAR standard in post-partum buffaloes.
- Comparative collective diversity analysis of rumen bacteria in cattle and buffaloes revealed their host specificity. Firmicutes was the major phylum with *Prevotella*, *Lachnospiracea incertae sedis*, *Butyrivibrio*, *Clostridium*, *Ruminococcus* and *Fibrobacter* were predominant genera in buffalo. Rarefaction analysis of abundant OTUs (having at least three members) indicated 99.6% sequences coverage in cattle and 78.9% coverage in buffalo at putative species level. These findings may open new directions for further characterization of rumen bacterial communities.
- Supplementation of garlic oil (1μl/30 ml buffered rumen fluid) has positive effects on rumen fermentation with 38.35% reduction in methane production without reducing *in vitro* dry matter digestibility.
- Analysis of sorghum stover from different types of sorghum revealed lowered acid detergent fibre and lignin contents in brown midrib sorghum than others. *In vitro* truly degradable dry matter was also highest in brown midrib sorghum and lowest in forage sorghum.
- Active ingredients such as beta-sitosterol, diisooctyl phthalate, solasonine, arborside A, and luteolin have been identified in herbal extracts for their effectiveness against G.I. parasite *Haemonchus.* A suitable mixture of these showed synergistic effects *in vitro*. This could facilitate development of herbal feed additive for controlling gastro-intestinal parasites in buffaloes.
- A feeding module for buffalo calves for meat production has been developed. Buffalo calves for meat can be reared economically on roughage based diet with a concentrate based finisher diet after attaining a body weight of about 170 kg.
- Identification of variation in feed efficiency in term of residual feed intake (RFI) has been examined, the result of which shall be utilized to identify the underlying genetic variation after corroboration from other parameters.
- Interspecies SCNT technique was attempted for the production of equine cloned embryos. 53 interspecies horse embryos were produced despite more than 90% cleavage, exhibiting first/subsequent cleavage; all were arrested at 16 cell stage.
- Seven scientists and two administrative staff members were trained at various institutions under capacity building.
- A total of 26 training programs (24 at main station and 2 at sub-campus) for 1469 farmers and farm women were organized.
- Eight trainings were organized benefitting 114 field veterinarians from states of Uttar Pradesh, Rajasthan, Haryana, Punjab, Gujarat, West Bengal, Karnataka and Chandigarh on ultrasonography in large animal reproduction for fertility augmentation. One of these trainings was sponsored by sponsored by Directorate of Extension, Ministry of Agriculture & Farmers' Welfare, Government of India, and six by UP Livestock Devlopment Board.
- One 'on campus training' of 10 days duration was organised exclusively for 60 SC/ST Youth on buffalo husbandry as an employment enterprise.
- Five 'off campus trainings', each of 03 days duration on buffalo husbandry practices were organised for 470 women farmers in villages.
- 550 rural women were covered under various capacity building and sensitization programs in villages on buffalo farming. Apart from these,

approximately 300 rural girls benefitted during various programs held at their schools. More than 100 women were trained as part of the training programs at campus. For economic empowerment of women of Rajasthan, six buffaloes were given to six women of BPL ST Category under tribal development sub plan. Four women were widows and 2 were orphans.

- Eleven infertility treatment camps were organized in 11 different villages wherein 232 cases were attended for anoestrus, repeat breeding, silent heat, metritis and pregnancy diagnosis etc.
- Buffalo Mela cum Exhibition was organized in Institute premises at Hisar on the occasion of Institute Foundation Day wherein 264 elite animals, buffalo bulls, milch animals, lactating, dry buffaloes, heifers etc. from all over Haryana and adjoining states participated. Category-wise champions were awarded.
- Sub-Campus Nabha organised its Foundation Day by organizing a Nili-Ravi Buffalo Mela and Kisan Gosthi. Hundreds of Nili-Ravi farmers from far flung areas participated in the mela.
- The institute actively participated in 6 melas organised at Kayodak, Kaithal (Haryana); twice in Motihari (Bihar); Muktsar (Punjab); SKUVS&T (Jammu); Krishi Unnati Mela (New Delhi) by putting up its stall and showcased the technologies.
- Four calf rallies were organized for female progenies born of the FPT project in 4 adopted villages. Competitions were held under three categories (calves <1 year, heifers-1-2 years and heifers >2 years).
- Milk recording for authentication of the high milk yielder buffaloes of the farmers were organised every month, wherein a total of 22 farmers' high yielding buffaloes participated. Two buffaloes were recorded over 24 Kg, two from 20-24 Kg and eight buffaloes from 18-20 Kg.
- The institute initiated Mera Gaon Mera Gaurav scheme, wherein scientists of the main campus of CIRB and sub-campus Nabha selected 32 villages from the states of Haryana, Rajasthan and Punjab and remained in touch by providing information to the farmers on technical aspects through personal interactions, demonstrations, capacity building programs and mobile telephony mainly on buffalo rearing.
- The scientists of institute participated in 12 different programs of media channels of Doordarshan and radio besides, participating in three Prashn Manch programs for the Kisan Channel of Doordarshan in villages.
- 87th ICAR Foundation Day was celebrated with the theme 'Employment Opportunities in Agriculture for the Rural Youth" in two Government schools situated in village Talwandi Rana and Juglan of Hisar. More than 350 school children from class X onwards participated in the programme. Lectures were delivered to sensitize the youth on "Career Opportunities in Agriculture" and "Role of ICAR" on the occasion.
- A sensitization program on the occasion of World Food Day on the theme "Social Protection and Agriculture: Breaking the Cycle of Rural Poverty" was organised at campus. About 80 people participated including 38 school children from Government school, Hisar.
- Jai Kisan Jai Vigyan Week (December 23-29, 2015) was organised and it attracted the students towards science and agriculture. Group discussion and science quiz competitions etc were arranged in schools.
- One day sensitization program was held for 80 women hailing from Women Dairy Cooperative Society in village Mingni Khera on improved buffalo husbandry practices.
- A total of 36 research and review publications were made in Indian and International journals of repute.
- Nine Institute funded projects have been completed. Institute has 12 ongoing and 14 externally funded projects.
- Scientists of the Institute received 06 awards and recognitions for presentations during conferences, seminar and symposia and participated in 21

different National and International conferences, meetings, workshops, symposia etc.

- Six post graduate research students completed their research work and submitted the thesis, whereas 14 students are pursuing M.V.Sc. /Ph.D. research work at CIRB.
- Agriculture farm at main campus, Hisar produced 39485.60 quintals of green fodder, 667.15 quintals of straw and 995.35 quintals of grain.
- At sub-campus Nabha, 52943 quintals green fodder, 6203 quintal grain including barseem, oats, mustard, barley,wheat and rice seeds and 3487 quintals dry fodder (turi/karbi) were produced.
- At main campus, fifteen acres of saline soil was reclaimed by growing paddy and barley crops. About 75 acres of Agriculture farm land was levelled with laser leveller. In about 50 acres of this land, roads channel and blocks were made.
- At sub-campus Nabha, 16 acres land was improved by removing dried trees, shrubs and leveling. 33 acres dhaincha were sown for green manuring that improved the physical property of land. 40 acres land was improved by spreading farm yard manure and compost. 1300 feet chain link fences were created to protect about 40 acres land from stray animals. 72 acres and 3 Marla land was deleased to Animal Husbandry Department, Punjab.
- Fodder harvester-cum-chopper were purchased both at main and sub campus for automation of farm operations. Besides, one 4x4 tractor was also purchased at sub-campus.
- Feed unit prepared about 600 tonnes of concentrate feed for feeding to farm animals using grinder and mixer. Also approx.15 tonnes of area specific mineral mixture are being prepared annually for farm animals as well as for sale to the farmers for its popularization.
- Three new scientists were appointed through ARS and two Principal scientists joined on transfer at CIRB. Besides, two skilled support staffs were appointed and one joined on transfer. Three scientists and other technical officers have been transferred from CIRB to other Institutes .Eight scientists and seven other staff of Institute promoted to next higher grade. Nine staff members have been superannuated during the period.
- Revenue generation increased during the year (2015-16) to Rs. 424.36 lakhs against Rs. 356.83 lakhs during 2014-15 and Rs. 312.13 lakhs during 2013-14.

Introduction

ICAR-Central Institute for Research on Buffaloes (ICAR-CIRB) was established by transfer of erstwhile Progeny Testing Bull Farm, Hisar from the Haryana State Government, to the Indian Council of Agricultural Research in the year 1985. Available infrastructure, land, assets and buffalo herd of the Progeny Testing Bull Farm were transferred to the CIRB and the institute started functioning from 1st February 1985. A sub-campus was established in December 1987 at Bir Dosanjh, Nabha, District Patiala, Punjab with the transfer of Nili- Ravi buffalo farm from the Punjab State Government. The main campus has established a highly pedigreed breeding herd of Murrah whereas sub campus has established a highly pedigreed breeding herd of Nili-Ravi buffaloes. The institute carries out research on various aspects of buffalo improvement including conservation, improvement and propagation of germplasm, development of optimum diets and feeding systems, enhancement of reproductive efficiency and health management practices for augmenting milk, meat and draught performance of the species

The Vision

To develop and propagate high yielding elite buffalo germplasm for quality milk and meat production while retaining inherent draughtability across different regions of the country.

The Mission

To improve buffaloes through identification, conservation and propagation of elite germplasm having high efficiency of reproduction and nutrient utilization for sustainable production and commercialization.

The Mandate

- To promote and undertake research on all aspects of buffalo production.
- To establish nucleus breeding herds of important buffalo breeds.
- To act as a repository of information on all aspects of buffalo production and development.
- To collaborate with national and international institutes in the area of buffalo research and development.
- To undertake extension activities for technology transfer.

Staff position as on 31st March 2016			
Category	**Sanctioned strength**	**Filled**	**Vacant**
RMP	01	01	0
Scientific	40	32	8
Technical	44	38	6
Administrative	20	17	3
Skilled Support Staff	73	63	10
Total	**178**	**151**	**27**

Priority setting and management

The institute has a Research Advisory Committee (RAC) comprising of eminent scientists who guide research agenda of the institute. The functioning of the institute is supervised by Institute Management Committee (IMC) headed by the Director and members drawn from different institutes and related agencies. A number of sections like Priority Setting, Monitoring and Evaluation Cell, RFD Cell, Institute Technology Management Unit and AKMU have been created and assigned responsibilities for smooth functioning of research activities of the institute. For the XII plan period flagship programs and priority areas were identified to focus on strategic research in niche areas. This institute is coordinating Network Project on

Buffalo Improvement with 10 centers across the country, addressing 7 important buffalo breeds. The institute is also carrying out technology transfer through conducting training for farmers, field days, web based extension activities besides traditional methods of extension in order to disseminate modern buffalo husbandry practices based on research and development in the area.

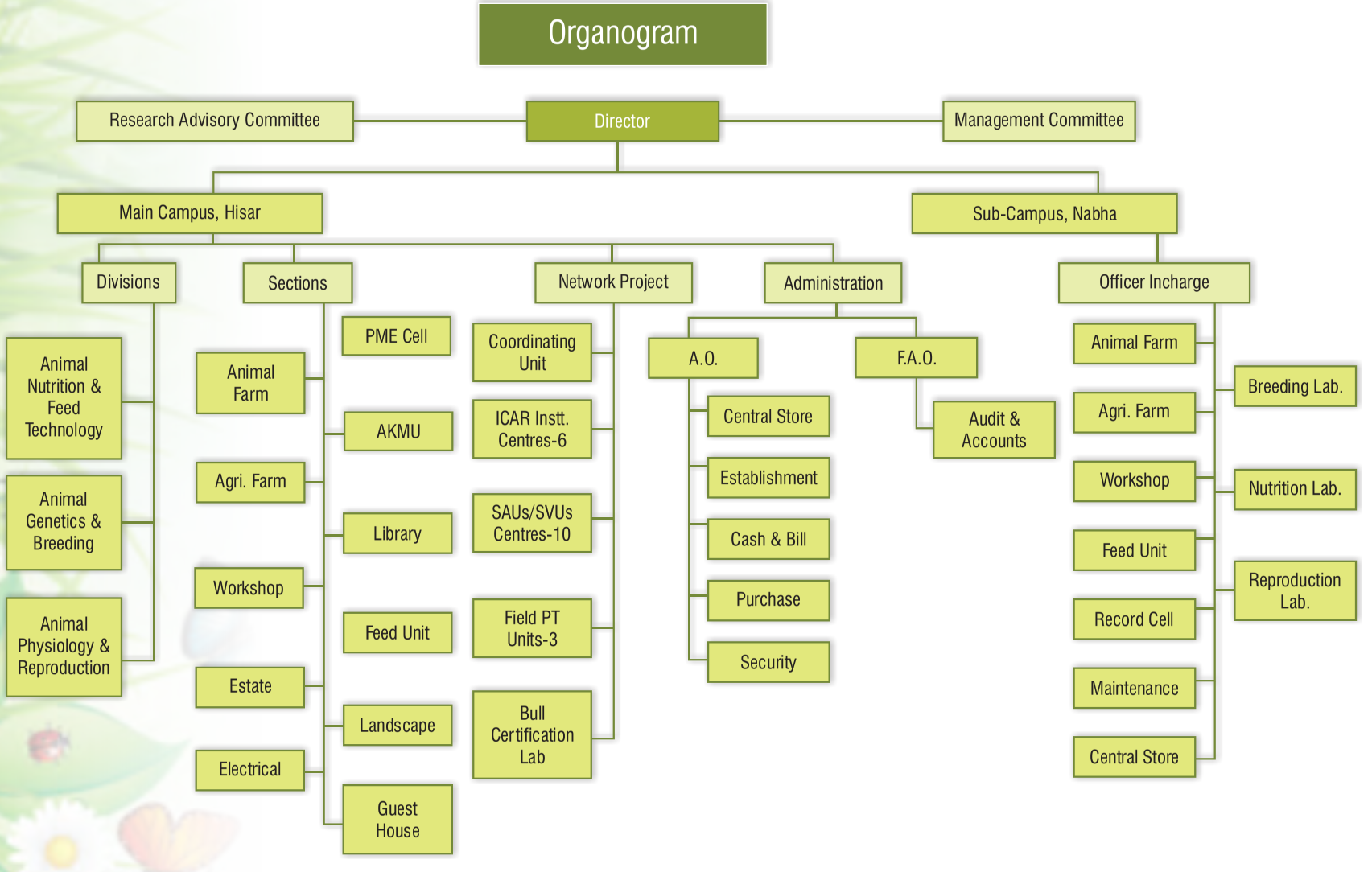
Financial Statement /Outlay (Rs. In lacs)

Heads	Sanctioned Budget 2015-16	Expenditure 2015-16
Plan 2015-16	385.00	353.86
Non-Plan 2015-16	2144.30	2080
Network Project on Buffalo Improvement	518.00	516.20
AICRP on Nutritional and physiological interventions for enhancing reproductive performance in animals	25.64	21.44
IPR & Commercialization of technology	6.00	3.72
DBT Project	2.95	2.95
NABG CABIn project	31.24	25.71

Revenue Generation

Revenue generation increased during the year (2015-16) to Rs. 424.36 against Rs. 356.83 lakhs during 2014-15 and Rs. 312.13 lakhs during 2013-14. This is apart from the savings affected in expenditure through the use of farm produce in animal feeds and fodder. Additional funds were attracted through contract research project.

Organogram


Research Advisory Committee
Director
Management Committee
Main Campus, Hisar
Sub-Campus, Nabha
Divisions
Sections
Network Project
Administration
Officer Incharge
Animal Nutrition & Feed Technology
Animal Genetics & Breeding
Animal Physiology & Reproduction
Animal Farm
Agri. Farm
Workshop
Estate
Electrical
PME Cell
AKMU
Library
Feed Unit
Landscape
Guest House
Coordinating Unit
ICAR Instt. Centres-6
SAUs/SVUs Centres-10
Field PT Units-3
Bull Certification Lab
A.O.
F.A.O.
Central Store
Establishment
Cash & Bill
Purchase
Security
Audit & Accounts
Animal Farm
Agri. Farm
Workshop
Feed Unit
Record Cell
Maintenance
Central Store
Breeding Lab.
Nutrition Lab.
Reproduction Lab.

Research Achievements

Genetic Resource Improvement

For accelerating the pace of improvement in water buffalo country requires large number of breeding bulls/semen doses of high genetic merit. At present a wide gap exists between the availability and the requirement of superior buffalo bulls. To bridge this, more emphasis is being given to include the farmers' buffaloes in the progeny testing programme. Traditional selection tools need to be combined with biotechnological tools. Institute has been following an integrated approach involving phenomics, genomics, proteomics and bioinformatics tools in buffalo breeding programs for improvement in desired traits.

Network Project On Buffalo Improvement (NPBI)

The NPBI was initiated in 1993 with the aim to produce progeny tested bulls for improvement in buffaloes. Seven important buffalo breeds are covered under Eighteen (funded/non funded/ICAR/University based) centres. Conservation of Bhadawari, Swamp and Nili-Ravi Breed is going on along with improvement. In 2001 field progeny testing programme in Murrah was initiated at CIRB, Hisar, NDRI, Karnal and GADVASU, Ludhiana with the aim to produce more number of daughters per bull for evaluating sires with more accuracy.

Genetic Improvement of Murrah Buffalo

Test mating from XV set bulls completed in December 2015 and XVI set of test mating initiated with 15 bulls (5 bulls from CIRB Hisar, 3 bulls from GADVASU Ludhiana, 4 bulls from NDRI Karnal and 3 bulls from LUVAS Hisar) in January 2016 and will continue upto July 2017 at associated centres and field units of Murrah for genetic improvement under the Network Project on Buffalo Improvement.

Progeny Test Evaluation of Bulls

Data of 133 daughters born from the XI set of bulls which completed their 1st lactation were compiled and bulls were evaluated. Bull no. 3267, 3591 from CIRB, Hisar ranked 1st and 2nd with sire index value of 2177.81 and 2176.56 kg respectively, followed by bull no 2133 from GADVASU, Ludhiana having sire index of 2175.40 kg.

Top Ranking Bull No 3267	
Number	3267
Location	CIRB, Hisar
Born On	27-09-2004
Dam No.	2263
Dam's Best Yield (kg)	2489 (Ist lactation)
Sire No.	1419 (VII set)
Breeding value	2177.81
% superiority	0.20
Frozen semen doses available	2016

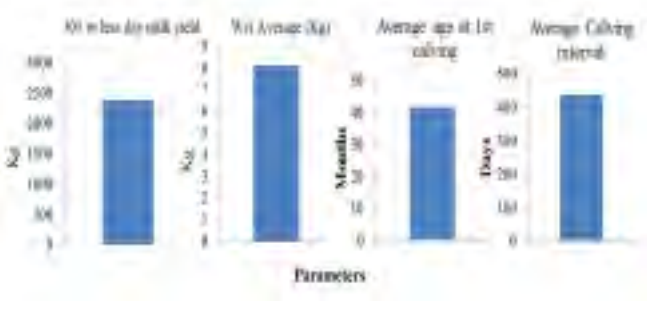
Information of the Participating Murrah Herds

The herd Strength of associated Murrah herds is 2058 which include 1045 breedable buffaloes.

Centre	Herd Strength	Breedable buffaloes	Percent Calf Mortality (0-3 months)	A.I.	CR %
NDRI, Karnal	585	328	17.13	333	40.50
CIRB. Hisar	505	229	4.87	363	51.81
GADVASU, Ludhiana	245	131	5.63	249	39.76
LUVAS, Hisar	302	162	2.86	271	43.17
IVRI, Izatnagar	188	74	17.91	84	48.80
LRS, Mamnoor	172	78	0.0	50	54.00
ICAR-RC for ER, Patna	61	43	10.0	35	51.40

Production and Reproductive Performance of Participating Murrah Herds

305 day or less day milk yield of all the participating herds was above 2300 kg except LRS Mamnoor, which is under the process of reestablishing the herd after relocation. GADVASU Ludhiana, LUVAS Hisar and NDRI Karnal centre produced >2500 Kg average 305 day or less day milk yield during the period. The performance of LUVAS centre is highest for wet average and herd average. Herd average of CIRB centre was nest to LUVAS only. GADVASU centre recorded highest 305 or less day milk among all the centres.



AI done at Murrah FPT centres and females born during 2015-16:

Parameter/centre	Observations
AI done	14664
Total PD	6944
Conception rate	47.35%
Calving Recorded	6379
Female Born	2969
Male born	3410

*PD till Dec 2015

General information of the Participating Herds of other breeds

Centre	Herd Strength	Breedable buffaloes	Percent Calf Mortality (0-3 months)	A.I.	CR %
Nili Ravi, CIRB Sub Campus Nabha	491	227	2.38	439	37.59
Surti, LRS Vallabhnagar, RAJUVAS	113	50	9.09	64	37.5
Pandharpuri, MPKV Kolhapur	78	35	5.26	33	51.51
Jaffarabadi, JAU Junagardh	290	174	6.25	81	66.7
Bhadawari,IGFRI Jhansi	104	59	16.13	52	73.00
Swamp, AAU Khanapara	53	35	30.0	29	58.00

Production and Reproduction Performance of Participating Herds of other breeds in 2015-16:

The Nili Ravi herd showed improvement in 305 day milk yield, wet average and herd average. Its performance is highest since its inception.

Centre	Productive Performance			Reproductive Performance	
	305 day or less day milk yield (kg)	Wet Average (kg)	Number of observation	Average Age at First Calving in months (n)	Average calving Interval in days(n)
Nili Ravi, CIRBSub Campus Nabha	2471	8.51	110	40.00 (56)	453 (88)
Surti, LRS Vallabhnagar, RAJUVAS	1477	5.13	20	46.29 (1)	484 (19)
Pandharpuri, MPKV Kolhapur	1526	4.22	10	45.24 (1)	464 (11)
Jaffarabadi, JAU Junagardh	1959	8.1	48	47.82 (11)	468 (42)
Bhadawari,IGFRI Jhansi	1322	4.49	25	47.25 (5)	523 (24)
Swamp, AAU Khanapara	480	1.03	4	53.00 (1)	523 (7)

Genetic improvement of Murrah and Nili-Ravi buffaloes

Seventy four breeding bulls/ young Murrah males were sold for breeding purpose to different agencies during the period. Five breeding males from CIRB unit were selected for test mating in XVI set under NWPBI. A total 95,426 semen doses of Murrah buffaloes were frozen and 24,114 doses were supplied under network project, 34,838 doses were sold. In case of Nili-Ravi, total herd strength of Nili-Ravi buffalo was 491 and 146 calves (73 males and 73 females) added due to birth. The overall wet average, herd average, 305 days milk yield, and total lactation milk yield during the period are highest since inception of the sub-campus. Reproductive traits such as service period, calving interval and age at first calving had shown an improvement over the years.

Performance of Murrah and Nili-Ravi buffalo herds

Traits	Murrah herd Hisar	Nili Ravi herd Nabha
Herd Strength	505	491
Breedable buffaloes	229	227
Conception rate (%)	51.81	37.59
Calf mortality (%)(0-3 months)	4.87	6.55
Overall mortality (%)	2.87	2.66
Wet average (kg/d)	8.04(114)	8.51 (110)
Herd average (kg/d)	5.21(176)	6.22 (151)
Peak yield (kg)	11.17±0.15(152)	12.4±0.21 (110)
Lactation length (d)	322.19±4.91(152)	305±5.39 (110)
TLMY (kg)	2483.11±43.68(152)	2564 (110)
305dMY (kg)	2336.06±33.36(152)	2471±49.3 (110)

Traits	Murrah herd Hisar	Nili Ravi herd Nabha
Service period (d)	138.39±7.39(111)	145.3±9.2 (88)
Dry period (d)	140.78±5.52(111)	150.8±7.7 (88)
Calving Interval (d)	449.26±7.43(111)	453.3±9.2 (88)
AFC (m)	44.96±1.24(24)	40.0±0.61 (56)
Bulls sold	74	25
Milk sold (kg)	302238	289058.5

Progeny testing of bulls under field conditions

Under field progeny testing program (FPT) semen of test bulls is used for artificial insemination, followed by pregnancy diagnosis, calving records, tagging and follow up of progenies till the completion of their first lactation for milk records on the basis of monthly test day recording. During the period from April 2015 to March 2016, 4434 AI using 15 test bulls of XV set and 9 test bulls of XVI set were performed in ten adopted villages under CIRB, Hisar. The use of XV set was ceased in December 2015 and XVI set was initiated from January 2016. The conception rate in the field was 53%. In this period 2486 pregnancies were confirmed and 1718 calving (900 males, 818 females) were recorded. In addition, 119 progenies, 7 of XI, 73 of XII and 39 of XIII set also calved and monthly test day milk yield were recorded / are being recorded. The average age at first calving for these 119 progenies was 41.52 months. During the year, 178 daughters were recorded, out of which 74 daughters completed the lactation, 33 daughters were sold before the lactation was completed and recording of 71 daughters is in progress. As on 31st March 2016, a total of 1345 female progenies of XII to XV set are standing in the field for future recordings, out of which 577, 578 and 190 daughters were less than 1 year, 1 to 3 years and more than three years, respectively. The physical identification using injectable microchips/ ear tagging has been done in all female progenies born in the field till December 2015.

Identification of SNPs in genes related to meat production and their association with meat parameters in buffalo

Analysis of meat from five buffaloes was performed. Average moisture, protein, fat and ash percentage were 77.6%, 18.5%, 1.1% and 1.3% respectively. The highest quality products reportedly tend to fall within a pH range of 5.7 to 6.0. The pH values of buffalo meat samples were ranging from 5.54 to 5.9 which show that the meat was of good quality. Water holding capacity indicates the structure of the muscles and intramuscular space. It varied from 7.5 to 10 percent in the samples.

Identification of genetic variants in genes related to oxidative status in relation to fertility in Murrah bulls

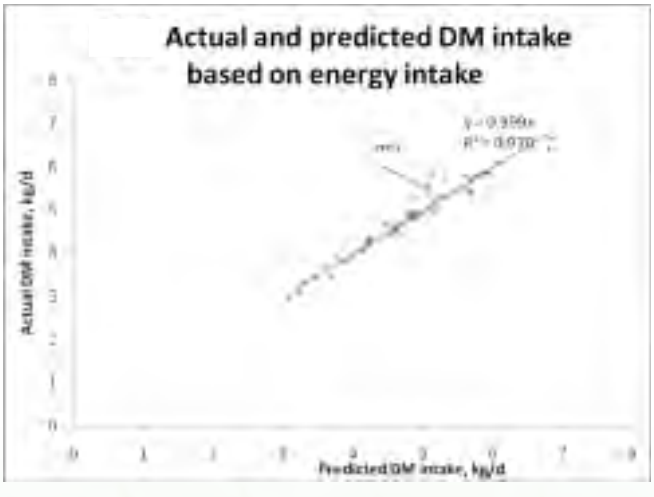
Frozen semen quality (CASA) estimates are used for bull selection, Percent decline in sperm quality parameters after cryopreservation was determined in bulls. Sperm head size, elongation, Mass, Progressive and Rapid motility was affected significantly due to cryo-stress which can be considered as phenotype determinant for selection. Post -thaw sperm quality data in sixty eight ejaculates of eight bulls over summer and rainy seasons was collected and subjected to dependant sample t–test which revealed that CASA parameters differ significantly (p-value$<$0.05) when compared with fresh state of semen during summer and rainy seasons. Individual variation in some of the CASA parameters was significant when measured by three level repeated measures ANOVA in fresh and frozen semen during seasons under study. Multivariate-regression revealed the semen quality attributes, affected prominently due to cryo-stress, as phenotype determinants for productivity and high and low resistance in bull semen. Gene expression w.r.t. cryo-stress management has been studied through sperm transcriptomic data generated in bulls of two levels of semen quality under cryo-stress.

Application of pedigree information and body condition score for development of buffalo breeding herd analyzer

Basic statistical analysis of digital data was carried out at the level of frequency distribution and its dispersion testing. Body weights along with production records were collected against the digital images of buffaloes. The complete patent entitled "KALRUMPSCALE- A device to measure buffalo rump angularity for identification of dairy characters" was designed for fabrication after seeking provisional patent. Data from available digital images of Murrah and Nili-Ravi buffaloes were extracted from downloaded file formats for further analysis. During 8th phase of the project, the steps on prediction modulation and simulation were carried out based on 2D digital images. Multiple correlations among linear measurements along with body weight were tabulated and their trends were studied.

Computational identification and modelling of genetic variation in relation to performance traits in buffaloes

To study the variation in feed efficiency, forty two Murrah heifers with average initial body weight of 155 kg were used for the study. The animals were fed individually weighed quantity of feed and residues were weighed daily. Animals were weighed at fortnightly interval. After about 45 days of feeding, a digestion trial of 6 day was conducted on 4 animals to assess digestibility and nutritive value of ration. Feed and faecal samples were analyzed for proximate composition.The feeding trial continued for 78 days. RFI was estimated as difference of actual and predicted DM intake based on energy intake. The animals had average daily gain in BW of 577g during the trial with ADG ranging from 382-807g/d. Residual feed intake (RFI) represents the amount of feed consumed, net of the animals' requirements of body weight and production. The RFI ranged from -0.437 to 0.359. Efficient animals eat less than expected and have a negative or low RFI, while inefficient animals eat more than expected and have a positive or high RFI. The study was able to identify variation in feed efficiency in term of RFI. The result of the study will be utilized for study of underlying genetic variation after corroboration from other parameters (blood biochemical). Estimation of metabolic indicators in animals under trial was done by blood indices measurement. Genotypes for different feed efficiency levels were selected from group of 42 Heifers and relation between performances i.e. average daily body weight gain/age and their blood profile were studied.14 blood parameters covering kidney/liver function tests, some microelements, growth related hormones/ growth factors were estimated in during period of 120 days (42 X 14 X 4 sampling = 2352 indices) metabolic trial at an interval of 30 days. It aims to infer the relationship between blood parameters and Age/ average daily gain of heifers. Genome level sequencing of genotypes selected for high and low performances for SNP detection with respect to production and reproduction traits is in progress.



Improvement of Reproductive Efficiency

Efficient reproduction is cumulative result of good nutrition, improved management and proper breeding strategies. An integrated approach of optimum nutrition, better management, point-of-care diagnostics and application of reproductive biotechnologies is the desired route which can lead to sustainable buffalo farming. Taking into consideration the new developments in different areas of research, strategies can be devised for boosting production potential of buffaloes. All aspects affecting health and production and their interrelationships in a holistic way with application of advanced techniques are important to understand the cumulative strength of these techniques. This integrated approach shall be helpful to provide better technology supported package of practices for end users.

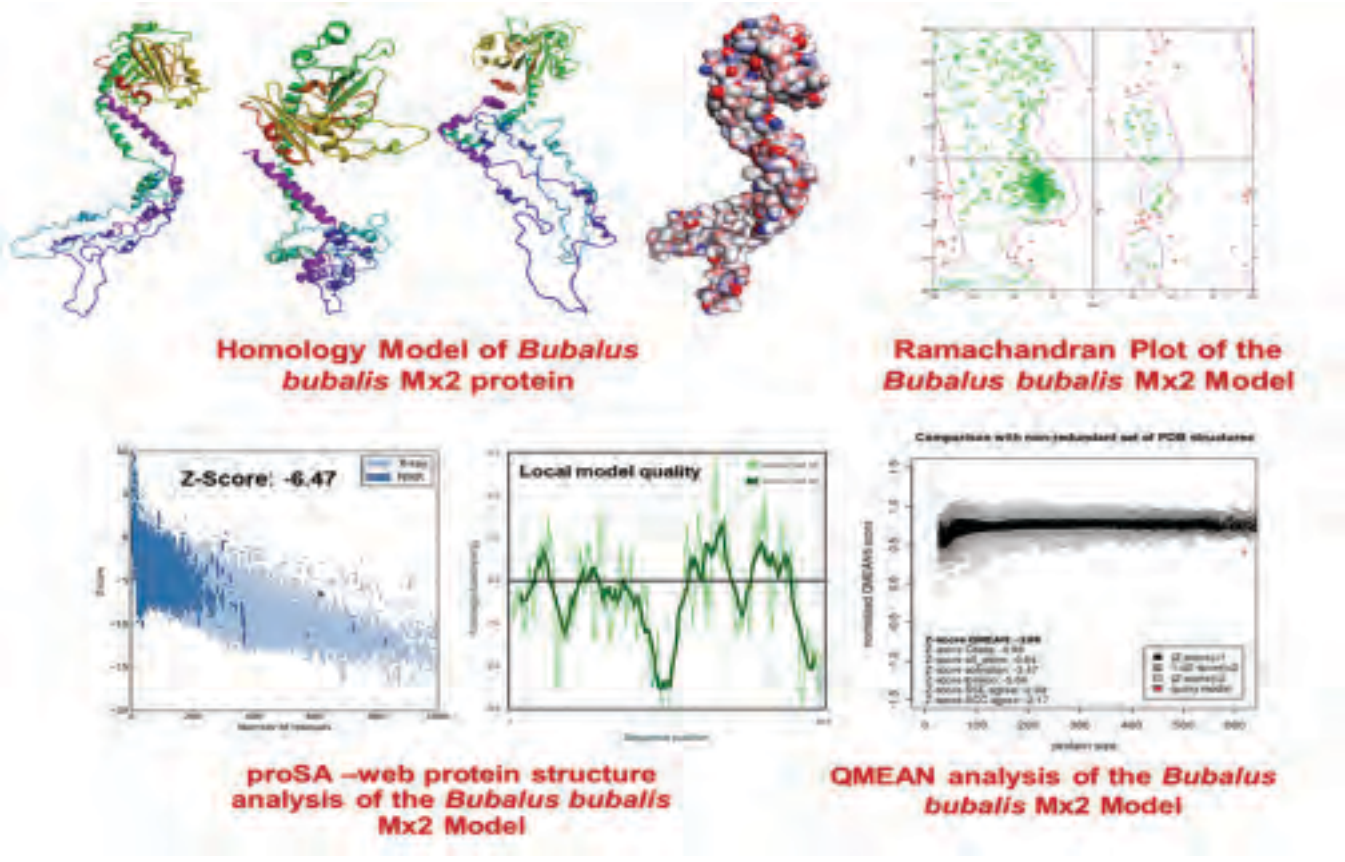
For improvement of reproductive efficiency, the major research focus is on the aspects of heat detection, estrus synchronization, induction of estrus and ovulation detection, semen cryopreservation, *in vitro* oocyte maturation, *in vitro* fertilization, cloning and establishing stem cells from different sources for conservation and multiplication of superior buffalo germplasm. Work is also being done for development of lactation stress associated postpartum anestrus SNP array, scientific validation of '*Doka*' for improvement of reproductive performance under field and farm conditions as well as generation of induced pluripotent stem (iPS) cells from fetal fibroblasts through non-viral approaches. Based on the much-needed development of diagnostics, efforts are now focused for biomarker discovery in the area of ovulation prediction, early pregnancy and other aspects of buffalo reproduction through the use of recombinant DNA technology, bioinformatics, and advances in transcriptomics, proteomics, metabolomics and nanoscience which are now being integrated for ultimate benefit of farmers.

Development of diagnostics for sensing candidate biosignatures of buffalo reproduction

There is a major gap in current research for durable diagnostic detection aids for buffalo farmers related to early pregnancy and silent heat as well as ovulation prediction. Therefore, the project aims at developing diagnostic platforms from our knowledge base of already known molecules. Buffalo Mx2 was targeted as it has shown promise as a biomarker during early pregnancy. The present work identified and designed oligopeptides, which have not been earlier, described, deduced and designed from the buffalo Mx2 protein and which can be used in the production of polyclonal antibodies by immunization in suitable laboratory animal. Buffalo Mx2 nucleotide sequences were retrieved from NCBI database, and the protein sequences were deduced from them and subjected to various bioinformatics analyses for finding the potential antigenic peptide regions. More than 3 potential peptides were identified by *in silico* analysis.

In this connection, a homology model of buffalo Mx2 protein was also developed. The model generated was visualized by 3-D Molecule Viewer (a component of Vector NTI Advance 11.5.2) and DSV. The model quality was also checked by PROCHECK, proSA and QMEAN analysis. The peptide sequences were superimposed/ identified on the model.

Potential epitope regions found in the Buffalo Mx2 protein: The buffalo Mx2 protein was subjected to several bioinformatics analysis and the antigenic regions were mapped based on the predicted antigenicity propensity score.



Homology model of Buffalo Mx2 Protein: The homology model of Buffalo Mx2 protein was developed, analyzed and mapped for identification of potential antigenic regions.

Lactation stress associated postpartum anestrus SNP array in buffaloes

Early lactation stress with negative energy balance or poor body condition may be implicated for many postpartum complications including post-partum anestrus, mastitis and metritis in dairy animals. The present research is aimed to identify the differential genes and proteins involved in postpartum lactation stress and their effect on ovarian function in buffaloes as well as on the association of variation in the genes involved with postpartum anoestrus to find genetic markers for this severe reproductive problem in buffaloes. The research work is being donewith NDRI (lead centre) & IOB as partners. The institute herd buffaloes were screened for identification of postpartum animals. The examinations were done from 30 days postpartum at 10 days interval and a total of 90 animals were selected. Several post-partum anestrous animals were identified. The collection of blood was done from heifers and post-partum anoestrus animals. Genomic DNA was isolated from the collected blood samples from the CIRB herd as well as from a village (Kungad, Hansi) of Haryana. In summary, a genetic resource repository of genomic DNA from the post-partum anoestrus buffaloes as well as cyclic heifers was made. It will be used for identifying the differential genes and proteins involved in postpartum lactation stress and their effect on ovarian function in buffaloes and on the association of variation in the genes.

Harnessing ITK: Scientific validation of *'Doka'* in buffaloes

Incidence of silent estrus and weak expression of estrus signs is rampant in buffaloes, thus efficient estrus detection is important for achieving high reproductive success. Farmers observe and pursue the phenomenon of 'Doka', a stage of temporary teat engorgement before and after milking, in buffaloes, in association with estrus. 'Extended 'Doka', typically called the 'Gub Doka' happening after service is considered as a sign of successful pregnancy.Therefore'Doka'

is 'being studied in a scientific manner. Personal interview and questionnaire based survey were conducted on 200 buffalo farmers of different villages of Haryana. The major pre-estrus and estrus sign, based on which buffaloes are taken for breeding, is 'Doka', followed by vaginal discharge, bellowing and frequent urination. Regular watching of animal is essential for identification of Doka. After identification of Doka/Gub Doka animals, milk/blood sample is collected in sterilized vial on 3rd /4th day of Doka expression. Biochemical analysis in serum and milk of Doka and Gub Doka samples revealed serum albumin and phosphorus having significantly lower values in Gub Doka compared to Doka cases. In milk, total protein (g/dl) was significantly lower in Gub Doka compared to Doka. Hematological parameters did not show any differences in "Doka" and "Gub Doka" cases. Ovaries were scanned with ultrasonography for follicles and corpus luteal status of buffaloes in Doka/Gub Doka. Number of large follicles (>10.0 mm) was more in Doka compared toGub Doka group. Doka showing buffalo were 80% cyclic, 10% acyclic and 10%with obscurecyclicity. Animals show estrus behavior after 2.22±0.60 days of Doka. Gub Doka behaviour appeared around two week after A.I. Milk losses during Gub Doka and Doka are 5.11±1.09 and 8.31±3.03%, respectively. Duration of Gub Doka is significantly ($p<0.006$) longer than Doka.

The photograph illustrates'Doka' in a buffalo.

Nutritional and physiological interventions for enhancing reproductive performance in animals

Data were collected on reproductive problems and feeding practices in Haryana. A survey on Nutritional and reproductive status of buffaloes was conducted from 1000 farmers of 40 villages in 10 districts of Haryana. The findings of this survey revealed that majority of respondents (25.1%) were belonging to medium (5-10 acres) land holding category and major purpose of buffalo in this area was for dairying. The average breedable buffalo herd size was 2.09 ± 0.04 heads. Majority (98.8%) of the farmers used intensive system of buffalo housing. Wheat straw (63%) was the sole roughage used during all seasons along with available green fodders. Cottonseed cake (75.1%) and broken wheat (46.3%) made the major part of concentrate in buffalo ration. Survey showed that majority of buffalo owner (52.8 %) did not feed mineral mixture to their buffaloes and had no tendency (67.3%) to maintain proper records of nutritional and reproductive aspects of their buffalo. The mean daily milk yield of lactating buffaloes was 10.63±0.11 kg. Majority (62.2%) of the surveyed respondents were adopting A.I. in the study area. Mean age at first conception of buffalo heifers was 31.98± 0.45 months. Mean age at first calving of buffaloes was 42.03± 0.47months. The mean service period was 110.81 ± 2.89 days in buffaloes. Majority (63.03%) of buffaloes conceived within 90 days postpartum. The mean calving interval observed was 420.80 ± 3.47 days. 46.18% buffaloes had calving interval of less than 400 days. Calving related disorders were retained placenta (2.41%), followed by prolapse (1.93%), dystocia (1.59%) and abortion (0.69%). Under field condition 9.47% of buffaloes were anestrus followed by repeat breeder (6.34%), whereas 9.69% of heifers were reported to be delayed pubertal followed by repeat breeder (6.79%) in the surveyed area.

Nutritional interventions for first 90 days to enhance postpartum fertility were also made. Forty post-partum buffaloes were divided into four groups with 10 animals in each, on the basis of their parity and milk production. Feeding of different groups was followed as: Control (C): fed balanced ration as per nutrient requirement using concentrate mixture with available green and wheat straw as basal roughage. Treatment 1 (T1, Bypass fat group): fed as per control diet with additional 15g bypass fat per Kg of milk production. Treatment 2 (T2, Bypass protein group): fed balanced ration as per nutrient requirement with available green and wheat straw as basal roughage. Treatment 3 (T3, Bypass protein + Bypass fat

group): fed as per bypass protein group with additional 15 g bypass fat per Kg of milk production. Reproductive parameters for resumption of cyclicity and pregnancy rate were not affected by protected nutrients (bypass fat and protein either alone or in combination) feeding over and above the ICAR standard (2013). However, overall mean values of fat corrected milk, milk fat, SNF, protein, lactose and total solids were higher ($P<0.05$) after feeding of these protected nutrients during first 90 days post-calving. Efforts were made for the application of estrus induction and synchronization protocol under field conditions. For oestrus synchronisation four protocols were followed i.e. Ovsynch, Ovsynch-plus, Heat synch, Progesterone implant. Animal infertility treatment camps were organized in different villages to meet the objectives. Anoestrous buffaloes were selected based on two examinations at 10 days interval by the veterinarian along with the history that animals are anoestrusfor more than 90 days and ultrasound examination at the start of treatment. The outcome of the activity is shown below.

S.No.	Protocol	Animals treated	Animals Induced (%)	Animals pregnant on first AI (%)	Animals pregnant in subsequent 2 months	Overall Pregnancy	NP	Animals sold/ not traceable
1	Ovsynch	110	76 (69%)	29 (28.7%)	37 (36.6%)	66 (65.3%)	35	9
2	Ovsynch-plus	118	93 (79%)	42 (41.6%)	36 (35.6%)	78 (77.2%)	23	17
3	Heat Synch	70	66 (94%)*	10 (18.2%)	20 (36.4%)	30 (54.5%)	25	15
4	Progesterone implant: Crestar	93	85 (91%)*	42 (46.2%)¶	15 (16.5%)	57 (62.6%)	34	02
5	Progesterone implant: CIDR	29	25 (86%)	8 (29.6%)	12 (44.4%)	20 (74.1%)	7	2

[*$p<0.0001$; ¶$p=0.008$]

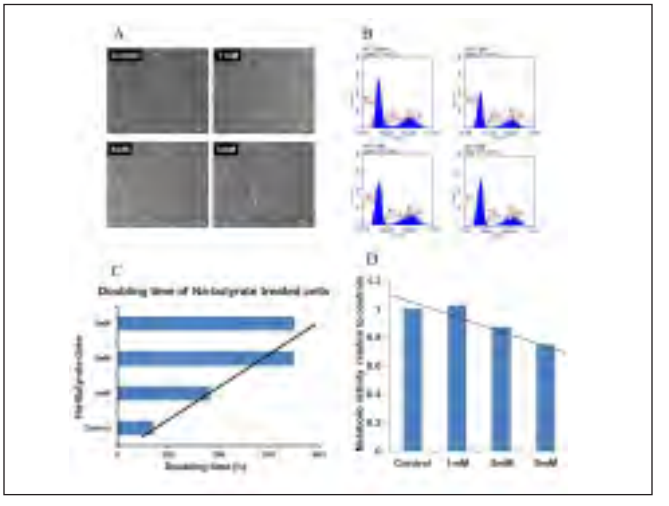
Buffalo Cloning for the conservation and multiplication of superior germplasm

A total of 328 cloned blastocysts were produced with high overall blastocyst rate of 37.5%. 48 cloned embryos were transferred in 48 recipient buffaloes resulting in 5 successfully pregnancies. Out of 5 pregnancies, two were aborted and two are continuing at advance stage. One live birth was recorded on 11.12.2015 of cloned calf, named 'Hisar-Gaurav' made from somatic cell isolated from tail of a superior Murrah bull no. 4354. With this achievement, the institute became India's second institute to produce a cloned buffalo.

Details of the cloned embryo transfer/ pregnancy and calving are shown in the table.

Total Recipients		Recipient pregnant	Embryonic mortality	Current status	Expected Calving
Farm	31	3	2	1 birth (Hisar Gaurav)	December 11, 2015
Field	17	2	nil	2 pregnant	Sep 2016; Oct 2016
Total	48	5	2	1 (Birth); 2 pregnant	

For improving the cloning efficiency, Na-butyrate was used for correcting abnormal epigenetic reprogramming by treating donor cells prior to SCNT. Effects of this modulator were observed on growth characteristics such as morphology, population doubling time, cellular toxicity and viability. Cell cycles studies were also made for the treated cells using flow cytometry.

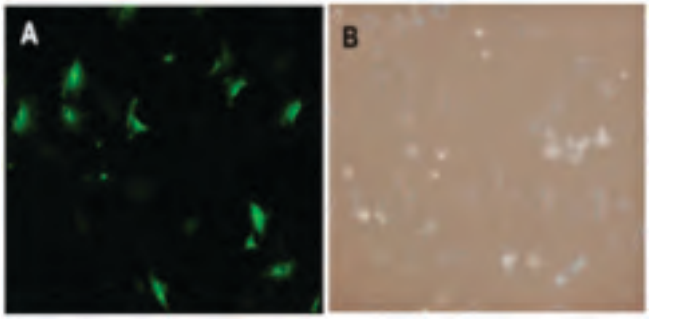


Effect of Na-butyrate on donor cells: A: Morphology, B: Cell cycle analysis, C: doubling time, D: cellular toxicity and viability.

Work was also done for the cryopreservation of somatic cells and cloned embryos for providing the future reproductive opportunities in buffalo. 14 primary somatic cell lines have been established and cryopreserved. These include 4 of adult bulls, 4 institute females, 3 champion females from field, 2 fetus and 1 new-born buffalo. These primary cell lines were characterized using expression of cytoskeleton markers viz. vimentin for fibroblast origin type and cytokeratin for epithelial origin type. Minimum 25 cryovials for each animal were preserved in Liq N2 for banking. During 2015-16, champion female buffalo (26 L) primary somatic cells were used for cloning experiments and fetal cells were used for generation of buffalo iPSC and GFP expressing cells. Also, adult institute female (Mu-3133) primary somatic cells were used to study effect of Na-butyrate for improving cloning efficiency.

Steps used for establishment of primary buffalo somatic cell lines

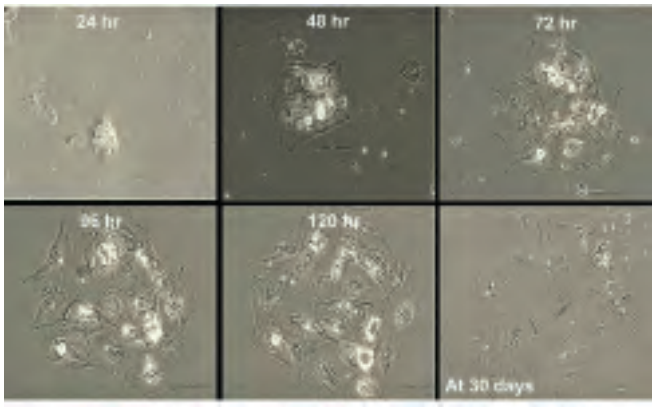
At the same time, optimization of conditions for gene transfer into buffalo somatic cells for transgenic embryo production is also underway. For optimization of conditions for gene transfer (GFP) into somatic cells, buffalo fetal fibroblasts were isolated and cultured in vitro as per established protocol in the lab. The buffalo fibroblasts were electroporated with GFP construct at 300 volt for 10ms with 1 pulse. In five trials, obtained ~30-40% cells integrated with GFP construct showing green fluorescence.The transfected cells are being enriched through selective passage for getting homogenous cells population expressing GFP. Cloned embryos shall be produced using these GFP positive cells as donor cells.



Buffalo fibroblast cells expressing GFP, A. under fluorescent microscope, B. under bright light of A.

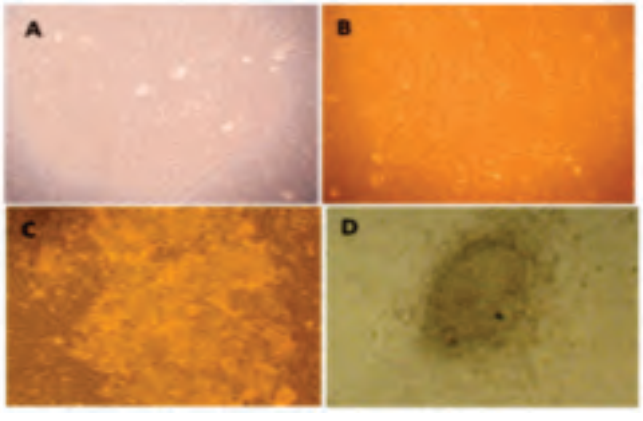
Similarly, for simplification of nuclear transfer technique for the production of elite buffalo bulls, research efforts were made. Successful attempts have been made for the isolation of somatic cells from cooled fresh semen stored at 4°C. Isolated somatic cells from cooled semen after 7 days were of epithelial origin, which was determined by expression of cytoskeleton markers. This indicated that fresh semen could be transported from distinct place to the lab, where cell culture facility exists for somatic cells culture and SCNT. For simplifying SCNT protocol, explored the use of single enucleated oocyte over optimized two-enucleated oocytes for generation of cloned embryos. Found that blastocyst production rate was extremely low in case of singlet embryos than that of doublet (15% vs

45%). Therefore, planning to optimize electric fusion settings in future experiments. Also attempted cloning of champion bull, Yuvraj and successfully established one cloned pregnancy of Yuvraj, unfortunately this pregnancy terminated after 3 months.



Isolation of semen-derived somatic cells and growth at different days in culture

Research works for the generation of induced pluripotent stem (iPS) cells from buffalo fetal fibroblasts through non-viral approaches was also started.The primary buffalo fetal fibroblasts (BFFs) were cultured from a 2- to 3-month-old fetus obtained from a slaughterhouse. Fetal tissues were trypsinized and seeded on tissue culture plates. BFFs were cultured and passaged with 0.25% trypsin/0.1% EDTA. Cells at passage 2 were electroporated with the piggyBac (PB) transposon system containing SOX2, OCT4, KLF4, c-MYC, NANOG and LIN28 transcription factors using single pulses at 300V (10 msec). The electroporated BFFs were cultured in fibroblast medium, which was later replaced by DMEM/nutrient mixture F-12, supplemented with 20% knockout serum replacement, 1mM L-glutamine, 0.1mM nonessential amino acids, 0.1mM mercaptoethanol, 100 U/mL penicillin, 100 lg/mL streptomycin, and supplemented with basic fibroblast growth factor (bFGF; 5 ng/mL or 10 ng/mL) and 1000 U/mL human leukemia inhibitory factor. After 12–17 days, the electroporated BFFs started to form round and compact colonies. Presumptive buffalo iPS cell colonies were picked with a pipette under microscopic control and plated into individual wells of 96-well culture plates containing trypsin. Presumptive buffalo iPS cells were maintained on gelatinized plates and enzymatically sub-passaged after confluency. BFFs and buffalo iPS cells were cultured in a humidified atmosphere consisting of 5% CO_2 in air at 37°C.



Generation of buffalo iPS cells, A. buffalo fetal fibroblasts, B. buffalo fetal fibroblast after electroporation, C. after 12 days of culture fibroblast changing morphology, D. buffalo iPS cells-like colony after 1st passage.

Fertility-associated seminal plasma proteins as biomarkers in buffalo

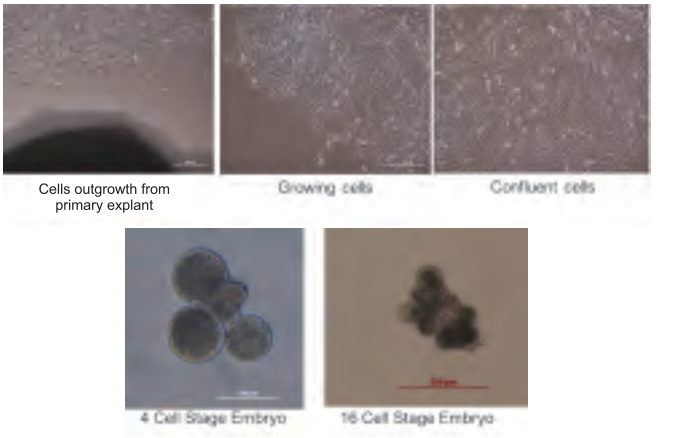
The level of osteopontin (OPN), antioxidants and malondialdehyde (MDA) in seminal plasma of buffalo bulls was estimated in relation to bull fertility and these assays might be valuable for the prediction of bull fertility in vitro. A total of 10 buffalo bulls' frozen semen doses were used for A.I. in institute adopted villages' animals. The number of A.I. ranged from 200 to 777 per bull. The CR was evaluated on the basis of establishment of pregnancy in animal and classified the bulls in two groups; and found that the CR of both the groups was significantly different. The concentration of OPN, TAC and CAT of Group I (CR> 50%) were greater ($P < 0.05$) than Group II (CR < 50%). No significant difference was observed in SOD concentration in seminal plasma of both the groups. Further, MDA concentration was lower ($P < 0.05$) in Group I compared to group II. The OPN and TAC were positively correlated with bull fertility but, no significant correlations were established with SOD, CAT and sperm motility. Thus, measurement of OPN, TAC and MDA in seminal plasma ought to be a discriminative tool to predict fertility in breeding buffalo bulls.

For identification of markers influencing semen quality, buffalo bulls (n=12) were divided into two groups of 6 each, based on average sperm concentration in ejaculates (Group I:>800 million sperm/mL and Group II:<500 million sperm/mL). Correlation between serum and seminal leptin level with semen

quality parameters of buffalo bulls were studied. From this investigation, it was found that seminal leptin positively correlated with sperm abnormalities and MDA concentration while negatively correlated with sperm concentration. This study did not reveal any correlation of sperm leptin with kinetic, motility parameters, membrane integrity and antioxidant enzymes activity. Seminal leptin concentration and seminal attributes were also not significantly correlated.

Interspecies SCNT technique for the production of horse *(Equus caballus)* cloned embryos

Skin tissue biopsies from 3 horses were taken by collaborating scientists from NRC on Equines and transported to CIRB laboratory with in 24h for isolation and culture of somatic cells. We have successfully cultured somatic cells from these tissues. Aliquots of cells at early passages (passage 2-3) were cryopreserved in DMEM/F12 containing 10% dimethyl sulphoxide (DMSO) and 20% FBS, and were stored in liquid nitrogen for future use. At least 20 cryovials were frozen in liquid nitrogen.For production of interspecies horse cloned embryos, isolated buffalo oocytes from slaughter house ovaries and undertook recipient oocytes preparation such as maturation, cumulus/zona removal, and manual enucleation, and were subsequently fused with horse somatic cells. Activation and culture of produced embryos were done as practiced in buffalo. We have produced 53 interspecies horse embryos, despite more than 90% cleavage, all were arrested at 16 cell stage. Current protocol warrant further fine tuning to get transferable quality blastocyst stage embryos.



Arrested interspecies horse cloned embryos at different stages of development

Feed Resource Utilization and Improvement

Nutritional inputs constitute over 70 per cent of the animal production costs. Further, nutritional inputs exert profound influence on performance parameters (production, reproduction, health) of animals. The basic nature of diet of ruminants is fibrous and major part of digestion (60-70%) takes place in the rumen. Development of economic rations based on the efficient utilization of available feed/ fodder resources including agro-industrial by-products, supplementation with critical/ deficient nutrients, development of complete feed diets/ total mixed rations, feeding modules including precision feeding have been the areas of research under this programme; in addition to studies on the rumen microbiome, fermentation pattern and mitigation of methane emissions. These were pursued further by conducting experiments in the following research areas.

Integrated investigation of rumen microbial communities involved in methane production and fibre digestion

This is the first study to present comparative collective diversity of rumen bacteria in cattle and buffaloes using meta-analysis approach. 16S rRNA gene sequences of cultured and uncultured rumen bacteria have been deposited in public databases. A total of 1481 chimera free sequences of ruminal bacteria of buffalo and 13432 sequences of ruminal bacteria of cattle were identified in GenBank data set. The sequences from rumen content of buffalo were assigned to 12 phylum, 52 classes, 30 orders, 48 families, 102 genera, 1133 species level OTUs (operational taxonomic units) and many unclassified groups in different taxonomic levels while sequences from cattle rumen origin were assigned to19 phyla, 98 classes, 56 orders, 94 families, 238 genera, 5616 species level OTUs and many unclassified groups in different taxonomic levels. A small number (235) of shared OTUs among cattle and buffalo datasets indicate that bacterial communities of rumen are greatly affected by host species. Firmicutes was the major phylum accounting 47.9% of the total sequences in cattle and 47.4% of the total sequences in buffalo. Prevotella (14.4% of sequences), Fibrobacter (3.5%), Butyrivibrio (2.2%), Clostridium XIVa (2.0%) and Ruminococcus (1.8%) were predominant genera in cattle. Prevotella (11.8% of sequences), Lachnospiracea incertae sedis (3.5%), Butyrivibrio (2.8%), Clostridium IV (2.5%), Ruminococcus (1.6%) and Fibrobacter (1.3%) were predominant genera in buffalo. Rarefaction analysis of abundant OTUs (having at least three members) indicated 99.6% sequences coverage in cattle and 78.9% coverage in buffalo at putative species level. This study will inspire future studies to further characterize rumen bacterial communities.

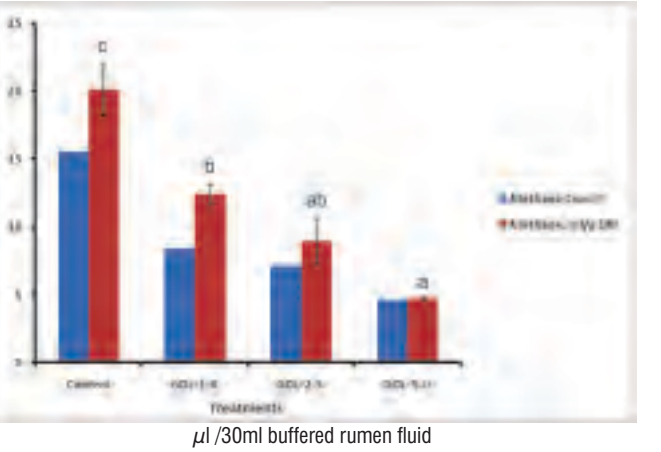
A feeding trial was conducted on four fistulated buffaloes and rumen contents were sampled at pre-dosing as well as post-dosing (1 month and at 4 month) period. DNA were isolated and checked for quality on AGE. Also sequencing primers were tested by PCR. Metagenomic study is being taken up.

Venn diagram at distance 0.03 showing 16.5292% of sequences are shared at species level

Garlic oil supplementation: effects on *in vitro* methanogenesis, rumen fermentation and gas production

Essential oils and organo-sulphur compounds present in garlic oil have selective antimicrobial activity and can favourably manipulate rumen fermentation. Garlic oil (GOL) was tested at four levels [0 (Control), 1.0 μl (GOL-1.0), 2.5 μl (GOL- 2.5) and 5.0 μl (GOL- 5.0) per 30 ml buffered rumen fluid] in three replicates for each treatment. Sorghum hay (200 $\pm$ 5 mg) was

used as substrate and incubated with 30 ml buffered rumen fluid in 100 ml calibrated glass syringes at 39°C for 24h following standard In Vitro Gas Production protocol. Total gas production was not affected by GOL supplementation. However, methane concentration in the total gas and thus, total methane production was reduced ($p<0.001$), irrespective of dose levels. Dry matter and fibre degradability remained similar to control in GOL-1.0, but these tended to decrease in GOL-2.5 with marked reduction ($p<0.01$) in GOL-5.0. acetate and propionate production was similar but acetate to propionate ratio was reduced in both GOL-1.0 and GOL-2.5. However, there were adverse effects on volatile fatty acids production in GOL-5.0. The study indicated that garlic oil in small dose (1μl in 30ml buffered rumen fluid) has a great potential to modulate rumen fermentation towards reduced methanogenesis.



μl /30ml buffered rumen fluid

(Mean bars with different superscripts a, b & c differ significantly)

Effect of garlic oil supplementation on in vitro ruminal methanogenesis

Table: Effect of garlic oil supplementation on in vitro ruminal methanogenesis and fermentation patterns.

Attributes	Garlic oil				SEM	P value
	Control	GOL-1.0	GOL-2.5	GOL-5.0		
	μl /30ml buffered rumen fluid					
TDDM, %	60.75^{b}	60.06^{b}	53.67^{ab}	45.43^{a}	3.68	0.007
NDFD, %	47.66^{b}	46.74^{b}	38.22^{ab}	27.25^{a}	4.90	0.007
Gas prod, ml/g DM	129.31^{ab}	148.69^{b}	124.06^{ab}	104.85^{a}	9.61	0.013
Gas prod, ml/g DDM	213.07	248.20	230.88	230.60	9.30	0.131
MBP, mg/g DM	322.96^{b}	273.44^{ab}	263.73^{ab}	223.67^{a}	22.49	0.024
MBP, mg/100mg DDM	53.13	45.40	49.21	49.27	2.05	0.131
PF	4.71	4.04	4.36	4.34	0.18	0.124
Acetate, mM/dl	3.49^{c}	3.41^{bc}	3.19^{ab}	3.05^{a}	0.10	0.002
Propionate, mM/dl	0.89^{b}	0.96^{b}	0.88^{b}	0.79^{a}	0.04	0.002
Butyrate, mM/ dl	0.25^{a}	0.28^{b}	0.27^{ab}	0.26^{ab}	0.01	0.044
A:P ratio	3.92^{b}	3.55^{a}	3.64^{a}	3.88^{b}	1.09	0.001

TDDM= Truly degradable dry matter; NDFD= Neutral detergent fibre degradability, MBP= Microbial biomass production; PF= Partitioning factor
(Means with different superscripts a,b and c within a row differ significantly)

Evaluation of sorghum cultivars for nutritional quality, *in vitro* fermentation pattern and methane production in buffalo

A number of sorghum hybrids/ varieties have been developed by the Indian Institute of Millets Research, Hyderabad which have the potential of early maturity, high fodder yield, less susceptibility to insects and pests, and moreover, low in HCN and lignin content. However, nutritional quality of these cultivars has not been tested. In the present experiments, sorghum stover from different types of sorghum viz. brown midrib sorghum (SPV 2017, SPV 2018), normal grain sorghum (CSV 27), forage sorghum (SSG 59-3, CSV 32F) and sweet sorghum (CSH 22SS, CSV 24SS) were analyzed for

proximate principles, fibre fractions and also in vitro fermentation patterns with rumen fluid inocula of cannulated buffalo steers. Brown midrib sorghum was lower in acid detergent fibre and lignin contents (31.35% and 1.67%, SPV-2017 and 36.93% and 1.27%, SPV- 2018) than others. In vitro truly degradable dry matter was highest in SPV- 2018 (63.78%) and lowest in SSG- 59-3 (40.33%), predicting better utilization of SPV- 2018 variety by the animals. Lower methane concentration in head space gas (15.04%, SPV-2018 and 13.73%, SPV-2017) and higher volatile fatty acids production were observed in both cultivars of brown midrib sorghum than normal grain sorghum (CSV 27). Thus, brown midrib sorghum cultivars may be preferred over others for better feed utilization in buffaloes.

Table. Evaluation of different sorghum cultivars for in vitro ruminal methanogenesis and fermentation patterns in buffaloes

Attributes	Treatments							SEM	P value
	C	T1	T2	T3	T4	T5	T6		
TDDM, %	52.16c	63.78e	40.33a	55.27c	60.99de	46.70b	57.59cd	3.07	<0.001
Gas prod, ml/g DDM	244.78b	288.49c	312.87d	207.42a	280.71c	243.66b	321.46d	15.24	<0.001
MBP, mg/100mg DDM	46.15c	36.53b	31.17a	54.37d	38.24b	46.39c	29.28a	3.35	<0.001
PF	4.09c	3.46ab	3.20ab	4.85d	3.56b	4.11c	3.11a	0.23	<0.001
Methane Conc, %	16.87a	15.04b	15.16b	14.04ab	13.28a	13.71a	13.73a	0.52	0.002
Methane, ml/g DDM	41.32cd	43.39cd	47.47d	29.06a	37.34bc	33.42ab	44.20d	2.56	<0.001
Acetate, mM/dl	3.47b	3.76c	3.25b	3.01a	3.69c	2.97a	3.45b	0.12	<0.001
Propionate, mM/dl	0.74c	0.90d	0.73bc	0.68ab	0.86d	0.66a	0.86d	0.04	<0.001
Butyrate, mM/ dl	0.24b	0.27c	0.27c	0.22a	0.28c	0.22a	0.27c	0.01	<0.001
A:P ratio	4.68c	4.18ab	4.45bc	4.44bc	4.30ab	4.47bc	4.02a	0.10	0.021

C=Control (CSV 27), T1- SPV 2018, T2- SSG 59-3, T3- CSV 24 SS, T4- CSV 32F, T5- CSH 22SS, T6- SPV 2017
MBP= Microbial biomass production; DDM= Digestible dry matter
Means with different superscripts a, b, c, d within a row differ significantly

Development of feeding modules for buffalo meat production

An experiment was conducted on growing male buffalo calves (4-5 months age and 80 kg body weight). Eighteen calves were divided in three similar groups and fed as follows. Group -1: All forage diet comprising of green and dry fodder ad lib, group -2: roughage: concentrate (70:30) and group -3: roughage: concentrate (30:70). The roughage: conc. ratio changed to 30:70 in group I and II in last four months. The feed intake per 100 kg B. Wt. in different groups was 2.56, 2.60. 2.63. The growth rate was 318.50, 435.69 and 605.55 g/d in G-I, G-II and G-III, till end of feeding trial 692.37, 704.95 and 688, respectively. The overall growth rate in different groups was 442.88, 528.02 and 628.2555 in G-I, G-II and G-III, respectively. The economics of production was calculated taking the prevailing cost of the feed ingredients and the values for cost of feeding per animal per day were (Rs) 34.50, 56.10 and 77.48 in group-1, II and III, respectively. The cost per kg gain in respective groups was (Rs) 77.89, 106.24 and 123.32. The buffalo calves for meat production can be reared economically on roughage based diet and given a concentrate based finisher diet after attaining a body weight of about 170 kg.

Effect of different feeding regimes on age at first calving

Nutritional status affects the puberty and subsequent reproduction. To study the effects of different feeding regimes on age at first calving in buffalo heifers, twenty four heifers (average age 17.15 months) were divided into two groups of 12 each and fed on 100% (group-I) and 115% (group- II) of their nutritional requirements. Age at first calving was 37

months 19 days in group I and 37 months 20 days in group II. After one year of study, average daily gain (ADG) was 532.20 and 538.90g in group-I and II, respectively and average daily intake (kg) was; concentrate mixture 2.59 and 2.58, green fodder 8.83 and 8.84 and wheat straw 1.20 and 1.19 in group-I and II, respectively. Average age at first AI was 26 months 22 days in group I and 26 Months in Group II. Average weight at first AI was 364.4 kg in group I and 377.0 kg in group II. Nutrient digestibility trial conducted at the end of the experiment showed non-significant ($p<0.05$) variation in digestibility of various nutrients between the groups.

Studies on development and supplementation of chelated minerals in buffaloes

Chelated minerals were prepared for copper, manganese and zinc and supplemented in the ration of growing buffaloes. Six months feeding trial was completed on 24 growing male buffaloes after dividing them into four equal groups. Control was fed these three trace minerals as per recommendations through their inorganic source, while in T1, T2 and T3; 50, 75 and 100% of these minerals as compared to control were given through their organic sources. Body weight gain recorded fortnightly during the period showed non-significant ($P>0.05$) effect among different groups. Blood samples were collected during the feeding trial and analysis is being undertaken.

Validation of ITK known herbs against gastro-intestinal parasites of buffalo calves

During the period under report, the mass spectral analysis of pooled purified fractions of the herbal extracts was done at AIRF, JNU New Delhi. The mass spectra of the separated peaks were analyzed and some active ingredients were identified. Further, these pooled purified fractions were tested for their anthelmintic activity. Amongst the main ingredients active against GI parasites were b-sitosterol, diisooctyl phthalate, solasonine, arborside A and Luteolin, which were identified in four different herbal effective extracts. The extracts prepared were mixed in 11 different combinations and the efficacy was tested against Haemonchus for determining synergistic/antagonistic properties in order to find the most suitable combination for the development of herbal feed supplement. The results indicated highest mortality of larvae in the combinations having all the four herbal products. However, the combination having solanum and embelia were equally effective statistically. Further statistical and probit analysis is being carried out. Thus the herbal supplement having these herbs alongwith essential mineral ingredients and essential amino acids are being prepared for its effectiveness in vivo.

Transfer of Technology and Entrepreneurship

Developing innovations and diffusion of new technologies in buffalo husbandry are important factors for entrepreneurship development and nutritional security. The Institute 'Transfer of Technology and Entrepreneurship unit' aims to transfer the sustainable technologies to various stakeholders. This unit organises various capacity building and extension programs specifically for farmers, youth and farm women on improved buffalo farming through various means including ICT tools for long-term support leading to enhanced productivity, profitability and sustainability. Extension personnels are also trained to update their knowledge and skills in scientific buffalo farming. Training of field veterinarians hailing from various states on ultrasonography is a regular activity. Conducting demonstrations, group meetings, interactions, calf rallies and mela etc are the other means to reach the farmers. All the scientists of the institute have adopted at least one village under 'Mera Gaon Mera Gaurav' scheme launched in 2015.

Convergence for Dairy Development

Need of convergence between different agencies working for dairy development has been identified as one of the key factors in improving the efficiency of dairy extension at grassroots level. The existing and desired status, constraints and ways to ensure effective convergence despite its importance has not been studied so far systematically. Studying this area would bring forward the level of convergence and the way forward for effective convergence. Developing and testing convergence model, if found effective, may be replicated at higher levels. In view of it, a new research project on convergence for dairy development: a synergistic approach was approved in December 2015. It aimed to study the nature and extent of convergence amongst different agencies working for dairy development, delineation of roles and expectations of each agency towards others, study the constraints in convergence of different agencies and lastly developing and testing a model of convergence for dairy development. During the period under report, parameters of convergence have been identified and detailed review of literature was done. Exploratory study has been conducted to identify technologies that may lead to convergence of different sub-systems of dairy development. Questionnaire is under preparation to initiate the process of data collection.

Attracting Rural Youth in Agriculture

Young farmers can play an important role in ensuring food security if they are encouraged to involve in farming and the challenges they face are addressed. Over the past few years, rural youth have been shying away from agriculture as a whole and globally there is an increasing interest in finding ways of engaging youth in agriculture. Large-scale migration of rural youth from farming to urban areas has caused concern among the country's agricultural policy makers, as such a trend, if not checked, is likely to affect agricultural activities in the future. In a bid to address this trend, the Indian Council of Agricultural Research (ICAR) initiated one scheme named 'Attracting and Retention of Youth in Agriculture' (ARYA) to encourage youth to take up farming. This has several implications for the future of Indian agriculture and India's food security. Keeping in view, a research project on factors influencing participation of rural youth in farming: an exploratory study was initiated to capture the factors influencing on attitude and aspirations of rural youth and parents towards farming and will lead to recommendations as outcome of the study for harnessing the huge potential of rural youth in farming of Hisar district and in similar situations. During the period under report, interview schedule has been developed and villages have been selected. The work of data collection is yet to be initiated.

EXTENSION ACTIVITIES AT THE INSTITUTE

Training achievements

The Institute organised a total of 26 training programs (24 at main station and 2 at sub-station) for 1469 farmers and farm women and 08 trainings for 114 Veterinary surgeons. The calendar of trainings was put on the Institute website for larger and wider participation of the farmers. Following trainings were held during 2015-16:

- Five off campus trainings on 'Buffalo husbandry practices' for 470 women farmers. (Total 15 days)
- Seven trainings on 'Improved buffalo husbandry' at campus for 796 rural youth. (Total 44 days)
- One training on 'Improved buffalo husbandry' at campus for 85 farmers of Rajasthan. (Total 03 days)
- One training on 'Improved buffalo husbandry' at campus for 35 farmers of Haryana. (Total 03 days)

- Two on campus trainings on 'Scientific buffalo management' for 86 farmers. (Total 20 days)
- One on campus training exclusively for 60 SC/ST youth on 'Buffalo husbandry as an employment enterprise' (Total 10 days)
- One on campus training on 'Scientific buffalo production and management' for 30 farmers (Total 12 days)
- Eight trainings for 114 field veterinarians from states of Uttar Pradesh, Rajasthan, Haryana, Punjab, Gujarat, West Bengal, Karnataka and Chandiarh on 'Ultrasonography in large animal reproduction for fertility augmentation.

On 9.1.2016, Dr. H Rahman, Deputy Director General, Animal Science, ICAR during his address to farmers in one of the training programs at CIRB hoped that the farmers will certainly be benefited with such trainings. Dr A.K. Srivastava, Director, NDRI also advised the farmers to adopt new technologies for scientific rearing of buffaloes and to harness maximum benefit with minimum inputs through value addition by making milk products. In another training, Dr. Suresh S Honnappogol, Animal Husbandry Commissioner, Govt. of India appreciated the interest of rural youth to undertake training on scientific buffalo management.

Infertility treatment camps at village level

During the period under report, 11 infertility treatment camps were organized, including some in collaboration with PNB Farmer's Training Centre, Sacha Khera, District, Jind. Six camps were organised in the month of April, 2015 in village Ninan of Hanumangarh district Rajasthan, village Jevra, Bugana, Kheri Barki, Juglan of district Hisar, and village Budhana Kalan of district Bhiwani, Haryana. In subsequent months, infertility treatment camps were organised in villages Makhand, Jhansal, Mirzapur, Gwalisar and Bhagela. A total of 232 cases were attended. Out of it, 191 cases of oestrus induction and synchronisation were performed. The animals were treated for anoestrus, repeat breeding, silent heat, metritis and pregnancy diagnosis etc.

Buffalo mela organised

Institute organised two buffalo mela; one at main campus, Hisar and another at sub-campus Nabha on the occasion of its Foundation day.

Buffalo mela cum exhibition at main campus: CIRB celebrated its 32nd Foundation day on Ist February by organising 'Buffalo Mela cum Exhibition' at Institute premises wherein 264 elite animals, buffalo bulls, milch animals, lactating buffaloes, dry buffalo, heifers etc. from all over Haryana and adjoining states participated. The competitions for breed characteristics under seven categories were held. National Institutes like NDRI, IVRI, NRCE, Central Sheep Breeding Farm and Tractor Training Centre and other companies participated and put up their stalls. More than 4000 farmers participated in these events. Padma Bhushan Dr R S Paroda, Former Secretary DARE and DG ICAR was the Chief Guest and inaugurated the mela while Dr R S Dalal, Member

Secretary, Haryana Kisan Ayog was the Guest of Honour. Prizes were distributed to the owners of winning buffaloes by Major General Dr Sri Kant SM, VSM, Vice Chancellor, LUVAS, Hisar, who graced the closing ceremony as chief guest. Dr B N Tripathi, Director NRCE was also present as Guest of Honour on the occasion. Dr Inderjeet Singh, Director of the institute presided over the function and highlighted the need for faster dissemination of improved technologies and practices on a wider scale in the field.

Nili-Ravi buffalo mela cum Kisan goshti at sub-campus Nabha

Nabha commemorated its 29th Foundation day on 11.12.2015 by organizing a Kisan mela and Kisan gosthi. Hundreds of Nili-Ravi farmers from far flung areas participated in the mela and expressed keen interest in elite true-to-breed Nili-Ravi buffaloes. A total of 57 buffaloes and bulls of Nili-Ravi breed were registered under different categories for competition. Dr Rajbir Singh, Director ICAR-ATARI, Ludhiana graced the occasion as Chief Guest while Dr Inderjeet Singh, Director ICAR-CIRB presided over the function. Competitions of Nili-Ravi under different categories were held and prizes were distributed to the winners.

Participation in melas

The institute has actively participated in 6 melas organised at Kayodak, Kaithal (Haryana); twice in Motihari (Bihar); Muktsar (Punjab); SKUVS&T(Jammu) and Krishi Unnati mela at New Delhi. The Institute also put up its stall and showcased technologies *viz.* area specific mineral mixture, balanced feeding and complete feed block etc. Models of different breeds of buffaloes were main attraction. Notable one was Krishi Unnati Mela, the National level Agriculture Fair-cum-Exhibition in New Delhi from 19-21 March, 2016, inaugurated by Hon'ble Prime Minister Shri Narendra Modi ji, who took keen interest in the elite buffalo animal's exhibited by the institute in the Mela. Dr. Inderjeet Singh, Director of the Institute explained the contribution of buffalo in country's milk production to Hon'ble PM.The other visitors to the animal show and the stall were Hon'ble Union Minister of Agriculture & Farmers Welfare and President of the ICAR Society, Shri. Radha Mohan Singh Ji, Dr Sanjeev Kumar Balyan and Shri Mohanbhai Kalyanjibhai Kundariya Hon'ble Ministers of State for Agriculture. Dignitaries like Dr.Trilochan Mohapatra, Secretary DARE & Director General, ICAR and DDG (AS) Dr. H Rahman evinced very keen interest in the stall of the Institute.

Kisan gosthi

The institute has organised two Kisan Gosthi with IIW&BR, Karnal on 15th August, 2015 and 16th January, 2016. Dr. Jeet Singh Sandhu, Deputy Director General (Crop Science) visited the seed production unit of IIW&BR and farms of CIRB, Hisar on 16.1.2016. Large number of farmers and farm women participated in these gosthies. Experts from both the institutes delivered lectures and answered queries covering various aspect of package of practices of wheat & barley production and scientific rearing of buffaloes.

Calf rallies

Calf rallies were organized for female progenies born of the Artificial Insemination under FPT project in 4 adopted villages; Jevra (18/1/16), Bichpari (21/1/16), Sarsod (25/1/16), and Juglan (29/1/16). Competitions were held under three categories (calves <1 year, heifers 1-2 years and heifers >2 years). The calf rallies were organized to observe the impact of technologies transferred in the field and interest of farmers for rearing quality buffaloes.

Milk recording competition of farmers' buffaloes

For identification and authentication of the high milk yielder buffaloes of the farmers, the milk recording is being regularly done starting1st Sunday of every month at ICAR-CIRB, Hisar, in which a total of 22 farmers' high yielding buffaloes participated during the period under report. Twelve high yielding buffaloes were given cash prizes along with a certificate and memento on the occasion of CIRB Foundation day. Two buffaloes were recorded over 24 Kg, two from 20-24 Kg and eight buffaloes from 18-20 Kg.

Meeting on contingency plan for Hisar

Contingency plan was discussed in length on 10th August, 2015 in view of the expected low monsoon situation and implementation of contingency plan for Hisar and adjoining districts. Scientists from CIRB, IIWBR, Karnal, CICR regional station, Sirsa and scientists of CCS HAU, Hisar representing various disciplines of dryland agriculture, agricultural meteorology and farm advisory services participated for development of the plan. Scientists were apprised of the same & farmers were made aware of appropriate intervention & practices.

Mera Gaon Mera Gaurav Scheme implemented

'Mera Gaon Mera Gaurav' scheme was initiated in August 2015 to promote direct interface of scientists with farmers in order to hasten the lab to land process. Under this scheme, scientists of the main campus of CIRB and sub-campus Nabha selected a total of 32 villages and remained in touch by providing information to the farmers on technical aspects through personal interaction, demonstrations, capacity building programs and mobile telephony mainly on buffalo rearing. Besides awareness was created on Government initiatives and time to time advisories were given on agriculture and allied areas. Emphasis was given on ill effects of residue burning by organising workshops. Out of total 32 adopted villages, 20 villages were from state of Haryana, 10 from Rajasthan and 02 from Punjab. Scientists also involved local Panchayats, development agencies, NGOs, private organisations, KVK and officials of line departments during organisation of

programs.Initially a benchmark report was prepared on farming, climate and social and economic conditions of the selected villages. Based on identification of problems and prioritization, interventions were made and quarterly reports were submitted to ATARI.

Doordarsan/Radio talk/Kisan prashn manch programs

The scientists/ technical officers of the institute participated in 12 different programs of various channels of Doordarshan and radio. Besides, scientists participated in three different Prashn manch programs of Kisan channel, Doordarshan held in villages Makhand, Kharkari and Jevra of Hisar and Jind districts, wherein they facilitated awareness of the participating farmers on various facets of improved techniques in buffalo husbandry.

ICAR-foundation day celebration

ICAR-CIRB celebrated 87th ICAR foundation day with theme 'Employment Opportunities in Agriculture for the Rural Youth' in two Government schools situated in village Talwandi Rana and Juglan of Hisar. More than 350 school children from class X onwards participated in the programme. The main purpose of the programme was to create awareness about Agriculture research, education and the technologies developed by ICAR and its Institutions. Lectures were organized to sensitize the youth on 'Career Opportunities in Agriculture' and 'Role of ICAR' on the occasion.

World Food Day celebration

A sensitization program on the occasion of 'World Food Day' 16th October, on theme 'Social Protection and Agriculture: Breaking the cycle of Rural Poverty' was organised where in three lectures were delivered on 'Food for health and illness' by Dr Sanjay Sharma; Ayurvedacharya 'Nutritional security through food for different strata of society' by Dr. Neelam Khetarpaul, Professor, Food & Nutrition, CCS HAU and 'Food Security: current situation and future predictions' by Dr. Hema Tripathi, Principal Scientist, CIRB. About 80 people participated including 38 school children from Government school of Talwandi Rana village.

Jai Kisan Jai Vigyan week

ICAR-CIRB celebrated 'Jai Kisan Jai Vigyan' week from 23rd to 29th December 2015 on the birth anniversary of former Prime Ministers Shri Atal Bihari Vajpayee and Late Chaudhary Charan Singh. To attract the students towards science and agriculture, group discussion and science quiz competitions were arranged in schools. Animal health camp was organised in village Mirzapur apart from showcasing buffalo related technologies. The week long programme culminated by organizing a training program on improved buffalo husbandry for rural youth.

Women sensitization program

One day sensitisation program was held on 20th November, 2015 for 80 women farmers hailing from Women Dairy Cooperative Society in village Mingni Khera. Scientists from

the institute delivered lectures and demonstrations about improved buffalo farming practices and schemes of dairy development for further augmentation of milk productivity.

Murrah Buffalo Breeders' Welfare Association (MBBWA)

With the support of ICAR- CIRB, Hisar, an association of progressive Murrah Breeders was registered as Murrah Buffalo Breeders Welfare Association in January, 2014. At present, it comprises more than 100 life members. Some are very famous as they participate and win prizes in different competitions organized at different locations in the country. The association was made with the objective to register, conserve and propagate superior germplasm, further improving elite germplasm of the farmers, improvement in production performance through progeny testing and data recording and creation of awareness for maintaining superior germplasm through organizing buffalo melas, health and infertility treatment camps. New executive committee of association was elected during the year. The association is working in close coordination with CIRB.

Interventions in Rajasthan Villages under Tribal Sub Plan

During the period under report, benchmark survey of four villages of Rajasthan namely; Roba, Chatpur, Bhainso ka Namla and Tulsion ka Namla under village Panchayat Kherar District, Udaipur was completed. In these villages, more than 90% population was ST and SC. Low milk production and poor reproductive performance of buffaloes were the major problems. To fulfil the technological gap, interventions were made in these selected tribal villages. Mineral analysis of soil of these villages were done and on the basis of deficient minerals, area specific mineral mixture was developed and 5.0 quintals of the mineral mixture was distributed among the ST farmers of these villages. After taking permission from state government 4 superior Nili-Ravi breeding bulls were given in these villages for buffalo improvement programme. Under women empowerment, six buffaloes were given to six women. Four women were widow and 2 were orphans. 7th buffalo was given to a person who was poor, old and weak. The entire seven beneficiaries were BPL and tribals. Five feed grinders, 20 manual chaff cutters and 160 rubber mangers were distributed to the tribal farmers to improve their livelihood through modern buffalo husbandry practices.

A four days training was also organised for tribal farmers at CIRB campus from 27th-30th August 2015 under the banner of "kissan kalyan avem poshan prashikshan". Three small cryocans were given to those ST youths who were trained at CIRB Hisar for AI and 20 litres cylinder was given for storage of semen straws. 1500 doses of semen were also given to improve buffalo productivity through superior Murrah germplasm. Literature related to modern farming was distributed to educated farmer families. All visits of scientists in tribal villages were educative/ informative and motivated the tribal buffalo keepers with respect to buffalo husbandry.

Development of Technologies and their Transfer to End Users

The institute has developed several technologies and transferred to the farmers with the aim to economise and increase the production potential and reproductive efficiency of their buffaloes. Some of the technologies which found acceptance with the users are given below.

Production, maintenance and dissemination of superior germplasm

Institute maintains highly pedigreed herds of Murrah and Nili-Ravi buffaloes aimed at breed improvement through selective breeding particularly for the production of superior breeding bulls and bull mothers. Nearly three lakh doses of frozen semen from test bulls and 63992 doses from progeny tested bulls are available for Murrah breed improvement. Since inception about 492 Murrah and 305 Nili Ravi bulls of high genetic merit have been supplied to various developmental agencies and village panchayats in different States for improvement of production performance of buffalo genetic resources.During year 2015-16, total 74 breeding Murrah bulls were sold to various developmental agencies, breeders, panchayats and farmers, while 25 Nili-Ravi bulls were sold primarily to Punjab State Animal Husbandry Department for frozen semen production and natural mating in breeding tract of the breed. This includes 4 bulls stationed in tribal village of Udaipur. Two top ranking bulls (Mu-3267 and Mu-3591) from 11th set were identified based on progeny testing and are used for nominated mating in elite buffaloes. During the period from April 2015 to March 2016, 95426 frozen semen doses were produced, 24114 doses supplied and 34838 doses sold for Murrah and In case of Nili-Ravi, 16460 semen straws were produced and 2350 straws were sold. 4434 A.I. were done in ten adopted villages. The conception rate in the field was worked out to be 53%. In this period, 2486 pregnancies were confirmed and 1718 calving (900 males, 818 females) were recorded for the purpose of bull evaluation.

Area-specific mineral mixture

Surveys of feeding practices carried out in Haryana revealed deficiencies of essential minerals like calcium, phosphorus, zinc, copper and manganese. On the basis of analysis of mineral intake vs requirement, an area specific mineral mixture (ASMM) was developed. With the supplementation of this mineral mixture in the ration of anestrus buffaloes, seventy per cent buffaloes conceived within a period of 4 weeks. The mineral mixture improves feed intake, milk production and reproductive efficiency. Institute has been preparing and selling mineral mixture to the farmers for encouraging adoption of this technology. During year 2015-16, mineral mixture worth Rs. 187642 was sold. Under Tribal sub Plan (TSP) Scheme, a separate area specific mineral mixture was developed based on assessment of macro and micro elements from available feeds and fodder resources in the area of adopted villages of Udaipur district in Rajasthan. Five quintals of this mineral mixture were distributed to tribal farmers of adopted villages for supplementation of cattle feed. The technology for preparation of ASMM is being licenced to a private firm.

Buffalo cloning

During the year, ICAR-CIRB produced cloned calf named **'Hisar-Gaurav'** using somatic cell isolated from tail; this way Institute becomes India's second institute to produce cloned buffalo. Use of adult somatic cells of proven males or quality females for cloning can bring revolution by multiplying the superior buffalo germplasm in country. This can help to mitigate the scarcity of superior progeny tested bulls for use in artificial insemination programs, which is grossly insufficient to meet the demands of the nation. Cloning can be demand driven option for multiplication of such bulls in shortest possible time.

Somatic cell lines from superior animals

Total 11 primary somatic cell lines were established and cryopreserved from adult elite buffaloes, which includes 4 from adult bulls (Yuvraj champion bull is one of them), 4 from institute females and 3 from champion females from field. These primary cell lines were characterized using expression of cytoskeleton marker include vimentin for fibroblast origin type and cytokeratin for epithelial origin type. Minimum 25 cryovials were preserved in Liq N_2 for banking. Cryopreserved cell lines would be viable genetic material for long term maintenance of elite germplasm, which have wide range of applications include cloning even after death of animal, induced pluripotent stem cells production and unlimited DNA/RNA/protein source for any research purpose.

DNA bank

During year 2015-16, total 456 DNA samples from Murrah (76), Nili-Ravi (116), Jafarabadi (116), Pandharpuri (77), Bhadawari (36) and Surti (35) were deposited in DNA repository. Total 4073 buffaloes DNA samples have been established at the institute for genome analysis. Phenotypic data on all the animals was collected which shall be used for establishing linkages with performance traits and identification of molecular markers.

Phenotypic marker for identification of Nili-Ravi and Murrah Buffaloes

Tongue colour pattern revealed that pink colour in Nili-Ravi and black tongue colour in Murrah buffalo are governed by incomplete dominance of genes. The mix type or gray or spotted colour of tongue might be due to the incomplete dominance gene interaction, which dilutes the basic colour of tongue. The findings on tongue colour conclude that pure bred Nili-Ravi buffaloes have pink colour of tongue and pure Murrah animals have black tongue as an added breed characteristic. The mixed tongue colour (pink and black), grey, pink in Murrah graded and black tongue colour in Nili Ravi graded animals indicates inter-mixing in these breeds.

Sericin for improved semen freezing

Sericin is a water-soluble globular protein (a protein hydrolysate) derived from silkworm Bombyx mori. Supplementation of 0.25-0.5% sericin in semen extender improved frozen-thawed semen quality through protecting sperm from oxidative stress.

Scrotal circumference for bull selection

Scrotal circumference (SC) of males is highly correlated with age and body weight and it can, therefore, be used for pre-selection of breeding bulls at an early age. According to this study, mean SC value was 35.23 ± 3.00 cm for mature Murrah bull (>600 Kg). It is recommended that, bull having scrotal circumference < 29 cm should not be used for breeding programme, while males with SC of over 41 cm (Mean $\pm$2 S.D.) should qualify as the best option.

Improved protocol for buffalo semen cryopreservation

There is huge demand of frozen semen or quality bulls to cover breedable livestock population in the country. A simple, reliable and economical method for freezing of buffalo semen was developed. After implementing, some advances through systematic experimentation, currently annual/per bull production of frozen semen doses has witnessed a steep increase.

Induction of lactation

Farmers are commonly facing the problems of conception failure, long calving interval, anestrous, cystic ovaries, abortions and repeat breeding. Such farmers can benefit by inducing their non-pregnant infertile animals into lactation with induced lactation therapy. In this therapy an appropriate dose of hormones such as Estradiol-17β and progesterone @ 0.1 mg/kg body weight/day is given for seven days. In brief, on the day of treatment, 1 ml of each hormone solution is administered subcutaneously in the morning and evening at 12 hourly intervals for seven consecutive days. Thereafter, on day 17, 19 and 21, 10 ml Largectil injection and on day 16, 18 and 20, injection of 20 mg Dexamethasone are also given intramuscularly. Between 15th and 21st day of treatment, udder massage is given for fifteen minutes each in morning and evening daily till the udder is turgid with milk, which is usually around 21st day when milking is started. The milk becomes normal in physical and chemical properties within 10-15 days of the start of milking and the amount of milk yield increases with time.

Embryo transfer technology

Efforts have been made for developing and improving the embryo transfer technology in buffaloes, which has resulted in birth of 34 calves in Institute. Technology for large scale

production of in-vitro fertilized (IVF) and cloned embryos using slaughter house ovaries have been standardized together with the embryo cryopreservation technique. The technique of IVF and cloning is of immense use in faster multiplication of elite germplasm. Poor retrieval of oocytes from live superior dams through ultrasound guided ovum pick up technique precludes suitability of this technique in buffaloes, therefore in-vitro abattoir oocytes is practicable option for IVF or cloning, though genetic potential of ovum donor remains obscure.

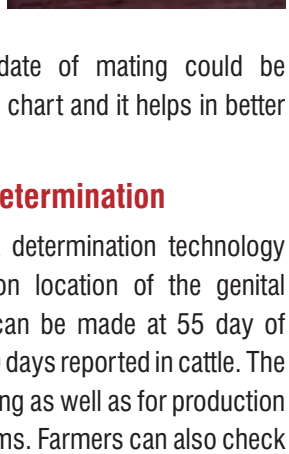
Superovulation protocol

Protocol was developed using progesterone implant that requires minimum handling and examination of donors for superovulation. Protocol consists of examination of donors and administration of norgestomet subcutaneous ear implant (Crestar, Intervet) to all donors having a well-developed CL on day 0 of examination. Five days FSH treatment is initiated between day 2-5 of Crestar insertion. Crestar is removed and prostaglandin injection is given on day 4 of super-ovulatory FSH treatment. Buffaloes are inseminated thrice at 12 h intervals, starting at 48h after Crestar removal. Embryo recovery is made on day 5/6 post-insemination. Using this protocol, only 12 to 17 days are required for programming, superovulation, insemination and embryo recovery. This protocol effectively reduces the programming to embryo recovery period by 50% as against conventional protocol.

OvSynch plus protocol for estrus induction

Anestrus is major infertility disorder, which delays calving interval and decrease life time productivity of a female such buffaloes can be induced to estrus with OvSynch plus protocol developed at CIRB. In this protocol, an injection of PMSG is administered 72 h prior to the first GnRH injection of Ovsynch treatment, in order to support ovarian follicular development so that at least one large follicle is available 72 h later for responding to the GnRH injection with ovulation/ luteinization. Resulting luteal structure in the ovary is then subjected to luteolysis by PGF given 7 days later. Further administration of GnRH 48 h later ensures synchronous ovulations of preovulatory follicles to allow fixed time insemination of treated animals. The major advantage of this protocol is that it induces oestrus in cyclic as well as acyclic animals within a close window. Buffaloes not coming into estrus within the defined period following this protocol also become cyclic and many of them get pregnant within one month of treatment, if initiated during breeding season.

Pregnancy diagnosis and estimation of gestational age



Pregnancy can be diagnosed as early as 26 days post insemination using ultrasound scanning of genitelia. A standard chart was developed for crown-rump length of buffalo fetus on different days post insemination for determining the age of fetus in pregnant buffaloes. The exact date of mating could be predicted very precisely using this chart and it helps in better management.

Ultrasonographic fetal sex determination

Ultrasonography guided fetal sex determination technology has been standardized. Based on location of the genital tubercle, an accurate diagnosis can be made at 55 day of gestation in buffaloes as against 50 days reported in cattle. The technique is useful in progeny testing as well as for production of breeding bulls in bull mother farms. Farmers can also check the fetal sex to help them in sale/ purchase of dams.

Ultrasonography for monitoring ovarian activity

The non-invasive technique of ultrasonographic scanning has been standardized for monitoring ovarian activity with respect to turnover of different sized follicles, development and regression of corpus luteum, presence of cystic ovarian structures and ovarian quiescence. Through this technique, time of ovulation can also be predicted very precisely to allow fixed time insemination and useful for follicular dynamics studies.

Feeding standards for different categories of buffaloes

Feeding standards have been developed for different categories of buffaloes, *viz.* growing males, growing heifers, breeding bulls, lactating buffaloes and pregnant buffaloes by taking into account the nutrient requirement for growth and production as well as gestation.

Superior isolates of anaerobic fungus

Superior isolates of anaerobic fungus were isolated and evaluated for ability to increase in vitro digestibility of straw by

buffalo rumen microflora. Such isolates have the potential to be used as feed additives. Among 165 isolates studied, the isolate *Neocallimastix* sp. CF 17 showed the highest CMCase and xylanase activity in pure culture medium containing straw. Growing buffaloes fed with encapsulated culture of the fungus resulted in 20 % increase in growth rate.

Thermal stress management

Buffaloes have poor thermoregulatory system and are much vulnerable to extreme climatic conditions particularly in summers. Buffaloes are more sensitive to direct solar radiation than cattle due to their black body color, which is conducive to heat absorption. Relatively small number of sweat glands per unit area of skin, and thick epidermal layer of the skin are other limiting factors in heat loss by conduction and radiation. Heat stress results from the animals' inability to dissipate sufficient heat to maintain homeothermy. Microclimate modifications together with supplementation of niacin @ 6 gms/day/animal, yeast @10 gms/day/animal and mustard oil @150 gms/day/animal lead to enhanced milk production of lactating buffaloes by reducing thermal stress. Another recommendation is to feed major part of ration during early morning (6-8 AM) and late night (8-10 PM) and also increase the frequency of feeding. It is also advisable to feed partially mixed wet ration (sanni), but moisture content should not exceed 50% in total ration. Wallowing at least twice daily or water sprinkling during hot period of the day helps in heat dissipation and lessen the impact of heat stress.

Enzyme supplementation

Fibrolytic enzyme supplementation can be used as feed ingredient in the concentrate mixture of calves to increase the growth rate. Further, the cost of enzyme can be reduced by using feed grade enzyme or enzymes used in textile industry (cellulase) and paper industry (xylanase). For this purpose, a study was undertaken on mixed supplementation of xylase and cellulose (cellulase and xylanase @ 6000 and 15000IU / Kg DM of substrate) in the diet of growing calves, which resulted in increased digestibility of DM, OM and CF digestibility. It resulted in significantly higher growth rate in supplemented group (486.42±25.28 g/d) as compared to control group (411.23±17.85 g/d). Its supplementation also increased the DMI/d in treatment group or in other words it increased the appetite. Supplemented group calves get more energy per unit of fodder with higher DMI. However, individual enzyme supplementation could not reach up the significant level. The inclusion level of this mixed enzyme is around 1 kg/ton of concentrate. The cost of commercial enzymes i.e. xylase and cellulose vary between Rs 200 to 250/kg and are usually used in huge quantities in textile industry (cellulose) and paper industry (xylanse).

Uromol preparation

Uromol is a compound prepared by heating urea and molasses in the ratio of 1:3 and then mixing it with equal amount of wheat bran/deoiled rice bran. Four kg urea along with 12 kg molasses is slowly heated in a container for 30 minutes. Then equal amount (16 kg) of wheat bran or deoiled rice bran is mixed in it and the mixture is cooled to room temperature. This material contains 36 percent DCP and 72 percent TDN and can replace conventional compound feeds in the ration of buffaloes yielding 8-10 liters milk/day.

Urea molasses mineral blocks

Urea molasses mineral blocks are prepared in the same way as Uromol, except the addition of mineral mixture, salt and binder. By *ad lib* feeding of these blocks along with other feed ingredients, about 20 percent of the conventional concentrate mixture can be saved. UMMB prepared by the 'cold process' technology yielded even better results.

Molecular markers for MAS

Seminal acidic fluid protein gene, known to govern sperm stability and thus the fertilization efficiency in cattle bulls has been partially sequenced in 35 Murrah bulls, recorded for high and low field conception rates. SNP genotyping and sequencing revealed nucleotide polymorphism across exon 4-5. Four haplotypes were identified from sequence analysis. Relation between occurrence of SNPs and mean sperm motility and other estimated semen quality parameters by CASA were analysed w.r.t. high and low conception rate bulls. Identified SNPs are suggestive markers for bulls screening w.r.t. conception rate.

Colostrum feeding for higher growth and calf survival

Higher levels of immunoglobulins get absorbed within 16 h of birth, reduce the mortality in calves and result in faster growth rate by 20-22 percent. High titer of circulating immunoglobulins in calves at an early age of 24 h was associated with weight gain up to the age of 2 years. Status of

immunoglobulins at such an early age could also predict the health status of calves. A critical level of these blood proteins required for the survival of calves has been assessed as 48-50 mg per 100 ml.

Antioxidants in survival and growth of neonates

Advanced pregnant (270 to 280 days' gestation) buffaloes, administered two doses of antioxidant micronutrients, consisting of vit A (Palmitate), vit D and vit E (dl- alpha 3 Tocopherol acetate) at 15 days intervals, secreted 25-80% more IgG protein in colostrum than control buffaloes. Calves born to treated buffaloes were also supplemented with mineral mixture @ 5 g/calf/day, colostrum feeding @ 10% of birth weight, concentrate mixture starting 10 to 15 days after birth and green fodder offered after 3 weeks, in order to achieve high growth rate and survival. These calves gained 10% higher body weight and had 30% better immunity as compared to non-supplemented calves.

Dry Colostrum for buffalo calves

Feeding of Colostrum after long awaited placenta -expulsion remains one of the major causes of low calf survival rates in buffaloes. Higher calf mortality is a loss of quality germplasm which affects heifer- replacement or bull development of profitable buffalo breeds. Drying of colostrum to achieve ready to feed powder form, without loss of its immunity property has been developed by spray drying of colostrum. It can ameliorate lowpassive immunity acquisition related health problems in neonatal calf.

Surplus colostrum was salvaged at farm and transported to Spray Drying machine in cold chain. Drying was done under controlled temperature and air pressure to ensure nutrient quality of colostrum. Powder comprised of 95% DM available for calf. Nutrient composition and protein quality was determinedDry colostrum powder is a 'supplementary diet' for calf health and survival. Weaned calves, kept segregated from dams were fed on this powder for four days, starting immediately after a five minutes of suckling (just sufficient for developing suckling- instinct in calves and milk let-down) for trial by reconstitution of powder and bottle feeding. Body weight gain during first three months after birth were comparable in supplemented and normally suckling calves.Dry colostrum formulation is a proven calf supplement diet for weaning and easy feeding management of healthy buffalo calves.

Technology Commercialized and Patented

During the period under report, Institute Technology Management Unit under NAIF filed a patent on 'Kalrump scale': a device to measure buffalo rump angularity for identification of dairy characters (1451/DEL/2015). A patent was also filed by our scientist during his Ph.D. at NDRI, Karnal on Novel peptide sequence and polyclonal antibodies for the detection of cow and buffalo luteinizing hormone (1854/DEL/2015) apart from his earlier patent (807/DEL/2015) filed there. These are in addition to patent already filed viz. 'BUFCOL: A complete diet for enhanced survivability and growth of neonatal buffalo calves (1840/DEL/2013)' and 'an *in vitro* method for detection of postpartum anestrus condition in buffaloes (2940/DEL/2013)'. Private Pharmaceutical Company M/S Titanic Pharma was motivated to sign an agreement with the institute to commercialize Area Specific Mineral Mixture and finally draft agreement was approved on 31st March 2016. Two technologies of the Institute *viz.* Area specific mineral mixture for improved production and reproduction and Ovsynchplus protocol for induction of oestrus and timed A.I. in buffaloes, found place during the Institute-Industry Meet and Technology for Commercialization organized by NDRI, Karnal in December 2015.

Research Publications

Research Papers

1. Baddela, V.S[1]., Nayan, V[1]., Rani, P., Onteru, S.K., & Singh, D. (2016). Physicochemical biomolecular insights into buffalo milk-derived nanovesicles. *Applied Biochemistry and Biotechnology*, 178(3), 544–557.
2. Bathla, S., Rawat, P., Baithalu, R., Yadav, M.L., Naru, J., Tiwari, A., Kumar, S., Balhara, A. K., Singh, S., Chaudhary, S., Kumar, R., Lotfan, M., Behare, P., Phulia, S.K., Mohanty, T.K., Kaushik, J.K., Nallapeta, S., Singh, I., Ambatipudi S.K., & Mohanty, A.K. (2015). Profiling of urinary proteins in Karan Fries cows reveals more than 1550 proteins. *Journal of Proteomics*, 127(PtA), 193–201.
3. Dey, A., Paul, S.S., Pandey, P., Punia, B.S., Dahiya, S.S., Lailer, P.C., & Saxena, N. (2015). Effect of extracts of fenugreek (*Trigonella foenum-graecum L.*) leaves on *in vitro* methanogenesis and fermentation of wheat straw based diet fed to buffaloes. *Sri Lanka Journal of Food and Agriculture,* 1(1), 9-13.
4. Dixit, V. B., Bharadwaj, A., Sikka, P. & Phulia, S.K. (2016). Training modules for promoting buffalo husbandry among different categories of respondents. *Indian Journal of Dairy Science*, 69(1), 120-123.
5. Dixit, V. B., Sharma, R.K., Bharadwaj, A., Sikka, P., & Phulia, S.K. (2016). An innovative approach to measure skill about artificial insemination in buffaloes. *The Indian Journal of Animal Sciences*, 86(2), 213-215.
6. Dixit, V.B., Bharadwaj, A., Singh, K.P., & Duhan, A. (2016). Perception of scientists and traders in deciding the price of a buffalo in Haryana. *Indian Journal of Dairy Science*, 69(2), 226-228.
7. Ghosh, K., Kumar, R., Singh, J., Gahlawat, S.K., Kumar, D., Yadav, S.P., Gulati, B.R., & Yadav, P.S. (2015). Buffalo (*Bubalus bubalis*) term amnion derived cultured cells exhibit mesenchymal stem cells characteristics in vitro. *In Vitro Cellular & Developmental Biology – Animal*, 51(9), 915-921.
8. Ghosh, K., Selokar, N.L., Gahlawat, S.K., Kumar, D., Kumar, P., & Yadav, P.S. (2016). Amnion epithelial cells of buffalo (*Bubalus Bubalis*) term placenta expressed embryonic stem cells markers and differentiated into cells of neurogenic lineage in vitro. *Animal Biotechnology*, 27(1), 38-43.
9. Ghosh, M., Gupta, M., Kumar, R., Kumar, S., Balhara, A.K., Singh, I. (2015). Relation between antioxidant status and postpartum anestrous condition in Murrah buffalo. *Veterinary World*, 8(10), 1163-1166.
10. Jerome, A, Srivastava, S. K., & Sharma, R.K. (2015). Expression profile of follicular genes vis-à-vis season and cyclicity in buffalo (Bubalus bubalis). *Indian Journal of Animal Sciences*, 85(5), 514-516.
11. Jerome, A., Pandey, A.K., & Sarkar, S.K. (2015). .Homology modeling of single nucleotide polymorphisms in candidate genes controlling embryonic growth of buffalo (*Bubalus bubalis*). *Indian Journal of Animal Sciences*, 85(6), 578-584.
12. Jerome, A., Srivastava, S. K., & Sharma, R. K. (2016). *In vivo* biocompatibility of fabricated polymer implant in buffaloes - a preliminary study. *Indian Journal of Animal Sciences*, 86(1), 49-50.
13. Kumar P., Pandey, A.K., Phulia, S.K., Kumar, S., Sharma, R.K., Bishnoi, N. & Kumar K. (2015). Effect of ovsynch estrus synchronization protocol on certain mineral profile of cyclic murrah buffaloes in summer and winter season. *Journal of Animal Research*, 5(4), 909-913.
14. Kumar, P., Saini, M., Kumar, D., Balhara, A.K., Yadav, S.P., Singh, P., & Yadav, P.S. (2015). Liposome-based semen extender is suitable alternative to egg yolk-based extender for cryopreservation of buffalo (*Bubalus bubalis*) semen. *Animal Reproduction Science*, 159, 38-45.
15. Kumar, P., Saini, M., Kumar, D., Jan, M.H., Swami, D.S. and Sharma, R.K. (2016). Quantification of leptin in seminal plasma of buffalo bulls and its correlation with antioxidant status, conventional and computer-assisted sperm analysis (CASA) semen variables. *Animal Reproduction Science*, 166, 122–127.
16. Kumar, S., Balhara, A.K., Kumar, R., Kumar, N., Buragohain, L., Baro, D., Sharma, R.K., Phulia, S.K, & Singh, I. (2015). Hemato-biochemical and hormonal

profiles in post-partum water buffaloes (*Bubalus bubalis*). *Veterinary World*, 8(4), 512-517.

17. Mohan, C., Saxena, N., Fozdar, B.I., Kumar, R., Sharma, M.L., Mudgal, V., Dey, A., & Punia, B.S. (2016). *In vitro* evaluation of few indigenously known herbal plants for their anthelmintic property. *Asian Journal of Chemistry*, 28(5), 1001-1003.
18. Onteru, S.K., Baddela, V.S., Ravinder, R., Kaipa, O., Nayan, V., Singh, P., Baithalu, R.K., & Singh, D. (2016). Direct saliva transcript analysis as a novel non-invasive method for oestrus marker detection in buffaloes. *Biomarkers*, 21(2), 99–101.
19. Paul, S.S., Deb, S.M., Dey, A., Somvanshi, S.P.S., Singh, D., Rathore, R., & Stiverson, J. (2015). 16S rDNA analysis of archaea indicates dominance of *Methanobacterium* and high abundance of *Methanomassiliicoccaceae* in rumen of Nili-Ravi buffalo. *Anaerobe*, 35, 3-10.
20. Ramadan, T.A., Sharma, R.K., Phulia, S.K., Balhara, A.K., Ghuman, S.P.S. and Singh, I. (2016). Manipulation of reproductive performance of lactating buffaloes using melatonin and controlled internal drug release device treatment during out-of-breeding season under tropical conditions. *Theriogenology*. http://doi: 10.1016/j.theriogenology.2016.03.034.
21. Sadeesh, E.M., Shah, F., Kataria, M., Yadav, P.S. (2015). A comparative study on expression profile of developmentally important genes during pre-implantation stages in buffalo hand-made cloned embryos derived from adult fibroblasts and amniotic fluid derived stem cells. *Cytotechnology,* http://doi.org/10.1007/s10616-015-9904-7
22. Sadeesh, E.M., Shah, F., Yadav, P.S. (2015). Differential developmental competence and gene expression patterns in buffalo (*Bubalus buablis*) nuclear transfer embryos reconstructed with fetal fibroblast and amnion cells. *Cytotechnology*. http://doi.org/10.1007/s106156-015-9936-z.
23. Sarla., Kumar, M., Phulia, S.K. & Chhokar, V. (2015). Genetic polymorphism in PR-A of progesterone receptor (PGR) gene in Murrah buffalo (*Bubalus bubalis*). *Annals of Agri Bio Research*, 20(1), 7-10.
24. Sarla., Kumar, M., Phulia, S.K. & Chhokar, V. (2015). Genetic polymorphism in exon 13 of estrogen receptor-β (ERβ) gene in Murrah buffalo (*Bubalus bubalis*). *Annals of Biology,* 31(1), 41-45.
25. Saxena, N., Promilla, Mohan, C., Sarkar, S.K., Sharma, M.L., Lailer, P.C., Kumar K., Devi R. & Singh, J.K. (2012-14). Effect of sewage water irrigation on soil characteristics and fertility. *Indian Buffalo Journal*, 10-12(1&2), 59-63.
26. Selokar, N.L., Sharma, P., Kumar, D., Sharma, R.K., & Yadav, P.S. (2015). Effect of donor cell type on in vitro and in vivo developmental competence of cloned buffalo (*Bubalus bubalis*) embryos. *Reproduction, Fertility and Development*, 28(2), 142.
27. Singh, A.K., Brar, P.S., Kumar, P., and Cheema, R.S. (2015). Effect of age and scrotal circumference on sperm motion characteristics of frozen-thawed semen in breeding bulls measured by computer-assisted semen analyzer. *Indian Veterinary Journal,* 92, 87-89.
28. Talluri, T.R., Kumar, D., Glage, S., Garrels, W., Ivics, Z., Debowski, K., Behr, R., Niemann, H., & Kues, W.A. (2015). Derivation and characterization of bovine induced pluripotent stem cells by transposon-mediated reprogramming. *Cellular Reprogramming*, 17(2), 131-140.
29. Yadav, S., Kumar, A., Maan S., Boora, A., Maan, N.S., Banger, R., Singh, K.P., & Singh, I. (2015). Isolation and characterization of *mannheimia varigena* from a Murrah buffalo. *Journal of Buffalo Science,* 4, 15-20.

Review Papers

1. Dahiya, S.S., & Mudgal, V. (2012-14). Feeding of buffaloes for meat production. *Indian Buffalo Journal*, 10-12, 93-98.
2. Dutta, N., & Dey, A. (2012-14). Plant bio-actives: effects on protein metabolism and gastro-intestinal parasitism in ruminants. *Indian Buffalo Journal*, 10-12(1&2), 99-104.
3. Kumar, D., Talluri, T.R., Anand, T., & Kues, W.A. (2015). Transposon-based reprogramming to induced pluripotency. *Histology & Histopathology*, 30, 1397-1409.
4. Mohan, C., Saxena, N., & Fozdar, B.I. (2015). Activity of indigenously known angiosprmic plants against

common GI parasites of livestock. *World Journal of Pharmacy & Pharm. Sciences*, 4(9), 1652-1667.

5. Nayan, V., Onteru, S.K., & Singh, D. (2015). Reproduction and nutriment–nurture crosstalk: epigenetic perspectives. *Journal of Reproductive Health and Medicine*, 1(2), 50–59.
6. Paul S.S., Chanu, Y.M., & Dey, A. (2016). Options for improving nitrogen utilization efficiency in ruminants. *Indian Journal of Animal Nutrition,* 33(1), 1-10.
7. Yadav, S.P., Sikka, P. & Pandey, A.K. (2012-14). Genomic tools for efficient production and reproduction in Animals. *Indian Buffalo Journal*. 10-12(1&2), 89-92.

Book Chapters

1. Chaudhary, A.P., & Singh, K.P. (2016). Production and reproduction performance of Banni buffalo under in-situ conservation. In N.S.R. Sastry (Ed.) Livestock Production under diverse constraints (pp: 98-101). Indian Society of Animal Production and Management.
2. Kumar, A., Kumar, S., Singh, M., Gokuldas, P.P. & Kumar, P. (2015). Non-infectious causes of bubaline abortions. In G. N. Purohit (Ed.). *Bubaline Theriogenology*. International Veterinary Information Service, Ithaca NY
3. Paul, S.S., & Dey, A. (2015). Domesticated Rare Animals (Yak, Mithun and Camel): Rumen Microbial Diversity. In A.K. Puniya, Rameshwar Singh, & D.N. Kamra (Eds.), *Rumen Microbiology: From Evolution to Revolution* (pp: 31-36), Springer (India) Ltd.
4. Singh, I. & Singh, K.P., (2016). Strategy, management and policy framework for improvement of indigenous buffalo germplasm. In N.S.R. Sastry (Ed.) Livestock production under diverse constraints (pp: 94-97). Indian Society of Animal Production and Management.
5. Singh, K.P., Boora, A., Balhara, S., & Yadav, S. (2015). Trends in buffalo meat production and export. In C.V. Singh and R.S. Barwal (Eds.) *Livestock and Poultry – Conservation and Improvement Techniques* (pp: 87-94). New India Publishing Agency.
6. Somvanshi, S.P.S., Paul, S.S., Singh, S.V., Ashutosh, & Upadhaya, R.C. (2016). Effect of climate change on livestock production and mitigation strategies. In: *Indian Agriculture and Farmers* (pp: 137-144). ISBN: 978-93-84215-53.

Book/ Vision Document

- Vision-2050 (2015) ICAR-Central Institute for Research on Buffaloes, Hisar, Haryana.

Annual report

1. Singh, K.P., Mudgal, V., Singh, G., Balhara, A.K., Selokar, N.L., Mehrara, K.L., & Chaudhary, R. (2015). Annual Report of CIRB (English) (2014-15), Pp. 1-66.
2. Singh, K.P., Mudgal, V., Singh, G., Balhara, A.K., Selokar, N.L., Mehrara, K.L., & Chaudhary, R. (2015). Annual Report of CIRB (Hindi) (2014-15), Pp. 1-66.

Training Manuals/ Compendium

1. Sharma, R.K., Phulia, S.K., Balhara, A.K., & Jerome, A. (2015). Manual on ultrasonography and fertility management in large animals, published by ICAR-CIRB Hisar.
2. Sharma, R.K., Phulia, S.K., Jerome, A., Khanna, S., & Yadav, P.S. (2016). Compendium of model training course on ultrasonography in large animal reproduction for fertility augmentation (15th-22nd Feb., 2016) at CIRB, sponsored by Directorate of Extension, Ministry of Agriculture & Farmers' Welfare, Government of India, published by ICAR-CIRB, Hisar.

Papers/ posters presented in conferences/ symposia etc.

(A) Invited/ Lead/ Award Presentations

1. Singh, I. & Singh, K.P. (2015). India's rich and diverse buffalo germplasm for global buffalo development. Invited Lead Paper presented in Asian Buffalo Congress, held at Istanbul – Turkey (21st-25th April, 2015), pp: xxxii – xxxviii. (*Invited/ Lead paper*)
2. Dey, A., Das, A.K., Paul, S.S., Dahiya, S.S., & Punia, B.S. (2015). Plant Phenolics: Potential benefits on health, methane mitigation and animal Performance. Presented in National Conference on ''Bioresources Management for Sustenance of Ecosystem and Livelihood'' organized at UBKV, Pundibari, W.B. (*Invited/ Lead paper*)
3. Mudgal, V., & Jain R.K. (2015). Nutritional management of macro minerals disorders in peri-parturient dairy animals. Presented in third national conference of

IAVNAH at COVASc, CSKHPKV, Palampur, Himachal Pradesh, India. (*Invited/ Lead paper*)

4. Nayan, V., Onteru, S.K., & Singh, D. (2015). In silico identification of a novel peptide epitope and generation of antibody for sensing buffalo Luteinizing Hormone." Paper presented at XXII Annual Convention (VIBCON-2015) and National Symposium on Immunomics and Proteogenomics in Livestock Health & productivity of the ISVIB at NRCE, Hisar, Haryana. (*mid-career award session paper*)
5. Paul, S.S. (2015). Oligonucleotide microarrays for comprehensive metagenomic analysis of rumen microbiome, Presented in National workshop on Metagenomics and nutrigenomics for research and teaching in animal nutrition in India,organized by ANA and AN Division, IVRI, Izatnagar, India. (*Invited/ Lead paper*)
6. Paul, S.S. (2016). Strategies for precision feeding of dairy animals. Presented in XVI Biennial Animal Nutrition conference on Innovative Approaches for Animal Feeding & Nutritional Research. Karnal, Haryana, India. (*Invited/ Lead paper*)

(B) Other Presentations

1. Bharadwaj, A. (2015). Field unit report, CIRB Hisar 2014-15. XIII Annual review meet of network project on buffalo improvement, 23-24 September, 2015, CIRB, Hisar
2. Bhardwaj, A., Nayan, V., & Gupta, A.K. (2015). Molecular docking studies of equine chorionic gonadotropin through in silico approach. Paper presented at XXII Annual Convention and National Symposium on Immunomics and Proteogenomics in Livestock Health & Productivity organized of the ISVIB at NRCE, Hisar.
3. Dey, A., Paul S.S., Dahiya, S.S., & Punia, B.S. (2016) Garlic oil supplementation: effects on in vitro methanogenesis, rumen fermentation and gas production in buffaloes. Paper presented orally at the International Livestock Conference and Expo (INDIGENOUS) and 23rd Annual Convention, ISAPM at PJTSAU, Hyderabad, Telangana.
4. Dey, A., Paul, S.S., Umakanth, A.V., Bhat, B.V., Lailer, P.C., & Punia, B.S. (2016). Nutritional quality, *In Vitro* fermentation patterns and methane production potential of Sorghum (*Sorghum bicolor*) cultivars in Buffaloes. Poster presented at the *XVI Biennial Animal Nutrition Conference* of ANSI at NDRI, Karnal, India.
5. Dixit, V.B., Tripathi, H., Duhan, A. & Singh, I. (2015). Promotion of buffalo husbandry through breeder's welfare association in Haryana: an innovative approach, In compendium of international conference on good governance in agriculture extension held during 3-4 September, 2015 jointly organised by MANAGE and CGG at Hyderabad.
6. Katiyar, G.S., Mudgal, V., Sharma, R.K., Jerome, A., Phulia, S.K., Balhara, A.K., Rathor, R., Khanna, S., & Singh, I. (2015). Effect of feeding bypass nutrients on feed intake, growth and reproductive performance of Murrah buffaloes. Paper presented at the third National Conference of IAVNAH at Palampur, HP, India.
7. Mudgal, V., Garg, A.K., Dass, R.S, & Rawat, M. (2016). Effect of copper and selenium supplementation on cell mediated and humoral immune response in male buffalo (*Bubalus bubalis*) calves. Poster presented at the *XVI Biennial Animal Nutrition Conference* of ANSI at NDRI, Karnal, India.
8. Nayan, V. (2015). Peptide based functionalization of gold nanoparticles for sensing buffalo luteinizing hormone." Paper presented *for Best Ph.D. thesis Award presentation* (Ph.D. thesis selected from Animal Biochemistry Division in Production category for competition on 01st March, 2016) at NDRI, Karnal Haryana
9. Paul, S.S., Dey, A., Baro, D., Jerome, A, & Punia, B.S. (2016). An Analysis of Comparative Global Diversity of Bacteria in Rumen of Buffaloes and Cattle. Paper presented at the *XVI Biennial Animal Nutrition Conference* of ANSI at NDRI, Karnal.
10. Saini, M., Selokar, N.L., Raja, A., Sahare, A., Singla, S., Chauhan, M., Manik, R. & Palta, P. (2015) Treatment with trichostatin-A and 5-aza-2'-deoxycytidine improves the developmental competence, quality and epigenetic status and alters the gene expression in cloned buffalo (*Bubalus bubalis*) embryos. Paper

presented at 48th Annual Meeting of SSR held at Puerto Rico, San Juan, USA.

11. Saxena, N., Mohan, C., Jain, S., Kumar, K., Sharma, M.L., & Mudgal, V. (2016). Effect of restricted feeding on the performance of replacement Murrah buffalo heifers. Poster presented at *XVI Biennial Animal Nutrition Conference* of ANSI at NDRI, Karnal, India.
12. Selokar, N.L., Saini, M., Agrawal, H., Palta, P., Chauhan, M.S., Manik, R. & Singla, S.K. (2015). Valproic acid induced the hyper histone acetylation level of donor cell does not improve the in-vitro developmental competence and epigenetic status of cloned buffalo (*Bubalus Bubalis*) embryos. Paper presented at 48th Annual Meeting of SSR at Puerto Rico, San Juan, USA.
13. Selokar, N.L., Kumar, D., & Yadav, P.S., (2016). Unprecedented prospect for the development of climate resilient livestock models using advanced reproductive biotechnologies. Paper presented at XXIV Annual Conference of SAPI and National Symposium on Physiological approaches for development of climate resilient livestock farming, CoVS, AAU, Guwahati.
14. Selokar, N.L., Kumar, D., Sharma, R.K., & Yadav, P.S. (2015). Successful cryopreservation of somatic cells and cloned embryos: Future hope for multiplication and conservation of quality buffalo (*Bubalus bubalis*). Paper presented at International Conference on Low Temperature Science and Biotechnological Advances, NASC Complex, Pusa Campus, New Delhi.
15. Selokar, N.L., Sharma, P., Kumar, D., Saini, M., Sharma, R.K., & Yadav, P.S. (2015). Somatic cells cryobanking: Future hope for multiplication and conservation of quality buffalo (*Bubalus bubalis*). Paper presented at XXII Annual Convention and National Symposium on Immunomics and Proteogenomics in Livestock Health & Productivity organized of the ISVIB at NRCE, Hisar.
16. Sharma, P., Selokar, N.L., Kumar, D., Kumar, D, & Yadav, P.S. (2015). Effect of sodium butyrate (histone deacetylase inhibitor) on donor cell physiology, those are used for production of handmade cloned buffalo (*Bubalus bubalis*) embryos. Poster, Ibid.
17. Talluri, T.R., & Kumar, D. (2015). Advances and applications of assisted reproductive technology in animal reproduction. Paper presented at XXXI Annual Convention of the ISSAR and National Symposium on current challenges and opportunities in animal reproduction, Department of Veterinary gynaecology and obstetrics, Veterinary College, Hebbal, Bengaluru.
18. Tripathi, H. (2015). Presentation on Food security – current situation and future predictions under theme: Social protection and agriculture: breaking the cycle of rural poverty on occasion of world food day at ICAR-CIRB
19. Tripathi, H. (2016). Presentation on Integrated farming with special reference to fish farming under technical session fisheries in 8th Livestock Championship & Expo, 2016 at Muktsar Sahib
20. Yadav, P.S., Selokar, N.L., & Kumar, D. (2015). Fetal adnexa tissues: Ideal source of mesenchymal stem cells. Paper presented at XXII Annual Convention and National Symposium on Immunomics and Proteogenomics in Livestock Health & Productivity organized of the Indian Society for Veterinary Immunology and Biotechnology, at NRCE, Hisar, Haryana

Technical/popular articles

1. Balhara, A.K., Nayan, V. & Bhardwaj, A. (2016). Advances in development of pregnancy diagnostics: strategies for development of field usable pregnancy diagnostic tests. Manual of ICAR 28th CAFT Course in Veterinary Microbiology on "Development of Validated Diagnostic Assays and Accreditation of Diagnostic Laboratories", LUVAS, Hisar, 63-70.
2. Dixit, V.B., Tripathi, H., Duhan, A. and Singh, I. (2015). Breeders' association in promotion of buffalo husbandry. Good Practices Blog article in Agricultural Extension in South Asia (AESA), 13, December 2015
3. Dey, A., & Paul, S.S. (2015). Effect of heat stress in buffaloes and strategies for its amelioration, Pashudhan, 42 (5): 1-4.
4. Dey, A., Paul, S.S., Pandey, P., & Rathore, R. (2015). Nutrition associated disorders of ruminants: dietary implications and ameliorations. Livestock Line, 9 (5): 13-20.
5. Jerome, A. (2015). Advances in reproductive research: an overview. Livestock Line, 9(6): 4-7.

6. Karuppanasamy, K., Sharma, R.K., Singh, I., Phulia, S.K., Narayanan, K., Jerome, A. & Kumar, S. (2015). Hormonal therapy vis-à-vis anoestrus in buffalo: an overview. Livestock Line, 9(8), 29-31.

7. Kumar, D., Selokar, N.L. & Yadav, P.S. (2015). Scope of transgenic buffalo production. Asian Buffalo Magazine, 9(2), 9-12.

8. Mudgal, V. (2016). Biomarkers of micronutrient status in livestock: Potentials in research and applications. In S.E. Jadhav, A.K. Pattanaik, A. Das, A.K. Garg, & A.K.Verma (Eds.), *Micronutrients in Animal Nutrition* (pp 140-150), Centre of advanced faculty training in Animal Nutrition, ICAR –Indian Veterinary Research Institute, Izatnagar, India. ,

9. Mudgal, V. (2016). Micronutrient-gene interactions: Exploring the nutrigenomics for animal health and Production. Ibid, (pp 179-187).

10. Sharma, R.K., Balhara, A.K., Jerome, A. & Phulia S.K. (2015). Ultrasonography in large animal reproduction. 3 day Technical training, Department of Animal Husbandry Jharkhand, Ranchi. 19-22.

11. Sharma, R.K., Balhara, A.K., Jerome, A. & Phulia, S.K. (2015). Oestrus induction and synchronization protocols in large animals. Ibid, 9-14.

12. Sharma, R.K., Balhara, A.K., Jerome, A., Phulia, S.K. & Singh. I. (2015). Key points for success of estrus synchronization and ETT in buffaloes. CAFT Training compendium GADVASU, 141-159.

13. Sharma, R.K., Jerome, A., Phulia, S.K., Kumar, D., Khanna, S. & Singh, I. (2015). Embryos transfer and other assisted reproductive technoques. 3-Day technical training manual at Department of Animal Husbandry, Jharkhand, Ranchi, 23-27.

14. Sharma, R.K., Kumar, P., Kumar, D. & Yadav, P.S. (2015). Bull management and cryopreservation of buffalo bull semen. 3-Day technical training manual at Department of Animal Husbandry, Jharkhand, Ranchi, 15-18.

15. Yadav, P.S., Kumar, D. and Selokar, N.L. (2015). Role of stem cells in animal production and reproduction. Short term training programme on molecular approaches for augmenting reproductive efficiency in cattle held at ICAR-CIRC, Meerut, 301-309.

16. Yadav, P.S., & Selokar, N.L. (2015). Fetal stem cells in animals. CAFT in veterinary physiology on Nanobiology and regenerative therapies in animal health and production held at IVRI, 113-118.

17. Technical articles in the Compendium of model training course on "*Ultrasonography in large animal reproduction for fertility augmentation (15th -22nd Feb., 2016)*".

- Singh, I. (2016). Application and scope of ultrasound in animal production system, 1-2.
- Jerome, A., Phulia, S.K. & Sharma, R.K. (2016). Ultrasonography:basic principles and concepts, 3-5.
- Sharma, R.K., Jerome, A., Phulia, S.K. and Singh, I. (2016). Evaluation of buffalo ovaries using ultrasound for its function, 6-12.
- Sharma, R.K., Kavya, K.M., Balhara, A.K., Kumar, R. & Phulia, S.K. (2016). Use of ultrasound in early pregnancy diagnosis, fetal age and sex determination in buffaloes, 13-22.
- Phulia, S.K. & Sharma, R.K. (2016). Ultrasonography of mammary gland in buffaloes. 27-29.
- Singh, S. & Vyas, S. (2016). Application of ultrasound in camel reproduction, 49-58.
- Yadav, P.S. (2016). Reproductive biotechnology-for higher animal production,108-112.
- Selokar, N.L. (2016). Science and art: cloned animal production, 113-116.
- Sharma, R.K., Kavya, K.M., Jerome, A., Khanna, S. & Phulia, S.K. (2016). Protocols for estrus synchronization program in buffaloes.117-126.
- Balhara, A.K. & Nayan, V. (2016) Achieving high productivity through early pregnancy diagnosis, 127-131.
- Nayan, V., Bhardwaj, A., Balhara, A.K., Jerome, A. & Sharma, R.K. (2016). Potential applications and prospects of nanotechnology for animal reproductive biotechnologies, 132-136.
- Kumar, D. & Kumar, P. (2016). Recent advancements in sperm cryopreservation of farm animals, 137-141.

- Kumar, P. & Kumar, D. (2016). Andrological investigation and breeding soundness evaluation of bulls, 142-146.
- Jan, M.H. & Tripathi, M.K. (2016). Estrus detection techniques in large animals under field and farm conditions, 147-149.
- Paul, S.S. (2016). Role of nutrition in reproduction and balanced ration formulations. 59-165.

18 Technical articles in the Compendium of model training course on "*Ultrasonography and fertility management in large animals*".

- Singh, I. (2015). Importance of animal reproduction in production system, 1-2.
- Jerome, A., Phulia, S.K. & Sharma, R.K.(2015). Principles of ultrasonography, 3-5.
- Sharma, R.K., Balhara, A.K., Jerome, A., Phulia, S.K., Khanna, S. & Singh, I. (2015). Oestrus induction and synchronization protocols in buffaloes, 6-18.
- Sharma, R.K., Jerome, A., Phulia, S.K. & Singh, I. (2015). Use of ultrasonography for evaluation of ovaries in buffaloes, 19-25.
- Balhara, A.K. & Singh, I. (2015).Importance of early pregnancy diagnosis- Different tools, 26-32.
- Sharma, R.K., Balhara, A.K., Jerome, A. & Phulia, S.K. (2015). Early pregnancy diagnosis, fetal age and sex determination using ultrasound in buffalo, 33-42.
- Kumar, P. & Sharma, R.K. (2015).Application of ultrasonography in male reproduction, 48-54.
- Phulia, S.K. & Sharma, R.K. (2015). Ultrasonographic examination of mammary glands in buffaloes, 55-60.
- Yadav, P.S. (2015). Recent biotechniques in assisted animal reproduction, 61-66.
- Selokar, N.L. (2015).Transvaginal ultrasound-guided Ovum Pick-up (OPU), 67-69.
- Kumar, D. (2015). Recent advancement of stem cells in farm animal reproduction, 70-78.
- Singh, S. & Vyas, S. (2016). Application of ultrasonography in camel reproduction, 84-96.
- Balhara, A.K. & Ghosh, M. (2016).Clinical use of hormones in animals, 97-102.

Abstracts

1. Buragohain, L., Nanda, T., Kumar, R., Ghosh, M., Gupta, S.S., Singh, I. & Balhara, A.K. (2016).Expression profile of MX2 gene and protein for early pregnancy diagnosis in Murrah buffalo. Annual Convention SVBBI, March 11-12, 2016, Bhubaneswar. pp. 79.
2. Choudhary, K.K., Kavya, K.M., Jerome, A., Bharadwaj, A. & Sharma, R.K. (2015). Resumption of post-partum cyclicity in relation to parity, body weight and body condition score in buffaloes under farm conditions Current Challenges and opportunities in Animal Reproduction by ISSAR at Bengaluru, December 3-5, 2015, pp. 90.
3. Dixit, V.B., Bharadwaj, A., Singh, K.P., Duhan, A. and Tripathi H. (2016). Opinion of scientists and traders in deciding the price of a buffalo in Haryana. International Extension Education Conference on Extension, Education and Services organized by Department of Extension Education. Institute of agriculture Sciences at BHU, Varanasi, (27-30 January 2016) IEEC/2016/ABS/027
4. Dixit, V.B., Tripathi, H., Duhan, A. and Singh, I. (2015). Promotion of buffalo husbandry through breeder's welfare association in Haryana: an innovative approach, In Compendium of International conference on Good governance in Agriculture Extension, jointly organised by MANAGE and CGG at Hyderabad, 3-4 September, 2015. pp. 21.
5. Ghosh, M., Sangwan, N., Kumar, N., Kumar, R., Chakravarti, S., Balhara, A.K., Mohanty, A.K. & Sangwan, A.K. (2016). Identification and characterization of Phosphatidylethanolamine-binding protein in salivary gland extract of Hyalomma anatolicum ticks as potential immunoprophylactic and therapeutic candidate. Annual Convention SVBBI, March 11-12, 2016, Bhubaneswar, pp. 59.
6. Jerome, A., Thirumaran, S.M.K, Kala, S.N., Sharma, R.K. & Phulia, S.K. (2015). MicroRNAs profiling in different physiological stages of corpus luteum in

buffalo (Bubalus bubalis) in ISSAR Conference: Current Challenges and opportunities in Animal Reproduction on 3rd-5th Dec., 2015, Bengaluru, pp. 107.

7. Katiyar, G.S., Mudgal, V., Sharma, R.K., Jerome, A., Balhara, A.K. & Singh, I. (2015). Effect of bypass fat and protein supplementation on resumption of cyclicity in post-partum buffaloes Current Challenges and opportunities in Animal Reproduction by ISSAR at Bengaluru, December 3-5, 2015, pp.85.
8. Katiyar, G.S., Mudgal, V., Sharma, R.K., Jerome, A., Phulia, S.K., Balhara, A.K., Rathore, R., Khanna, S. & Singh, I. (2015). Effect of feeding bypass nutrients on feed intake, growth and reproductive performance of Murrah buffaloes.3rd conference of Indian Academy of Veterinary Nutrition and Animal Welfare at Palampur. Nov. 4-5, 2015. pp. 147-148.
9. Nayan, V., Baddela, V.S., Rani, P., Onteru, S.K., & Singh, D. (2015). Nanostructural characterization of buffalo milk-derived nanovesicles: physicochemical and Fourier transform infrared spectroscopy biomolecular perceptions" ICSID-2015 (International Conference on Sustainable Innovations in Dairying) Rajgir, Nalanda, Bihar, April 2-5, 2015. (*Selected for Young scientist award presentation*).
10. Pippal, R.S., Punia, B.S. & Dutt, G. (2016). Effects of wallowing, splashing water and washing during summer on the performance of lactating Nili-Ravi buffaloes. In: Proc. International Livestock Conference and Expo (INDIGENOUS) and 23rd Annual Convention, ISAPM at PJTSAU, Hyderabad, Telangana from January 28-31, 2016, pp. 90.
11. Pippal, R.S., Punia, B.S., & Dutt, G. (2016). Effect of summer stress ameliorative measures on some physiological parameters of lactating Nili- Ravi buffaloes. In: Proc. International Livestock Conference and Expo (INDIGENOUS) and 23rd Annual Convention, ISAPM at PJTSAU, Hyderabad, Telangana from January 28-31, 2016, pp. 42.
12. Rajput, D.S. & Tripathi, H. (2016). Difference in level of satisfaction of pastoralists with respect to animal health service received from organized and unorganized sector in arid zone of Rajasthan. In proc. International Extension Education Conference on Extension, Education and Services at BHU, Varanasi, January 27-30, 2016. pp. 194-19.
13. Rathore, R., Mudgal, V., Sharma, R.K., Phulia, S.K., Jerome, A., Balhara, A.K. & Singh, I. (2015). Efficacy of synchronization protocols in inducing cyclicity in anestrous buffaloes under field conditions Current Challenges and opportunities in Animal Reproduction by ISSAR at Bengaluru, December 3-5, 2015, pp. 31.
14. Selokar, N.L., Sharma, P., Kumar, D., Sharma, R.K. & Yadav, P.S. (2015). Effect of donor cell type on in vitro and in vivo developmental competence of cloned buffalo (Bubalus bubalis) embryos. Reprod. Fertil. Dev., 28(2), 142-142.
15. Tripathi, H. (2016). Nature and extent of drudgery reported by male and female workers in livestock rearing. In proc International Extension Education Conference on Extension, Education and Services at BHU, Varanasi, January 27-30, 2016, pp. 29-30.
16. Yadav, J., Tripathi, H., Balaraju, B. L. and Yadav, R. (2016) Constraints perceived by women livestock farmers in availing the livestock extension services delivered by State Department of Animal Husbandry personnel In proc. *ibid*. pp. 170-171.
17. Tripathi, H., Tripathi, B.N., Shyam, J., Balaraju, B.L. and Dixit, V. B. (2015). In proceedings Risks and knowledge of rural women with regard to health hazards in livestock rearing. Golden Jubilee seminar of ISEE at BHU, November 2015.
18. Yadav, J. Tripathi, H., Yadav, R. and Balaraju, B.L. (2015) Preferences for various credit lending sources among female headed households engaged in small scale dairying: A gender perspective. *Ibid*.

Farmer oriented literature/Leaflet developed

1. 'मुर्रा भैंसों में ब्याने की अनुमानित तिथि–तालिका' द्वारा डॉ. हेमा त्रिपाठी, डॉ. वी.बी. दीक्षित, आस्थ दूहन एवम् डॉ. इन्द्रजीत सिंह।
2. 'पशुओं के मुख्य संक्रामक रोग एवं बचाओ हेतु टीकाकरण तालिका' द्वारा डॉ. हेमा त्रिपाठी, डॉ. सज्जन सिंह, डॉ. वी. बी. दीक्षित एवं डॉ. इन्द्रजीत सिंह।
3. भा.कृ.अनु.प.–केन्द्रीय भैंस अनुसंधान संस्थान–एक झलक।

Research Projects

LIST OF COMPLETED RESEARCH PROJECTS			
1.	Identification of SNPs in genes related to meat production and their association with meat parameters in buffaloes *(Bubalus bubalis)*	A.K. Pandey, P. Sikka, S.P. Yadav, S.S. Dahiya, N. Khanna	October 2010- December 2015
2.	Effect of different feeding regimen on age at first calving	P.C. Lailer, V. mudgal, S.S. Dahiya, A.K. Boora, B.S. Punia	April 2012 - December 2015
3.	Effect of stimulants on fibre degradation, methane emission and fungal population in buffaloes	A. Dey, S.S. Dahiya, B.S. Punia, P.C. Lailer, N. Saxena, S.S. Paul	April 2012- December 2015
4.	Validation of ITK known herbs against gastro-intestinal parasites in buffalo calves.	N. Saxena, A. Dey, V. Mudgal, B.S. Punia, M.L. Sharma	November 2012- October 2015
5.	Development of modules for buffalo meet production	S.S. Dahiya, A. Dey, P.C. Lailer , V. Mudgal	January 2013- December 2015
6.	Silage as enterprise for self-employment, milk production and crop diversification	P.C. Laliler	April 2013- March 2015
7.	Identification of genetic variants in genes related to oxidative status in relation to fertility in Murrah Bulls	P. Sikka, P. Kumar	July 2013-December 2015
8.	Development of feeding modules for Nili-Ravi buffalo meet production	R. Malik, S.S. Dahiya	December 2013- December 2015

LIST OF ONGOING RESEARCH PROJECTS			
	Projects	**Investigators**	**Duration**
1.	Cloning for conservation and multiplication of superior buffalo Germplasm	P.S. Yadav, R.K. Sharma, D. Kumar, N. Selokar, S. Khanna	September 2010 – March 2017
1.1	**Sub-Project 1:** Cryo-preservation of somatic cells and cloned embryos for providing future reproductive opportunities in buffaloes.	N.L. Selokar, P.S. Yadav, R.K. Sharma, D. Kumar	October 2015- September 2018
1.2	**Sub-Project 2:** Optimization of conditions for efficient gene transfer into buffalo somatic cells for transgenic embryo production	D. Kumar, N.L. Selokar, P.S. Yadav	November 2015 – November 2017
2.	Application of pedigree information and body condition score for development of buffalo breeding herd analyser	S.N. Kala	July 2011-March 2016

	Projects	Investigators	Duration
3.	e-BhainsVigyan Kendra (ई भैंस विज्ञान केन्द्र)-CIRB's virtual centre for training in buffalo husbandry and platform for scientist-farmer interactions	S. Balhara, A.K. Balhara S.K. Phulia, P.C. Lailer P. Sikka	November 2013- October 2016
4.	Establishment of fertility-associated seminal plasma proteins as biomarkers through proteomics and nanotechnological approach in buffalo	P. Kumar, D. Kumar, A.K. Balhara, S.P. Yadav, P.S. Yadav	December 2012 - March 2016
5.	Studies on development and supplementation of chelated minerals in buffaloes.	V. Mudgal, N. Saxena, S.S. Dahiya, B.S. Punia, K. Kumar, M.L. Sharma	April 2013-March 2016
6.	Effect of different feeding regimen on age at first calving in Nili-Ravi buffaloes	R. Malik, K.P. Singh, B.S. Punia	November 2013 to October 2017
7.	An integrated investigation of microbial communities involved in methane production and fibre digestion	S.S. Paul, A. Dey, B.S. Punia, A. Jerome, P. Sikka	April 2014- March 2017
8.	Evaluation of Sorghum cultivares on growth rate and feed utilization in buffalo (Inter-institutional)	A. Dey, P.C. Lailer, S.S. Paul (CIRB) V. Bhat, A.V. Umakanth (IIMR, Hydrabad)	April 2015- March 2016
9.	Development of diagnostic platforms for sensing candidate biosignatures of buffalo reproduction	Varij Nayan, A.K. Balhara, A. Bhardwaj (NRCE), R.K. Sharma	November 2015-November 2018
10.	Convergence for dairy development: A synergistic approach	V.B. Dixit, H. Tripathi, S. Singh	November 2015-January 2019
11.	Factors influencing participation of rural youth in farming: an exploratory study	H. Tripathi, V.B. Dixit, S. Singh	November 2015-December 2017
12.	Optimization of interspecies somatic cell nuclear transfer technique for production of horse *(Equus caballus)* cloned embryos **(Inter institutional)**	N.L. Selokar, D. Kumar, P.S. Yadav (CIRB),T.R. Rao, S.K. Ravi, T. Anand (NRCE)	November 2015- October 2018

LIST OF EXTERNALLY FUNDED PROJECTS			
1.	Early detection of pregnancy in calve and buffalo by pregnancy associated proteins (PAPs) (NFBSFARA)	A.K. Balhara, I. Singh, S.K. Phulia	June 2012- May 2015
2.	Computational identification and modelling of genetic variation in relation to performance traits (NABG CABIn scheme)	P. Sikka, K.P. Singh, S.S. Paul, A. Jerome, S. Balhara, A.K. Balhara, Varij Nayan	July 2015- June 2017
3.	An open label study to assess the efficacy of spectramast in the therapy and control of clinical and sub-clinical mastitis in buffaloes (Zoetis India Sponsored)	A. Boora, K.P. Singh	September 2015- March 2017

	Projects	Investigators	Duration
4.	Simplification of nuclear transfer technique for the production of elite buffalo bulls (SERB)	N. L. Selokar	October 2015-September 2018
5.	Studies on antagonists/inhibitors of signaling molecules to prevent cryocapacitation and development of species specific semen extender for buffalo semen cryopreservation (SERB)	P. Kumar	October 2015- November 2018
6.	Generation of induced pluripotent stem (iPS) cells from buffalo fetal fibroblasts through non-viral approaches (DBT)	D. Kumar, N.L. Selokar, P.S. Yadav (CIRB), T. Anand, N. Virmani, B.C. Bera (NRCE)	February 2016- February 2019
7.	Lactation stress associated postpartum anestrus SNP array in Buffaloes (NASF)	S.K. Onteru, D. Singh (NDRI), R K Sharma, Varij Nayan (CIRB), T Keshva Prasad (IOB)	July 2014- June 2019
8.	Network project on buffalo improvement	I. Singh, A.K. Pandey	July 1991 - continuing
9.	Nutritional and physiological interventions for enhancing reproductive performance in animals (AICRP)	R.K. Sharma, S.K. Phulia, V. Mudgal, Jerome A., P. Kumar	November 2014- March 2017
10.	Genetic Improvement of Murrah buffaloes (Network project CIRB, Hisar centre)	K.P. Singh, A. Bharadwaj, A. Boora, P. Kumar, S. Balahara, S. Khanna	July 1991-continuing
11.	Genetic Improvement of Murrah buffaloes (Network project CIRB, CIRB Sub- Campus Nabha	Sajjan Singh, K.P. Singh, K. L. Mehrara	April 1990- continuing
12.	XII Plan Scheme - National Agricultural Innovation Fund.	V.B. Dixit, S.K. Phulia, P. Sikka, A.K. Balhara	2008- continuing
13.	Genetic Improvement of Bhadawari buffaloes (Network project centre)	B.P. Kushwaha	2001-continuing
14.	Progeny testing of bulls under field conditions (FPT)	A. Bharadwaj,V.B. Dixit, H. Tripathi (wef November 2015)	2001- continuing

Awards and Recognition

- Ms. K. M. Kavya (M.V.Sc. Student) was presented 'Young Scientist Award' for the work by team Choudhary, K. K., Kavya, K. M., Jerome, A., Bharadwaj, A., Sharma, R. K. (2015). Resumption of post-partum cyclicity in relation to parity, body weight and body condition score in buffaloes under farm conditions in ISSAR Conference: Current Challenges and opportunities in Animal Reproduction (December, 3rd –December 5th, 2015), Bengaluru.
- Dr. Hema Tripathi received 'Best Oral Presentation Award' during session on 'Good Governance in private Extension' for paper 'promotion of buffalo husbandry through breeder's welfare association in Haryana: an innovative approach' authored by Dixit, V. B., Tripathi, H., Duhan, A., and Singh, I. at the International Conference on Good Governance in Agriculture Extension (2015) jointly organized by MANAGE and Centre of Good Governance at Hyderabad.
- Dr. Selokar, N.L. name was entered in Limca Book of Records-2015 for producing 'Poornima' cloned calf of high yielding buffalo at NDRI farm.
- Paul, S.S., Dey, A., Baro, D., Jerome A., Punia, B. S. were presented 'Best Paper Award' for the paper 'An analysis of comparative global diversity of bacteria in rumen of buffaloes and cattle' in the XVI Biennial Animal Nutrition conference on Innovative Approaches for Animal Feeding & Nutritional Research.(February 6th-8th ,2016) at Karnal, Haryana.
- Dr. Varij Nayan was presented 'Certificate of Appreciation' for the academic year 2014-15 at NDRI, Karnal in recognition of his outstanding research work in the field of Dairy Production. His Ph.D. thesis was selected from Animal Biochemistry division in Production category for Best Ph.D. thesis Award presentation competition on 01st March, 2016.
- Buragohain, L., Nanda, T., Kumar, R., Ghosh, M., Gupta, S. S., Singh, I., Balhara, A. K. were presented 'Best Paper Award' for the paper 'Expression profile of MX2 gene and protein for early pregnancy diagnosis in Murrah buffalo' in the Annual Convention of SVBBI (March 11th- 12th, 2016) at Bhubaneswar.

The 8th Asian Buffalo Congress was held in Instanbul, Turkey, during April 21st-25th, 2015, co-hosted by the Istanbul Provincial Buffalo Breeders' Union and the Asian Buffalo Association, amongst others. Dr. Inderjeet Singh, Director, ICAR-CIRB, participated in the Congress and presented a lead paper on 'India's rich and diverse buffalo germplasm for global buffalo development' during the opening plenary session. During the General Body meeting of the Asian Buffalo Association, Dr. Inderjeet Singh, Director ICAR-CIRB was elected President of the ABA and it was decided that the next Asian Buffalo Congress be hosted by India, preferably in Hisar. Keen interest was evinced by all delegated in India's buffalo germplasm.

Training and Capacity Building

Human Resource Development

Participation in trainings (Category-wise)

Category	Name & Designation	Training program / Topic	Date	Institute /Organization
Scientific staff	Dr. N. Selokar Scientist	Workshop on Basic Confocal Microscopy	27.12.2015-06.01.2016	IISc, Banglore
	Dr. D. Kumar Scientist	Genome informatics	13-14th July, 2015	Chandigarh
		Brain storming workshop on Transgenic Livestock	10.02.2016-20.02.2016	NIVEDI & DBT Bengaluru
	Dr. A. Boora Scientist	Entrepreneurship Development & Management	07.12.2015-11.12.2015	EDII - Ahmedabad
	Dr. M. K. Tripathi Scientist Dr. M.H. Jan Scientist	Molecular approaches for augmenting reproductive efficiency in Cattle	08.12.2015-21.12.2015	ICAR-CIRC Meerut
	Dr. K.P. Singh Principal Scientist	Workshop on Training needs assessment for HRD Nodal officers of ICAR	10.02.2016-12.02.2016	NAARM, Hyderabad
Administrative Staff	Sh. Raj kumar, AAO	Administrative Vigilance	14.09.2015-18.09.2015	ISTM, New Delhi
	Sh. Narendra Kumar, AAO	Procedure for Public Procurements	22.07.2015-27.07.2015	NIFM, Faridabad

Training organised by various categories of employees : NIL

HRD fund allocation and utilization:

Funds allocated: 1.0 Lakh

Funds utilized: 100%

Workshop on 'Complete Feed Blocks' (CFBs)

A workshop was organized by the ICAR-CIRB Hisar on 28.05.2015 on the topic of Complete Feed Blocks. During the workshop, topics pertaining to the technological advances in preparation of CFBs, use and importance of CFBs were discussed by scientists/experts from various ICAR Institutes and some other organization in the region. Further, draft specifications for roughage based feed blocks (large and small ruminants) were finalized for submission to the BIS.

Post Graduate Students Research

COMPLETED					
Students name	**Degree program**	**University**	**Year**	**Thesis title**	**Major Advisor/ co-advisor**
Mr. Mahaveer Chaudhary	Ph.D	LUVAS, Hisar	2012-2015	Genetic studies on production, fertility and longevity traits in Murrah and Nili-Ravi buffaloes	Dr. K.P. Singh
Dr. Jyoti Yadav	Ph.D	ICAR-IVRI, Izatnagar	2012-2015	Evaluating the effectiveness of livestock extension services among dairy farmers	Dr Hema Tripathi
Ms. Kaushalya Ghosh	Ph.D	CDLU Sirsa	2012-2016	Studies on stemness properties of cultured buffalo amniotic membrane cells	Dr. P.S. Yadav
Dr. Gyanender Singh Katiyar	M.V.Sc	ICAR-IVRI, Izatnagar	2014-2015	Effect of rumen protected fat and protein supplementation on reproductive performance and blood biochemical profile in post-partum buffaloes (Bubalusbubalis)	Dr. Inderjeet Singh
Dr. Rahul Rathore	M.V.Sc	ICAR-IVRI, Izatnagar	2014-2015	Field investigation of infertility and efficacy of GnRH based protocols for treatment of anestrus condition in buffaloes	Dr. R.K. Sharma
Dr. Praveen Kamboj	M.V.Sc	LUVAS, Hisar	2014-2015	Comparative studies on Ovsynch vs. double synch protocol for oestrus synchronization during summer and winter season in buffaloes	Dr. S.K. Phulia
CONTINUING					
Mr. Chander Mohan	Ph.D	IGNOU, New Delhi	2012- Contd.	Identification of active ingredients against gastro-intestinal parasites in indigenously known angiospermic plants	Dr. N. Saxena
Dr Balaraju,BL	Ph.D	ICAR-IVRI, Izatnagar	2014- Contd.	Role of indigenous cattle in livelihood security of resource poor farmers: an exploratory study in Karnataka	Dr Hema Tripathi
Dr. Papori Sharma	Ph.D.	LUVAS, Hisar	2014- Contd.	Studies on epigenetic characteristics of somatic cells in water buffaloes	Dr. P.S. Yadav
Dr. K. Ratika	Ph.D	ICAR-NDRI Karnal	2014- Contd.	Performance of transition buffaloes fed diet supplemented with rumen protected methionine, lysine and choline	Dr. S.S. Dahiya
Dr. Y. Mary	Ph.D.	ICAR-NDRI Karnal	2014- Contd.	Hyper ammonia producing bacteria from rumen of buffalo and evaluation of additives for their inhibition	Dr. S.S. Paul
Dr. Ranjeet Verma	M.V.Sc	ICAR-IVRI, Izatnagar	2015-2016	Age at first calving in Murrah buffaloes: genetic variations and subsequent reproductive performances	Dr. Inderjeet Singh
Dr. Kavya	M.V.Sc	ICAR-IVRI, Izatnagar	2015-2016	Fertility prediction and Metabolic hormones in relation to early resumption of cyclicity in postpartum Buffaloes.	Dr. R.K. Sharma
Dr. Ram Kumar Singh	M.V.Sc	ICAR-NDRI Karnal	2015-2016	Effect of some plant bioactive compound on methane production, growth and nutrient utilization on buffalo calves	Dr. B.S. Punia
Dr. Kamlesh Chaudhary	M.V.Sc	ICAR-NDRI Karnal	2015-2016	Heat detection efficiency and postpartum ovarian cyclicity in Murrah buffaloes	Dr. A. Bharadwaj
Dr. Mala Singh	M.V.Sc	ICAR-NDRI Karnal	2015-2016	Proteomic analysis of saliva during early growth in buffalo calves	Dr. A.K. Balhara
Dr. Ravindra Kumar	M.V.Sc	ICAR-NDRI Karnal	2015-2016	Effect of freezing rates on buffalo sperm during cryopreservation	Dr. Jerome A

Students name	Degree program	University	Year	Thesis title	Major Advisor/ co-advisor
Mr. Deepak Kumar	M Tech	ICAR-NDRI Karnal	2015-2016	Transposon- mediated reprogramming of buffalo fibroblasts to generate induced pluripotent stem cells	Dr. Dharmendra Kumar
Dr. Lokesh Kumar	M.V.Sc	LUVAS, Hisar	2015-2016	Evaluation of efficacy of different treatment protocol of estrus induction in buffaloes under field conditions	Dr. S.K. Phulia
Dr. Maninder Sheoran	M.V.Sc.	LUVAS, Hisar	2015-2016	Analysis of Hariana cow urine for presence of various proteins/peptides in comparison to Murrah buffaloes	Dr. Varij Nayan
Dr. Dheer Singh Swami	M.V.Sc	LUVAS, Hisar	2015-2016	Studies on buffalo (Bubalusbubalis) semen quality following supplementation of male specific mineral mixture in feed and semen additives in freezing extender	Dr. Pradeep Kumar

Trainings for Field Veterinarians on Ultrasonography in large Animal reproduction for Fertility Augmentation

S.N.	Date & Duration	Number	States covered	Co-ordinators
1.	22-27 June, 2015 (06 days)	6	Haryana, Rajasthan and Uttar Pradesh	R.K. Sharma, S.K. Phulia and A. K. Balhara
2.	13-18 July, 2015 (06 days)	9	Haryana, Rajasthan, Uttar Pradesh W.Bengal, Gujarat, Karnataka & Chandigarh	R.K. Sharma, S.K. Phulia and A. Jerome
3.	15-22 February, 2016 (08 days)	28	Haryana, Rajasthan, Uttar Pradesh Madhya Pradesh, Kerala, Nagaland, Delhi and Punjab, Karnataka, Manipur and Assam.	R.K. Sharma,S.K. Phulia, A. Jerome and S. Khanna
4.	4-7 August, 2015 (04 days)	15	Uttar Pradesh	R.K. Sharma, S.K. Phulia and EM Sadeesh
5.	1-4 Sept., 2015 (04 days)	11	Uttar Pradesh	R.K. Sharma, P.S. Yadav, S. Khanna
6.	3-6 Nov., 2015 (04 days)	12	Uttar Pradesh	R.K. Sharma, D. Kumar and P. Kumar
7.	8-11 March, 2016 (04 days)	17	Uttar Pradesh	R.K. Sharma, Varij Nayan, N.L. Selokar
8.	14-17 March, 2016 (04 days)	16	Uttar Pradesh	R.K. Sharma, Mustafa H. Jan, R. Kumar

Participation of scientists in conferences, meetings, workshops and symposia etc.

- N.L. Selokar participated in the International conference on low temperature science and biotechnological advances on 30th April, 2015 at NASC, New Delhi.
- B.S. Punia, S.S. Dahiya, P.C. Lailer, N. Saxena, S.S. Paul, A. Dey and V. Mudgal participated in the Workshop on complete feed blocks on 28th May, 2015 at ICAR-CIRB, Hisar.
- H. Tripathi participated in the International conference on good governance in Agriculture Extension on 3-4th September, 2015 at Centre of Good Governance, Hyderabad.
- B.S. Punia, P. Sikka, A. Bharadwaj, A.K. Pandey, K.P. Singh and A. Boora participated in the XIII Annual review meet of Network project on improvement of buffaloes during 23-24thSeptember, 2015 at ICAR-CIRB, Hisar.
- A. Bharadwaj participated in the Workshop of vigilance officers on preventive vigilance as a tool of good governance on 28th October, 2015 at NASC, New Delhi.
- V. Mudgal participated in the Third national conference of Indian academy of veterinary nutrition and animal health during November 4-5th, 2015 at CSKHPKV, Palampur, Himachal Pradesh.
- P.S. Yadav participated in the DBT task force meeting on animal biotechnology during 16-17th November, 2015 at CGO Complex, Delhi
- A. Dey participated in the National conference on Bio resources management for sustenance of ecosystem and livelihood during 26-29th November, 2015 at UBKV, Pundibari, West Bengal.
- A. Jerome participated in the ISSAR conference on research and innovations to improve animal fertility and fecundity during 3-5th December, 2015 at Bengaluru.
- P.S. Yadav, V. Nayan, D. Kumar and N.L. Selokar participated in the XXII Annual convention and national symposium on immunomics and proteogenomics in livestock health & productivity during 17-19th December, 2015 at ICAR-NRC on Equines, Hisar.
- V.B. Dixit participated in the National dialogue on innovative extension systems for farmers' empowerment and welfare during 17-19th December, 2015 at New Delhi.
- P.S. Yadav participated in the XXIV annual conference of society Animal physiologists of India during 21-22nd January, 2016 at CVSC, Khanapara, Guwahati, Assam.
- H. Tripathi participated in the International extension education conference on extension, education and services during 27-30th January 2016 at BHU, Varanasi.
- A. Dey participated in the International livestock conference indigenous & 23rd annual convention of Indian society of animal production & management during 28-31st January, 2016 at PJTSAU, Hyderabad.
- B.S. Punia, S.S. Dahiya, N. Saxena, S.S. Paul, A. Dey, V. Mudgal participated in the XVI Biennial animal nutrition conference during 6-8th February, 2016 at ICAR-NDRI, Karnal.
- A. Bharadwaj participated in the International trade fair for dairy farming, processing, packaging, distribution & products on 18th February, 2016 at ICAR-NDRI, Karnal
- H. Tripathi participated in the ILRI-ICAR Workshop on communication and knowledge management in animal science research and development on 4th March, 2016 at NASC, New Delhi.
- P.S. Yadav participated in the Brain storming session on reproductive biotechnologies during 21-22nd March, 2016 at CVSC, Khanapara, Guwahati, Assam.

Meetings of Various Committees

Institute Management Committee (IMC) Meeting

The XXIV meeting of the Institute Management Committee (IMC) was held at CIRB, Hisar on 1st August, 2015 under Chairmanship Director of *i*nstitute, Dr. Inderjeet Singh. Progress made by the Institute in research and extension activities particularly for conducting infrastructure development, herd performance, agricultural farm report, trainings for farmers and overall management including administration and accounts was highlighted. The projects being undertaken at the institute were also briefed. Institute Management Committee approved the agenda items.

Quinquennial Review Team (QRT) Meeting

QRT meeting was held on Feb 18-19th 2016 at CIRB, Hisar. Dr. K.M. Bujarbaruah, VC, AAU and former DDG(AS) was the chairman and the members include Dr. C.S. Prasad, former VC, Maharastra Animal and Fishery Science University, Nagpur and former Director, NIANP; Dr. J.S. Bhatia, former ADG(Edu); Dr. B.K. Joshi, former Director, NBAGR; Dr. S.V.N. Rao, Retd. Prof. and Head, Extension Dept., Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry. Dr. S.S. Paul, Principal Scientist served as Member-Secretary. During the meeting, presentations were made by Dr. Inderjeet Singh (Director, CIRB) about institute acivities. The section incharges and HODs also briefed about 5 years achievements.

Research Advisory Committee (RAC) Meeting

The XVIII RAC meeting was held on April 29th-30th, 2016 in the committee room of CIRB under the chairmanship of Dr UK Mishra, Vice Chancellor, Chhattishgarh Kamdhenu Vishwavidyalaya, Durg. On 29th April, all the members observed the activities of animal farm, agriculture farm, modern animal shed and various laboratories of the institute. The members had discussion with the individual scientists who apprised them about the projects, facilities and research achievements in respective divisions/laboratories.

On 30th April, 2016, the meeting started with a welcome address by Dr Inderjeet Singh, Director, CIRB. He welcomed the Chairman and other members of RAC including Dr BS Prakash, ADG (AN&P) as well as the special invitees to the meeting. Chairman in his opening remarks described buffalo, a black diamond which produces healthier milk containing A2 casein and is backbone of farmers' economy. He congratulated the scientists team associated with the birth of 1st cloned calf 'Hisar Gaurav' at CIRB and also lauded the high conception rate of inseminators trained at CIRB. He also appreciated the efforts put in to improve institute's landscaping, agriculture farm, animal farm and other infrastructure and shown satisfaction for the overall development of the institute as well as its projection at National

level. Dr BS Prakash was of the view that this institute must strive hard to build on the platform provided by birth of a cloned calf on research front and projection of institute in the Krishi Unnati Mela 2016 on extension front. A farmers' hostel and a vehicle are essentially needed to cater the needs of the extension activities such as Mera Gaon Mera Gaurav programme, training, field visits etc.

The action taken report on the recommendations of the XVIII RAC was presented by Dr SS Dahiya, Member Secretary which was approved after discussion followed by presentations by Heads / In-charges on research activities and achievements of respective division/ section. Shri.Ved Pal, a representative of farmers on RAC while endorsing the views of the Chairman, showed satisfaction for the work and research being undertaken at CIRB and hoped that the farmers will surely be benefited by this. After thorough discussion RAC made recommendations and made some general suggestions for improving the management of herd and improvement in the on-going research projects. Recommendations of RAC were approved by the Council and are being addressed by the Institute through its research agenda.

Annual Review Meet of the Network Project on Buffalo Improvement (NPBI)

XIII Annual Review Meet of the Network Project on Buffalo Improvement (NPBI) was conducted on 23rd-24th September 2015 under the Chairmanship of Dr. RS Gandhi ADG (AB&P) ICAR in the presence of Dr. Inderjeet Singh, Director-cum - Project Coordinator (NPBI) and Dr. Vineet Bhasin, Principal Scientist (AG&B) ICAR. Dr. Arjava Sharma, Director (NBAGR), also attended the inaugural session. All the PI s of network centres participated in the review meet. Dr. Inderjeet Singh presented brief progress report of different participating centres of the Network Project with comparative performance over the previous three years. Strengths, improvements and achievements vis-à-vis targets for various breeds / centres

were highlighted. Project coordinators also presented their report. Action Taken Report on the recommendations of the XII annual review Meet held at LRS, Vallabhnagar was presented by Dr. AK Pandey, Principal Scientist and Incharge NWP (BI). It was accepted with satisfaction. The progress of each centre was discussed in view of the presentations made by respective PIs. Appropriate decisions were taken for effective implementation of the project.

Institute Research Council (IRC) Meeting

XXXI IRC was held at ICAR-CIRB from 4-7th November 2015. The meeting was attended by the scientists of the main and sub-campus and chaired by the Director. Progress of research projects were presented by respected Principal Investigators and new projects were finally approved in this meeting. A total of 33 projects were discussed that included new proposals, on going, external funded and completed projects.

Institute Animal Ethics Committee (IAEC) Meeting

Two meetings of IAEC were conducted on 12/06/15 and 17/08/15. Nine projects submitted for clearance were approved by IAEC. Inspection of animal house facilities was also done by nominee of CPCSEA on 30/03/2016 and the report was submitted to Member Secretary CPCSEA, New Delhi.

Important Events

ISO 9001:2008

The Annual Surveillance Assessment was successfully conducted by M/s BSCIC on 26th September, 2015 at ICAR-CIRB facility and based on surveillance report (CIRB/SA/09/15) as submitted by the Lead Auditor, ICAR-CIRB has been again recommended for continuation of ISO 9001:2008 for the scope of "Improved Buffalo Germplasm Production".

Vigilance Awareness Week

The institute observed Vigilance Awareness Week from 26-31st October, 2015. Essay-writing competition on the topic 'Preventive Vigilance - A Tool of Good Governance' in English and "Poorn Satarkta – Sushasan ka ek Upkaran" in Hindi was conducted on 30/10/2015 amongst the employees of the institute. Different posters related to anti-corruption were also displayed at prime location in the office. The Vigilance officer of the Institute attended a review meeting of vigilance officers of ICAR Institutes on 06/07/2015 and workshop of vigilance officers on 'Preventive Vigilance as a Tool of Good Governance', organized by the council on the occasion of observing Vigilance Awareness Week on 28/10/2015 at NASC, PUSA New Delhi.

Rashtriya Ekta Diwas (National Unity Day) celebration

Rashtriya Ekta Diwas was celebrated on 31st October, 2015 at CIRB to commemorate the birth anniversary of Sardar Vallabh Bhai Patel who played a pivotal role in the country after independence. Scientists and staff of the Institute paid rich tributes to the patriot, Sardar Vallabh Bhai Patel, on his birth anniversary by remembering his extraordinary works for the country. The pledge was administered by Director, Dr Inderjeet Singh.

Swachh Bharat Mission

The scientists, technical, administrative and supporting staff of CIRB, Hisar and sub-campus, Nabha whole heartedly undertook 'Swachh Bharat Mission' program with high spirit as a weekly activity. During the period, 104 hours were spent in 22 different activities at main campus carried out to clean Institute and residential premises, labs, offices, weeding out of old records, animal shed, feed stores. Renovation/ construction was also done for dung collection tank, parking shed, roads, paddocks etc. Main boundary wall, kerb stones and other structures were also repainted.

Independence Day Celebration

Sixty eighth Independence Day was celebrated on15th August 2015 with great zeal and enthusiasm. Dr. Inderjeet Singh,

Director, ICAR-CIRB, unfurled the National Flag. The event was witnessed by scientists, staff and their family members, who also participated in the singing of patriotic songs and poem recitation. Director addressed the gathering and cited the sacrifices of the Martyrs for making the country independent and emphasized on the sincerity, devotion, honesty and integrity to serve the institute and the nation to realize the dreams of our martyrs.

Republic Day Celebration

With great patriotic enthusiasm, ICAR-CIRB, Hisar celebrated the Republic Day of India on 26th January 2016 which marked the 67th anniversary of the adoption of the Constitution of India. The event commenced with the flag hoisting by Dr. Inderjeet Singh, Director, ICAR-CIRB followed by the National Anthem sung by one and all. The staff and children delivered speeches in Hindi and English. The Director CIRB greeted the scientists, technical, administrative staff and their family with his motivational address and laid emphasis upon the role of every staff in the progress of the institute and country. Later on sweets were distributed amongst the staff and their families.

हिन्दी सप्ताह का आयोजन

हिन्दी सप्ताह का आयोजन संस्थान में 14 से 21 सितम्बर तक किया गया। इस अवसर पर अनेक कार्यक्रम आयोजित किए गए। हिन्दी की निबन्ध प्रतियोगिता संस्थान के कर्मचारियों के बच्चों के लिए तथा संस्थान एवं अन्य केन्द्रों के कर्मचारियों के लिए परिच्छेद अनुवाद (अंग्रेजी से हिंदी), हिन्दी (शब्दानुवाद अंग्रेजी से हिन्दी), हिंदी निबंध प्रतियोगिता एवं हिंदी टंकण प्रतियोगिताओं का आयोजन किया गया। हिंदी सप्ताह में संस्थान के अलावा हिसार स्थित अन्य संस्थानों के कर्मचारियों ने भी भाग लिया। कर्मचारियों के अतिरिक्त स्कूल में पढ़ने वाले बच्चों ने भी विभिन्न प्रतियोगिताओं में बढ़चढ़कर हिस्सा लिया व आयोजन को सफल बनाया। हिंदी सप्ताह का समापन समारोह दिनांक 21 सितम्बर को आयोजित किया गया जिसमें नजदीकी संस्थान राष्ट्रीय अश्व अनुसन्धान संस्थान के निदेशक डॉ. भूपेन्द्र नाथ त्रिपाठी की गौरवमयी उपस्थिति में पुरस्कार वितरण किया गया। समापन समारोह के दौरान वाद–विवाद प्रतियोगिता का भी आयोजन किया गया।

Distinguished Visitors at CIRB, Hisar and Nabha

- Dr. RS Paroda, Ex Secretary (DARE) & Director General (ICAR) , Chairman, Trust for Advancement of Agricultural Sciences, New Delhi
- Dr. H. Rahman, Deputy Director General (Animal Science) , ICAR Hqr. New Delhi
- Dr. A.K. Srivastava, Director cum Vice Chancellor, ICAR-NDRI, Karnal
- Dr. Jeet Singh Sandhu, Deputy Director General (Crop Science) ICAR Hqr. New Delhi
- Prof. K.M.L. Pathak, Deputy Director General (Animal Science) , ICAR Hqr. New Delhi
- Maj Gen Shri Kant, SM, VSM (Retd), Vice-Chancellor, LUVAS, Hisar
- Shri Mandeep Singh Sandhu, IAS, Additional Chief Secretary, Animal Husbandry and Dairy Development, Government of Punjab CEO,PLDB, Chandigarh
- Prof. P.K. Uppal, Advisor, Animal Husbandry Fisheries & Dairy Department, Government of Punjab
- Dr. R.K. Singh, Director cum Vice Chancellor, ICAR- Indian Veterinary Research Institute, Izatnagar
- Dr Rameshwar Singh, Project Director (DKMA), ICAR Hqr. New Delhi
- Dr. K.M. Bujurbaruah, Vice-Chancellor, Assam Agricultural University, Jorhat - Assam
- Dr. K. Pradhan, Ex-Vice Chancellor, Odisha University of Agriculture and Technology, Bhubneswar, Odisha
- Dr. R.S. Dalal, Member Secretary, Haryana Kisaan Ayog
- Dr Harinderjit Singh Sandha, Director Animal Husbandry, Punjab, CEO,PLDB, Chandigarh
- Dr Arjava Sharma, Director, ICAR-NBAGR, Karnal
- Dr B.N. Tripathi, Director, ICAR-NRCE, Hisar
- Dr. S.K. Agarwal, Director, ICAR-CIRG, Makhdoom
- Dr. Alok Sharma, Prof & Head, HPKV, Palampur
- Dr S.N.S. Randhawa, Director of Research, GADVASULudhiana
- Prof (Dr.) Rakesh Rao, Director of Research and Registrar, RAJUVAS, Bikaner, Rajasthan
- Prof (Dr) Md. Omar Faruque, Professor, Bangladesh Agricultural University, Dhaka
- Brig. Sandeep Singh Kashyap, Commandant, Equine Breeding Stud, Hisar
- Ms. Sonali Singh Phogat, National Executive Member of Mahila Morcha, BJP
- Sh. Jaswant Singh Bisnoi, Chairman, Central Wool Development Board, Jodhpur, Ministry of Textiles, GOI
- Dr. R.S. Gandhi, ADG (AP& B), ICAR Hqr. New Delhi
- Dr. Vineet Bhasin, Pr. Scientist (AGB), ICAR HQ, New Delhi
- A 40 member delegation of Extension functionaries from Kenya, Liberia and Malawi
- Officers from RVC Centre and College, Meerut Cantt.
- A team from PCC, Phillipines (Annabelle S. Sarabia, Nova A. Ramos, Franklin T. Rellin, Eric P. Palacpac, Edwin C. Adaba, Ester Plores, Jerome M. Balaoirg)

Infrastructure Development

Agriculture Farm

Fodder and grain production: During the year, Agriculture farm at main campus, Hisar produced 39485.60 qtls of green fodder, 667.15 qtls of straw and 995.35 qtls of grain. At sub-campus Nabha, 52943 qtls green fodder and 3487 quintal dry fodder (turi/karbi) were produced. Total 6203 qtls grain/ seed were produced that included 2126 qtls wheat, 2048 qtls barley, 1890.15 qtls paddy grain 128 qtls oat, 9.5 qtls mustard grain and 1.5 qtls berseem seed.

Land improvement: At main campus, fifteen acres of saline soil was reclaimed by growing paddy and barley crops. In this area, crops were taken for the first time since inception of the institute. Due to encouraging result, it is proposed to grow paddy in another 30 acres of saline soil during next year. About 75 acres of farm land was levelled with laser leveller. Last year bushes were uprooted from 170 acres of land that was lying unused. During the year about 60 acres of this land, roads, channel and blocks were made. At sub-campus Nabha, 16 acre land was improved by removing dried trees and shrubs, 33 acre Dhaincha were sown for green manuring that improved the physical property of land, 40 acre land was improved by spreading of farm yard manure/compost, 1300 feet chain link fences were created to protect about 40 acre land from stray animals. 72 acre and 3 marla land was transferred to Animal husbandry department, Punjab.

Farm Machinery and Workshop: Two fodder harvester cum choppers (a labour saving equipment) for automation of the farm operation of fodder harvesting, chopping and trolley loading were purchased both at main and sub-campus for automation of farm operation costing approximately Rs. 19.60 lakh. At sub-centre Nabha, one 4x4 tractor was also purchased.

Animal Farm

The institute is maintaining a Murrah herd of about 500 buffaloes out of which 229 were breedable buffaloes. The overall wet average of 8.04 kg/day was achieved and 152 calves of high genetic merit were born during the period. Besides, more than 3 lakh kg of milk and 74 breeding bulls were also sold by the institute. The reproductive traits *viz.* service period (138 days), calving interval (449 days) and dry period (141 days) were lowest in last ten years. Modern layout open paddocks with bio-security boundary wall wallowing pond is nearly completion, besides providing comfortable housing and management for animals, it also allows labour saving feeding arrangement.

Modern Animal Shed: The construction of modern animal shed for 200 buffaloes with automatic feeding, cleaning, milking and data recording system were taken up by the institute. The civil work was completed and dung scrappers were installed. The commissioning of biogas plant and 2x6 stationary herringbone milking parlour integrated with animal

identification activity metering system & herd management software is in progress.

Feed Unit

Feed unit prepared concentrate feed for feeding to farm animals by formulating feed for different categories of animals. Feed unit prepared about 600 tonnes of concentrate feed for feeding to farm animals using grinder and mixer. Also approx. 15 tonnes of area specific mineral mixture is being prepared annually for farm animals as well as for sale to the farmers for its popularization. Feed processing unit and store covers an area of about 4500 square feet for feed storage with an open drying place of about 1500 sq. ft. with automatic feed grinder cum mixer of capacity (10 Q/hr) with lifts for grinding and mixing of concentrate mixture.

Agriculture Knowledge Management Unit (AKMU)

Institute AKMU provides internet and e-mail connectivity to all the scientists/officers. It also looks after the work related to installation and maintenance of computers, peripherals, network equipments etc. Maintenance and updation of institute website, biometric system, CCTVs, EPABX, Cyberaom were the other activities carried out by this unit. Computer and internet facilities are also given 24 hours to student. ICAR-FMS-IMS has been fully functional at Institute. Personal information of the Institute employees is also regularly updated at permisnet of ICAR. Institute also has free helpline services for farmers (18001801443) during office hours.

Library

The institute library is subscribing selected foreign journals including Journal of Dairy Science and Journal of Animal Sciences and number of national journals of repute. In addition to this, about 1100 books are available on various disciplines *viz.* livestock production, nutrition, physiology, genetics, breeding, biotechnology, analytical techniques etc. Good collection of journals for the past 30 years as bound volumes are also available to the scientists and students. The library subscribes seven newspapers, two periodicals and magazines to keep the staff of the institute updated about the surroundings. The photocopying facility is also available in the library. The library is being visited by scientific, technical, administrative and supporting staff along with students, research fellows, young professionals and the contractual workers on a regular basis. CIRB library is member of consortium for e-resources in Agriculture (CeRA). Under CeRA, the institute gets access to full text online journals, which is available to the researchers 24x7.

Estate and Electrical Section

Electrical section of the institute is responsible for providing round the clock electric supply to the laboratories of institute. It maintains 11 KV sub-station comprising of 500 KVA transformer, OCB, ACB, LT panels and two DG sets of 250 and 110 Kva capacities for emergency power backup. The section attends to all day to day electric maintenance related complaints of different labs, guest house and residential units. Repair, servicing and maintenance of more than 70 air

conditioners, geysers, electric motors upto 25hp, street lights, different size underground LT cables and HT and LT overhead lines of the agriculture farm of the institute are part of the day to day activity. It also operates and maintains audio visual equipments of the seminar hall like, power amplifiers, audio mixer, dbx- complete sound management system and LCD projectors.

Landscape: This section looks after greens at the campus including gardens, roadside maintenance and colony parks. Tree plantation, pruning of trees, removal of fallen dry trees, removal of horticulture wastes, plantation/landscaping at campus, creation & maintenance of nurseries of saplings of

trees, shrubs & seed beds of ground covers & seasonal flowers are the responsibilities of this section .

Guest house

Institute guest house has fourteen well furnished rooms for accommodating 28 guests at a time. It has separate reception with attached well furnished lounge and dining hall to cater to the requirements of visitors as well as get together for institute fraternity. During the period, Rs 1,97,035 revenue has been generated by hosting 827 guests.

Semen Freezing Lab

Semen freezing laboratory is an important constituent of the institute and is equipped with ultramodern facilities like CASA, fluorescent and DIC microscope, and biofreezer for cryopreservation of Murrah buffalo bull's semen. Production and maintenance of quality of frozen semen and its dissemination is primary aim of this lab. The lab is engaged with semen collection, evaluation, dilution, equilibration, cryopreservation, maintenance and distribution of frozen semen from genetically superior Murrah bulls. Frozen semen is provided at a nominal price to the developmental agencies, farmers and inseminators engaged in buffalo improvement programme in the country.

The lab has a stock of more than three lakh doses of frozen semen from about 180 breeding bulls out of which more than fifty thousand doses are of progeny tested bulls. Frozen semen doses prepared from farmers' prize winning superior bulls are also available with the institute and these are distributed to the inseminators for buffalo improvement programme.

Central Laboratory

A central laboratory facility was developed at ICAR-CIRB after merging of laboratories from Animal Physiology and Reproduction (APR) & Animal Nutrition & Feed Technology (ANFT) divisions that provides optimum conditions for scientific or technological research, experiments, and measurement. The CLF facilitates interdisciplinary research by supporting the re-use and accessibility of hardware and software, developing and maintaining research platforms, improving methods and tools for measuring interaction, and making research results sustainable. Central laboratory facility is open to every eligible person, scientists and students. In this laboratory, all the necessary facilities are available related to biochemistry, proteomics, genomics and other '-omics' research. Available instruments include picodrop, gel documntation system, thermal cycler (PCR), gel electrophoresis systems, IEF system for 2DGE, ELISA Reader, refrigerated centrifuge, laminar flow, shaking incubator, TFF system, freezers and analysis softwares etc. It is suitable for experiments being performed in a single bench system. The central laboratory at ICAR-CIRB is committed for providing operational excellence in the researchable areas concerning buffalo, the 'black gold' and our farmers.

Sectoral News

Buffalo milk composition and commercial viability

Buffalo milk has 58% more calcium, 40% more protein but 43% less cholesterol than cow milk. In addition, buffalo milk is also richer source of phosphorus, vitamin A, protein and contains high levels of the natural antioxidant. For those people who suffer from cow milk allergy, buffalo milk is an alternate. The presence of higher levels of various bioprotective factors, such as immunoglobulins, lactoferrin, lisozyme, lactoperoxidase as well as bifidogenic factors, render buffalo milk more suitable than cow milk for the preparation of a wide range of special dietary and health foods. There is practically no difference in the nutritive value and digestibility of milk and milk products obtained from cow and buffalo milk. Animal bioassays have shown the Protein Efficiency Ratio (PER) value of buffalo milk proteins to be 2.74 and that of cow milk as 2.49. It has be seen that buffalo milk has about 11.42 per cent higher protein than the cow milk. Buffalo milk is also superior to cow milk in terms of important minerals, *viz.* calcium, iron and phosphorus which are higher by 92 per cent, 37.7 per cent and 118 per cent respectively than those present in cow milk. Buffalo metabolizes all the carotene into vitamin A, which is passed on to milk as such.

Buffalo milk is commercially more viable than cow milk for the manufacture of fat-based and SNF-based milk products, such as butter, ghee and milk powders because of its lower water content and higher fat content. Lower cholesterol should make it more popular in the health conscious market. By the virtue of greater opacity of casein miscelles, coupled with higher levels of colloidal proteins, calcium and phosphorus, buffalo milk is more densely white and has superior whitening properties as compared to cow milk. Buffalo milk is, therefore, more aptly suitable for the production of tea and coffee whiteners than cow milk. Higher innate levels of proteins and fat render buffalo milk a more economical alternative to cow milk for the production of casein, caseinates, whey protein concentrates and a wide range of the fat-rich dairy products.

Proteins of buffalo milk, particularly whey proteins, is more resistant to heat denaturation as compared to the cow milk proteins. Dried milk prepared from buffalo milk exhibit higher levels of un-denatured proteins when processed under similar conditions.

All Buffaloes Produce A2 casein milk

β-Casein is one of the major proteins in milk of cows, buffaloes and other mammals. Research studies have shown that there are different variants of β -casein in milk evolved over hundreds of years due to mutation and selective breeding for high milk and protein yields. There are 15 known variants of β -casein out of which A1 and A2 are major. β-casein-A1 (alleged bad casein) differs from A2-casein only by one amino acid at position 67 (proline in A2 and histidine in A1). This substitution increased susceptibility of A1 β-casein to hydrolysis by digestive enzymes to produce physiologically active β-casomprohin (BCM), a decapetide. The A1- A2 milk controversy is that one group of scientists claim that active β-casomprohin (BCM), a decapetide produced from hydrolysis of A1 β-casein - a milk protein may cause many health problems in human whereas other groups report beneficial effects of BCM and declare both types of milk safe for children and adults. National Bureau of Animal Genetic Resources (NBAGR), Karnal, has been active in surveying the A1/A2 situation in India since 2009. Their first report confirmed that A2 gene frequency in Indian breeds of cattle is around 98 % (almost 100 % in major milch breeds), whereas all the buffalo breeds studied were found to be of A2A2 type. Studies published in 2012 also clarified that even in crossbred cow population, the predominant gene is A2. NBAGR has therefore rightly concluded that the situation in India demanded vigilance on breeding program but there is no immediate need to change breeding strategy. In April 2015, Indian Council of Agricultural Research, New Delhi has approved a study involving Punjab University, NDRI and NBAGR to investigate and gather evidence about health safety of milk from Indian crossbred cows.

Better Cheese: Cheese made from buffalo milk displays typical body and textural characteristics. More specifically, where chewing and stringing properties are specially desired as in the case of Mozzarella cheese, buffalo milk is technologically preferable over cow milk. In Italy, recently legislation has been introduced to restrict the use of term "Mozzarella" only to products made exclusively from buffalo milk (without admixture with cow milk). Certain traditional cheese varieties, such as paneer in India or pickled cheeses from the Middle-East countries, are best made from buffalo milk.

Gender Mainstreaming and Women Empowerment

There is no tool for development more effective other than women empowerment -Kofi Annan

Dairying has been considered as a potential means of alleviating large scale unemployment, especially in rural areas. In most communities, women are responsible for the day to day care and management of animals. Their participation is rapidly increasing because of multiple factors but the prime reason is out-migration (temporary or permanent) of male members of the family in search of alternative avenues for income, thus leaving the women of the household to be fully involved in these activities. Despite this fact, women's contribution remains mostly invisible.

Efforts of ICAR-CIRB: The services delivered by CIRB aim to assist farmers and farm women through an educational process to improve dairy farming methods and techniques, strengthen the infrastructure and services to increase production efficiency and income, enabling them to enhance their quality of life. Here extension services are delivered through various methods including participatory group approaches, mass media, buffalo mela, calf rallies, on and off campus trainings, demonstration units/plots and promotion of improved buffalo farming using ICT tools. During the period under report, 550 rural women were covered under various capacity building and sensitization programs in villages on buffalo farming. Apart from these, approximately 300 rural girls benefitted during various programs held in their schools. More than 100 women were trained as part of the training programs at campus. Under Mera Gaon and Mera Gaurav scheme, awareness was created among the women farmers on health, hygiene, sanitation and nutritional aspects besides the improved buffalo farming. Opportunies were provided to discuss their farm and household problems during women scientists interaction programs. Literature was also distributed on vaccination schedule of animals, clean milk production, colostrum feeding, advantages of artificial insemination in animals etc. Eight demonstrations were also made for women farmers on silage making and preparation of mineral mixture. For economic empowerment of women of Rajasthan, six buffaloes were given to six women of BPL category under tribal development sub plan.

CIRB Personnel (as on 31.03.2016)

General Administration

Dr. Inderjeet Singh	**Director**
Sh. Chetan S. Issar	Administrative Officer
Sh. Mahesh Kumar	Finance & Accounts Officer
Sh. Raj Kumar	Assistant Administrative Officer
Sh. Joginder Singh	Private Secretary
Sh. I.S. Kundu	Assistant Administrative Officer
Sh. Viksit Kumar	Assistant
Sh. Rajesh Kumar	Assistant
Sh. Girdhari Lal	Assistant
Sh. Abdul Mazid	Assistant
Sh. Ashok Kumar	UDC
Smt. Indira Devi	UDC
Sh. Satbir Singh	UDC
Sh. Dharam Pal	LDC
Sh. Sunil Kumar	LDC
Sh. Mahabir Singh	LDC

Animal Genetics & Breeding Division

Dr. (Mrs.) P. Sikka	**Principal Scientist & Head**
Dr. A. Bharadwaj	Principal Scientist
Dr. A.K.Pandey	Principal Scientist
Dr. K.P. Singh	Principal Scientist
Dr. S.N. Kala	Senior Scientist
Dr. A. Kumar	Scientist
Mrs. S. Balhara	Scientist (On study leave)
Sh. A.K.S. Tomar	ACTO

Animal Nutrition & Feed Technology Division

Dr. B.S. Punia	**Principal Scientist & Head**
Dr. S.S. Dahiya	Principal Scientist
Dr. P.C. Lailer	Principal Scientist
Dr. N. Saxena	Principal Scientist
Dr. S.S. Paul	Principal Scientist
Dr. A. Dey	Senior Scientist
Dr. V. Mudgal	Senior Scientist
Dr. M.L. Sharma	ACTO
Sh. K. Kumar	Senior Technical Officer

Animal Physiology & Reproduction Division

Dr. P.S. Yadav	**Principal Scientist & Head**
Dr. R.K. Sharma	Principal Scientist
Dr. S. Singh	Principal Scientist
Dr. S.K. Phulia	Principal Scientist
Dr. V. Nayan	Scientist
Dr. A.K. Balhara	Scientist
Dr. D. Kumar	Scientist
Dr. J. Andonisammy	Scientist
Dr. P. Kumar	Scientist
Dr. Sadeesh E.M.	Scientist (on PDF)
Dr. N. Selokar	Scientist
Dr. R.S. Pippal	STO
Sh. J. Singh	Technician

Transfer of Technology and Entrepreneurship Unit

Dr. S.S. Dahiya	**Principal Scientist & Incharge**
Dr. V.B. Dixit	Principal Scientist
Dr. H. Tripathi	Principal Scientist
Sh. G.D. Tiwari	Technician

Network Project on Buffalo Improvement

Dr. I. Singh	**Project Coordinator**
Dr. A.K. Pandey	Principal Scientist & Incharge
Dr. B.P. Kushwaha	Principal Scientist (Posted at IGFRI, Jhansi)
Dr. S. Yadav	Scientist (On study leave)
Sh. R. Chander	Technical Officer

Prioritizing Monitoring & Evaluation (PME) Cell

Dr. S.S. Paul	Principal Scientist
Dr. A.K. Balhara	Scientist Scientist
Dr. D. Kumar	
Sh. Raj Kumar	STO

Agriculture Knowledge Management Unit (AKMU)

Dr. H. Tripathi	Principal Scientist & Incharge (w.e.f. 15.02.2016)
Mrs. S. Balhara	Scientist & Incharge (upto 14.02.2016) (On study leave)
Sh. Raj Kumar	STO

Results Framework Documents (RFD) Cell

Dr. D. Kumar	Scientist
Sh. R. Chander	TO

ISO Management Committee

Dr. I. Singh	Chairman
Dr. A. Bhardwaj	Management Representative
Dr. V. Nayan	Secretary

PRO

Dr. A.K. Balhara	Scientist
Sh. Raj Kumar	STO

CPIO/APIO

Dr. R.K. Sharma	Principal Scientist & CPIO
Sh. Raj Kumar	AAO & APIO

Library

Dr. N. Saxena	Principal Scientist & Incharge
Sh. K. Kumar	STO

Rajbhasha Anubhaag

Dr. V. Mudgal	Senior Scientist & Incharge LDC
Sh. S. Kumar	

Vigilance Officer

Dr. A. Bharadwaj	Principal Scientist

Agricultural Farm Section

Dr. P.C. Lailer	Principal Scientist & Overall Incharge
Sh. S. S. Malik	ACTO & Incharge
Sh. S. Kumar	Technician

Animal Farm Section

Dr. A. Bharadwaj	Principal Scientist & Overall Incharge
Dr. S. Khanna	CTO & Incharge
Dr. S. Kakkar	Chief Technical Officer
Sh. S. Chander	Technical Officer
Dr. R. Kumar	Technical Assistant

Workshop Section

Dr. P.C. Lailer	Principal Scientist & Overall Incharge
Dr. S. Singh	STO & Incharge
Sh. B. Raj	Sr. Technical Assistant
Sh. S. Lal	Sr. Technical Assistant
Sh. K. Singh	Sr. Technical Assistant
Sh. Satpal	Sr. Technical Assistant
Sh. Ram Kumar	Technical Assistant

Estate and Electrical Section

Dr. S.K. Phulia	Principal Scientist & Overall Incharge
Sh. B. P. Singh	ACTO & I/C Estate
Sh. R. Parkash	ACTO & I/C Electrical

Sh. S. Kumar	STO
Sh. G. Singh	Technical Officer

Internal Security

Sh. B.P. Singh	ACTO & Incharge
Sh. S. Kumar	STO

Landscape Section

Sh. A.K.S. Tomer	ACTO & Incharge

Guest House

Sh. Raj Kumar	STO & Incharge

CIRB Sub-Campus, Nabha

Scientists

Dr. G. Singh	Principal Scientist & Officer Incharge (on leave)
Dr. S. Singh	Principal Scientist & Officer Incharge (Addl. charge)
Dr. M. K. Tripathi	Scientist
Dr. M. H. Jan	Scientist

Technical

Dr K.L. Mehrara	CTO
Sh. V. Singh	CTO (On deputation to Govt of India)
Sh. J. Prashad	CTO
Sh. R. Mehta	ACTO
Dr. T.P. Singh	ACTO
Dr. A. Saini	STO
Sh. D. Singh	TO
Sh. B. Singh	TO
Sh. M. Singh	STA
Sh. N. Singh	Technician
Sh. S. Singh	Technician
Sh. D. Singh	Technician

Administrative

Sh. N. Kumar	AAO
Sh. T. Singh	UDC
Sh. J. Singh	SSS

Scientists/officers/other staff appointed/joined

Dr. Manoj Kumar Tripathi	Scientist 09.04.2015 (Appointed)
Dr. Mustafa Hassan Jan	Scientist 10.04.2015 (Appointed)
Dr. Ravi Dutt	Scientist 10.04.2015 (Appointed)
Dr. Sajjan Singh,	Principal scientist 01.05.2015 (Joined) on transfer from NRCC, Bikaner
Dr. (Mrs.) HemaTripathi	Principal Scientist 04.05.2016 (Joined) on transfer from IVRI, Izatnagar
Shri Satpal	STA 01.06.2015 (Joined) on transfer from CIAH, Bikaner
Shri Radhey Krishan	Skilled Supporting Staff 24.07.2015. (Appointed)
Shri Joginder Singh	Skilled Supporting Staff 24.07.2015 (Appointed)

Scientists promoted to the next higher grade

Dr. Varij Nayan	Scientist (Animal Biochemistry) 17.11.11
Dr. Sarita Yadav	Scientist (Veterinary Medicine) 07.01.13
Dr. Dharmendra Kumar	Scientist (Animal Biotechnology) 21.04.13
Dr. Satya Pal Yadav	Sr. Scientist (Animal Biotechnology) 17.01.14
Dr. Ashok Kumar	Scientist (Veterinary Medicine) 21.04.14
Dr. Pardeep Kumar	Scientist (Animal Reproduction) 17.05.14
Dr. Avijit Dey	Sr. Scientist (Animal Nutrition) 17.06.14
Dr. Jerome A	Scientist (Animal Reproduction) 23.08.14

Officers and other staff promoted

Shri Daljit Singh	STA, CIRB Sub-campus Nabha promoted as TO 01.1.15
Shri Balwinder Singh	STA, CIRB Sub-campus Nabha promoted as TO 12.2.15
Shri Jagdeep Singh	SSS promoted as Technician 08.09.15
Shri Gopal Dutt Tiwari	SSS promoted as Technician 08.09.15
Shri Nishan Singh	SSS CIRB Sub-campus, Nabha promoted as Technician 08.09.15
Shri Santokh Singh	SSS CIRB Sub-campus, Nabha promoted as Technician 08.09.15.
Shri Dalbara Singh	SSS CIRB Sub-campus, Nabha promoted as Technician 08.09.15

Scientists/officers/other staff transferred /relieved

Shri Ram Abtar Pachauri	TO transferred to ICAR-NRCE, Hisar 15.04.15
Dr. S.P. Yadav	Sr. Scientist transferred to ICAR-DPR, Hyderabad 30.05.15
Shri Jitender Kumar	STO transferred to ICAR-CIRC, Grass Farm Road, Meerut Cantt 31.10.15
Dr. Raman Malik	Principal Scientist transferred to NDRI, Karnal 13.11.15
Dr. J.K. Singh	Sr. Scientist transferred to ICAR-CIRC, Meerut 13.11.15
Shri V.P.S. Poonia	CTO transferred to CSWRI, Avikanagar 08.01.16

Scientists /officers/other staff superannuated

Shri Ram Kumar	CLTS	30.6.15
Shri Nanku	CLTS	30.6.15
Shri Fateh Singh	CLTS	30.6.15
Shri Gian Singh	CLTS	30.6.15
Shri Ram Dass	Casual Labourer	30.6.15
Shri Lakha Singh	Casual Labourer	30.6.15
Shri Sharanjit Singh	SSS, Nabha	30.6.15
Shri Ram Kishan	CLTS	13.1.16
Shri Roop Ram	CLTS	31.3.16

Resignation

Dr. Ravi Dutt	Scientist	18.11.2015

Sad demise

Shri Sube Singh	CLTS	14.1.2016
Shri Balbir Singh	Casual Labour	17.1.2016
Shri Harpal Singh	SSS	8.2.2016
Shri Mahender Singh	STA	9.2.2016
Shri Mitthu	CLTS	31.3.2016

भाकृअनुप
ICAR


मुर्रा MURRAH


नील–रावी NILI RAVI

भाकृअनुप – केन्द्रीय भैंस अनुसंधान संस्थान
ICAR-CENTRAL INSTITUTE FOR RESEARCH ON BUFFALOES


जाफराबादी JAFRABADI

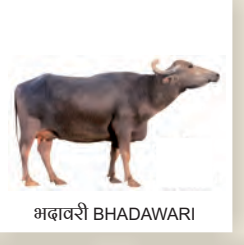

बन्नी BANNI


महसाना MEHSANA


सुरती SURTI


नागपुरी NAGPURI


पंढारपुरी PANDHARPURI


भदावरी BHADAWARI


मराठवाडा MARATHWARA


चिल्लका CHILLKA


टोडा TODA


कालाहाण्डी KALAHANDI


स्वम्प (दलदल की भैंस) SWAMP

भा.कृ.अनु.प. – केन्द्रीय भैंस अनुसंधान संस्थान, हिसार

ICAR-Central Institute for Research on Buffaloes, Hisar

हिसार–गौरव : पूंछ से ली गई कोशिका से उत्पन्न क्लोन कटड़ा

Hisar-Gaurav : Cloned calf produced from tail-derived somatic cell

क्लोन कटड़ा : हिसार–गौरव

Cloned calf : Hisar Gaurav

दाता झोटा

Donor Bull (CIRB-4354)

www.cirb.res.in