Changing Scenario of Bovine Semen Production in India

By
Dilip Rath, R.Kasiraj
and M.U. Siddiqui

Introduction

With a total milk production of 146.3 million tonnes in the year 2014-15, India continues to be the highest milk producer in the world since 1997. This significantly improved the per capita availability of milk to 322 gm per day during 2014-15 from 130 gm per day in 1950-51 (DADF website, http://dadf.gov.in/about-us/divisions/cattle-and-dairy-development as on August, 2016). India also possesses the largest bovine population in the world consisting of 190.9 million cattle and 108.7 million buffaloes (19th Livestock Census-2012).

The demand for milk is increasing due to enhanced purchasing power of average population, urbanization and increased population. Due to accelerated economic growth, the demand for milk and dairy products is expected to grow at a higher rate compared to the previous decade. Dairying is slowly transforming into an organized sector to cater to the increasing demand for milk. With more organized dairy farming, the demand for Artificial Insemination (AI) and thereby for frozen semen is expected to rise in the near future. In 2005-06, 57 semen stations produced 40.77 million frozen semen doses, whereas in 2014-15, 50 semen stations produced 97.12 million semen doses. This signifies a phenomenal growth in semen production in the last ten years (NDDB's Annual compilation of semen production data).

It is a well-known fact that production of good quality disease free semen from high pedigreed bulls and effective AI services are the keys to a successful genetic improvement programme. Awareness on the need for good quality high pedigreed semen is rising among progressive dairy farmers. Semen stations are making efforts towards producing high quality disease free semen from High Genetic Merit (HGM) bulls through stringent bull selection and procuring bull calves from approved Progeny Testing (PT)/ Pedigree Selection (PS) programmes.

To achieve economies of scale, the concept of mega semen stations with modern facilities and enhanced production is gaining ground in the semen production industry. Slowly the semen stations, which were earlier considered as developmental activity, are becoming economically viable units. The present review will traverse through the national journey of development of bovine semen production in India.

Inception of semen production activities in India

AI in India started before World War II in the barns of Maharaja of Mysore. Dr. J.D. Sampath Kumaran was the first person to do AI in cattle at the palace dairy of Maharaja of Mysore. He inseminated Hallikar cows with fresh semen collected from Friesian bulls in 1939 (Banerjee, 1998; IASRI online course http://ecoursesonline.iasri.res.in/mod/page/view.php?id=153815 as on August, 2016). However, AI with chilled semen was started mainly for crossbreeding with exotic cattle breeds like Holstein Friesian, Jersey, Red Dane and Brown Swiss in the projects funded by international development agencies like DANIDA, SWIDA etc. In early 1950s, a Central Artificial Insemination Centre was established at National Dairy Research Institute, Bangalore. Later, in 1961, a semen bank was established there with a view to supplying semen from Jersey bulls for cross-breeding and from bulls of superior Indian dairy breeds for selective breeding/upgrading work. Semen was supplied to different parts of the country from this semen bank.

Frozen Semen Production was started in India with the launch of "Indo Swiss Project" at Mattupatty in Kerala in the mid 1960s (KLDB, 2004). Subsequently, a few more semen stations were set up by AH Department,

To reduce the dependence of dairy farmers on Natural Service, coverage of breedable cattle and buffaloes under AI has to increase at a rapid rate. Keeping pace with the demand, the semen stations have expanded their production capacity with financial assistance from various central sector schemes like NPCBB and NDP-I. Delivering semen doses to the farmer is the ultimate aim of producing high quality disease-free semen doses leading to better productivity.

Karnataka and Govt. of India at Hessarghatta (Bangalore), BAIF in Urulikanchan (Pune) and NDDB at Sabarmati Ashram Gaushala (SAG), Bidaj in mid to late 1970s. By mid 1980s, major milk producing states had established semen stations to cater to their demand of semen for cross breeding/upgrading programmes. Demand for frozen semen went up with the launch of "Operation Flood (OF)" programme and its expansions. Consequent availability of technical inputs for the milk producing small holders at their doorstep, further fuelled the demand for semen. In 1988, in order to meet the ever increasing demand for bovine semen, the Govt. of India, as a part of "Technology Mission for Dairy Development (TMDD)" supported modernization of semen stations.TMDD funding was used for making buildings and purchase of semen processing equipment. Recently, as a sub project activity of "National Dairy Plan Phase I", many semen stations in the country have been strengthened to produce top quality disease free semen from HGM bulls.

Impact of semen production efforts during Operation Flood

During the implementation of OF programme, NDDB assisted a few Milk Unions and Federations to set up frozen semen stations. By the end of OF in 1997, there were 13 semen stations in the cooperative sector to take care of requirement of frozen semen doses for cross breeding of cattle and upgrading of buffaloes. These semen stations are listed in ***Table 1*** (Review mission on operation Flood II activities).

These semen stations have played a very important role in producing cattle and buffalo semen to fulfil its demand. This is a crucial technical input provided by cooperative milk unions/federations to dairy farmers in milk shed areas of the country. During 1995-96, these semen stations together produced approximately 5.3 million frozen semen doses, which was about 40% of the total semen doses produced then in the country. These stations made the dairy cooperatives self-sufficient as far as their demand for semen doses was concerned.

Out of 13 semen stations established under OF, four (Bhopal, Jalgaon, Erode and Siliguri) have discontinued producing semen due to various reasons and the remaining nine stations are still functioning and producing 30.2% of total semen produced in the country (2014-15).

Evaluation of semen stations and its impact on semen quality:

Necessity of production and supply of good quality semen led to initiation of a 'Quality Improvement' intervention by NDDB for the semen stations established under OF. In 1998-99, a Minimum Standard Protocol (MSP) for Semen Production was prepared by NDDB in consultation with all the existing OF semen stations. Semen stations managed by NDDB and Cooperatives (Coops) were brought under annual evaluation by a committee of experts and evaluated stationswere graded. The poor performing stations were suggested to improve or close down. This resulted in substantial improvement in the quality and quantity of semen produced by the stations managed by NDDB and Coops over a five year period.

By 2003-04, Govt. of India, after funding the semen stations of different State Governments under NPCBB, came out with a status report of the stations. Looking at variation in procedures, processes, chemicals used, etc. at different stations, it was felt necessary to adopt MSP as a measure to streamline the system. Subsequently, with the help of all stake holders, GOI finalised and adopted the MSP and constituted a Central Monitoring

Table 1: List of semen stations established under Operation flood

Semen Station	State
AMUL semen station, ARDA, Ode (Anand)	Gujarat
PashuSamvardhan Kendra, Dudhsagar Dairy, Jagudan	Gujarat
SAG semen station, Bidaj	Gujarat
Semen station, Bhadbhada, Madhya Pradesh State Cooperative Dairy Federation Ltd. (MPCDF), Bhopal	Madhya Pradesh
Jalgaon semen station	Maharashtra
Semen station, Rajasthan Cooperative Dairy Federation Limited (RCDF), Bassi (Jaipur)	Rajasthan
Bhattian semen station, Milkfed, Khanna	Punjab
Rohtak semen station, Haryana Dairy Dev. Co-Operative Federation Ltd. (HDDCF), Rohtak	Haryana
Dalpatpur semen station, Pradeshik Cooperative Dairy Federation(PCDF), Moradabad	Uttar Pradesh
Nandini Sperm Station, Karnataka Co-operative Milk Producer's Federation Ltd. (KMF), Hessarghatta (Bangalore)	Karnataka
Semen station, Nucleus Jersey and Stud Farm (NJ&SF), Tamil Nadu Cooperative Milk Producers' Federation, (TCMPF), Ooty	Tamil Nadu
Erode semen station	Tamil Nadu
HIMUL Semen Station, West Bengal Cooperative Milk Producers Federation Ltd., Siliguri	West Bengal

Table 2: Number of semen stations with different grade as per CMU evaluation

Year	Grade A	Grade B	Grade C	Not Graded	Not Evaluated	Proposed for strengthening	Advised Closure	Total
2005-06	6	11	4	8	0	16	9	54
2007-08	11	16	7	13	2	1	6	56
2010-11	20	17	3	7	4	0	0	51
2012-13	30	14	0	5	2	0	0	51

Table 3: Semen production scenario during last 10 years (Numbers in lakh)

Organization	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Government	236.18 [46]	270.08 [42]	267.92 [42]	299.63 [41]	356.22 [40]	335. 41 [41]	391.59 [37]	406.83 [37]	447.96 [37]	482.63 [37]
Dairy Coop.	77.36 [8]	87.44 [8]	96.51 [8]	111.83 [9]	124.42 [9]	123.72 [9]	131.11 [8]	137.47 [8]	141.96 [8]	151.67 [8]
NDDB	61.81 [2]	73.33 [2]	75.14 [2]	94.57 [2]	107.54 [2]	120.76 [2]	161.80 [3]	176.56 [3]	191.17 [3]	233.10 [3]
NGO & Private	32.37 [2]	53.23 [2]	51.07 [3]	61.67 [3]	70.52 [3]	87.80 [3]	88.24 [3]	89.14 [2]	104.46 [2]	103.78 [2]
Total	407.73 [58]	484.08 [55]	490.64 [55]	567.70 [55]	658.70 [54]	667.69 [55]	772.74 [51]	810.00 [50]	885.55 [50]	971.17 [50]

Values in the parenthesis '[ ]' designate number of operational semen stations.

Unit (CMU) in 2005. MSP covered all the aspects of the semen production. Several experts as CMU members went around the country and evaluated all semen stations giving emphasis on adherence to MSP, disease free status of breeding bulls and quality of semen produced and graded them based on scores received by each station. Recommendations were given for improvement or closure of the poor performing stations. As a result of regular interventions to improve production and quality of semen, the number of semen stations came down from 58 in 2003-04 to 51 in 2012-13 (*Table 2*; As per GoI notification number F. No.3-3/ 2013-AHT (NPCBB)). Total semen doses produced increased from 33.79 million in 2003-04 to 97.12 million in 2014-15 (NDDB's Annual compilation of semen production data).

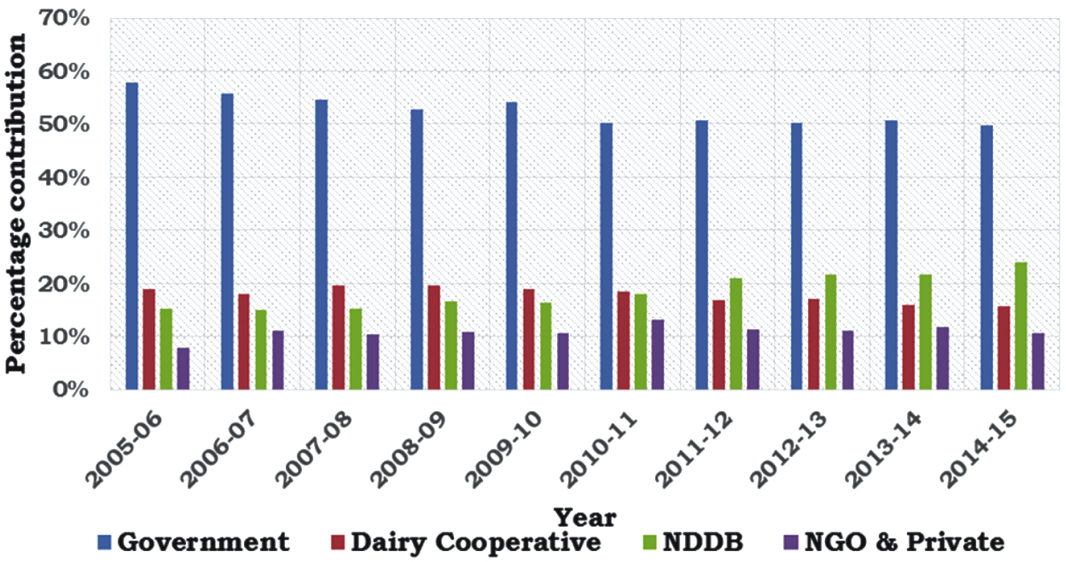

Fig. 1: Changing contribution of different stake holders in semen production

The outcome of regular CMU evaluation of semen stations could be seen in terms of a steady improvement in the number of A and B graded semen stations as well as quality and quantity of semen produced by HGM bulls of cattle and buffalo in the country and seriousness of semen stations in following MSP.

Changing dynamics of semen production in the country and current scenario

In the last 10 years, semen production scenario has gone through many changes (*Fig. 1*). The Govt. semen stations together produced the largest number of semen doses. However, the share reduced from 58.5% of total semen produced in the country in 2005-06 to 49.7%in 2014-15. The number of semen stations has also gone down from 46 to 37 during the same period. Semen production in Cooperative semen stations together remained almost at the same level in the past 10 years. They together contributed 15.6% of the total semen production in the country during 2014-15. During this period, NDDB managed semen stations maintained a steady rise in semen production. Three semen stations (SAG, Bidaj; ABC, Salon; SAG, Rohtak) together produced about 24% of country's total semen production in 2014-15. SAG, Bidaj is a single frozen semen production unit producing highest number of semen doses in the country. Two more semen stations recently established at Alamadhi in Tamil Nadu and Rahuri in Maharashtra came into operation during the year 2015-16.

The most phenomenal growth has been observed in the following two semen stations: BAIF managed by NGO, and Chitale by a private company. Both have together increased semen production from 32.33 lakh in 2005-06 to 103.78 lakh dosesin 2014-15 (*Table 3*). However, BAIF semen station is the major contributor (30.68 lakh and 73.99 lakh doses in 2005-06 and 2014-15, respectively). Semen production at Chitale semen station also increased from mere 1.70 lakh in 2005-06 to 29.79 lakh doses in 2014-15. The rise in semen production at both stations is due to the fact that they are operating on commercial lines.

National Dairy Plan Phase-I and its impact on semen production

National Dairy Plan Phase-I (NDP-I) is a central sector scheme funded by the World Bank and implemented by NDDB with the objectives to increase the productivity of milch animals and to provide rural milk producers greater access to the organized milk processing sector. The process of productivity enhancement involved production of HGM bulls through scientifically designed Progeny Testing (PT), Pedigree Selection(PS) programmes and import of bovine germplasm, production of high quality disease free semen and covering of large number

of breedable females under AI network. During the time of planning NDP-I in 2009-10, the total semen production in the country was 65.87 million frozen semen doses. It was envisaged that there would be a demand of 100 million semen doses during the year 2016-17 to cater to the need of semen doses for AI in that year considering AI coverage of 35% breedable bovines. To meet the gap, it was planned to strengthen and expand the semen stations in terms of bull management, laboratory, biosecurity and manpower. This gave rise to Semen Station Strengthening (SSS) projects. At the end of 2015-16, 22 A or B graded semen stations were funded by NDP-I across the country. These include semen stations of governments, cooperatives, trusts and NGOs.

The following activities were envisaged under SSS projects:

- Creation of infrastructure and facilities at semen station
- Biosecurity Management
- Disease screening, vaccination and Environmental and Social activities
- Capacity building in semen stations to create trained manpower
- Deployment of Management Information System (MIS) in semen stations

Moreover, to cater to the need of exotic semen doses in the country, import of live purebred bulls and embryos of HF and Jersey breeds were envisaged and implemented under NDP-I.

With multipronged planning, active participation of the semen stations and stringent monitoring by NDDB, the semen stations are striding forth towards their goal of producing desired quantity of high quality frozen semen doses. As per the annual compilation of semen production data, total semen production in these 22 semen stations was 71.23 million doses during 2015-16 compared to 43.43 million semen doses during 2009-10.

With this momentum NDP-I semen stations will definitely meet the production target of 100 million semen doses by the end of the project (2016-17). Moreover, the facilities created under NDP-I will enable the semen stations to expand their capacity manifold in the years to come. This will serve as a strong foundation to the dairy development efforts of the country.

Strengths of semen production activities in India

Production of frozen semen was so far considered as a service activity and not a commercial business. Unlike dairy advanced nations where the semen stations are run by breeding companies, most of our semen stations are operated by State Governments. However, there are a few semen stations which are run by Cooperatives, NGOs and private organizationson a semi-commercial or commercial mode.

This developing area of dairying activity in India has following strengths and opportunities in the changing scenario:

- As per latest CMU evaluation there are 51 operational semen stations in the country (2012-13) that have the potential to produce the required number of semen doses
- Strengthening of 22 semen stations with financial assistance of NDP-I has further increased semen production potential of these stations
- Availability of HGM bulls has also increased due to systematic implementation of PT and PS projects in NDP-I
- Key personnel of 22 semen stations were trained in different aspects of semen production, making these stations equipped with trained human resource
- At present, around 28% breedable bovines are covered under AI. This will increase with increasing awareness among dairy farmers. As a result,the demand for semen will increase
- Inclusion of 'Indigenous Breed Development Programmes' in various Central Schemes will increase the demand for semen of indigenous breeds.
- Policy makers fully recognize the importance of strengthening semen production system and formulate programmes accordingly.

To continue working on the strengths, semen stations should have strong infrastructure focused on biosecurity of bulls and quality control of semen doses. Aiming at producing quality product, breeding bulls should be sourced only from scientific breed development programmes like PT and PS after conducting proper disease screening and breeding soundness examination. A robust data recording system is crucial for regular analysis and continuous improvement in the quality of semen. To get regular feedback on the performance of semen produced, each semen station should have an AI delivery system in a small area. This will increase AI coverage and improve semen quality. A strict legislation is urgently required to check production of spurious semen by non-graded stations which spread diseases and

results in poor conception rate and financial loss to farmers.

New initiatives in semen production

As mentioned elsewhere, the semen production system is evolving fast and steadily converting to a viable business model. Technological advancement in semen biology is also making the pace of change faster. In line with the international scenario, many new initiatives are directed in Indian semen production scenario.

- ***Viability of semen stations:***

With the advent of intensive dairy farming and concerted efforts by different State governments, dairying is advancing. The awareness among farmers is also increasing. All these lead to an increased demand for dairy animals which is met by providing AI service with top quality semen. This has increased the need of frozen semen doses. Considering the demand, NDDB Dairy Services (NDS) ventured to develop mega semen stations with modern facilities and very high semen production capacity. BAIF semen station in Urulikanchan (Maharashtra) is also transforming into a Mega semen station. The idea behind these mega stations is to consistently produce high quality semen in large quantity using modern and fully bio-secured facility, which is not possible in small scale operation. This concept is changing the semen production activity from a mere service to dairy farmer with high subsidy, to a self-sustainable commercial activity.

(a) Quarantine station

(b) A mega semen station

(c) Inside view of semen processing laboratory

Fig. 2: Concept of mega semen station

- ***Production of sex sorted semen:***

For increasing productivity, dairy farmers, world over want to produce animals of the desired sex. Among the several techniques available, use of sex sorted semen for AI is recognized as a more pragmatic and easy way to preselect the sex of the offspring. The technology was developed by the USDA (United States Department of Agriculture) researchers in Livermore, California, and Beltsville, Maryland. The technology was patented as "Beltsville Sperm sexing technology". The commercialization of sexed semen started in United States in 2001 by Sexing Technologies (ST), Texas, which is holding the patent for the technology. Now ST commercially produces sex semen in many countries of Europe, USA, Canada, Mexico, Brazil, China, Japan, etc. by providing license to different breeding companies. The cost of sexed semen varies from US $20-80 based on the breed and genetic merit of bull. The demand of sexed semen is expected to rise in India as dairy farmers are not interested to rear the male calves owing to the fact that they are not needed for agricultural operations in the era of farm mechanization. As importing sexed semen is not cost effective, there is a need to develop an indigenous technology to cater the need of millions of Indian dairy farmers. Several organizations in India are working to develop the technology for production of sex semen of indigenous cattle and buffalo. So this is high time that researchers from different backgrounds such as semen biology, biomedical science, mechanical and electrical engineering, etc. join hands to make a consolidated effort. In future, this technology is going to benefit the Indian dairy farmers.

- ***Semen processing at farmers' doorstep by mobile laboratory:***

There are many high pedigreed indigenous bulls with the farmers and gaushalas which are used for natural service in field condition. Preserving semen of such bulls through production of frozen semen and spread of superior germplasm to the larger part of bovine population will lead to faster genetic growth. However, bringing those bulls under semen production activity is a tough job as brining the bull to the semen station is not always possible. Considering the constraint, a new trend of

(a) Mobile semen processing laboratory

(b) Semen collection using mobile facility

(c) Semen freezing inside mobile van

Fig. 3: Mobile Semen Freezing Laboratory – Collection, processing and freezing of semen in field condition

creating mobile semen station has emerged. On this line, NDDB has designed and developeda special mobile van (Bovine genetics on wheel) fitted with clean room and equipment for semen processing in field conditions on pilot mode. This may turn into a promising and emerging area in semen production where semen from precious breeding bulls owned by farmers/gaushalas could be collected and processed using mobile facility adhering to Minimum Standards (MS) for production of bovine frozen semen.

- ***Embryo Transfer (ET) and in vitro Fertilization (IVF) for bull production:***

Production of HGM bulls through the breed development programmes is time consuming. So, the use of elite dams and proven sires through ET and IVF will be a faster alternative for production of breeding bulls. Few semen stations are taking up this route forcaptive bull production to meet their requirement of HGM bulls. Multiple Ovulation and Embryo Transfer (MOET) is well established in the country. However, Ovum Pick Up(OPU) and *In Vitro* Fertilization (IVF) for production of bovine embryos and breeding bulls, if implemented on mass scale would definitely benefit the dairy farmers.

Animal breeding should be considered as a linked event starting from selection/procurement of bulls from scientifically designed genetic improvement programme, quarantine and rearing of bulls, producing high quality disease free semen, delivering semen doses to the AI service provider and finally gathering data from the field.

Future prospects

To reduce the dependence of dairy farmers on Natural Service, coverage of breedable cattle and buffaloes under AI has to increase at a rapid rate. This is happening with rising awareness among dairy farmers. Consequently, the demand for frozen semen is also rising. Keeping pace with the demand, the semen stations have expanded their production capacity with financial assistance from various central sector schemes like NPCBB and NDP-I. In near future, these stations are going to be the heart of the dairy development. Considering the importance, following are the areas where semen stations should focus more in the coming days:

- Continuing stringent biosecurity measures, disease screeningof breeding bulls, quality control of semen doses and training of personnel working in semen stations;
- Procuring HGM bulls only from approved systematic and scientific genetic improvement programmes like PT, PS etc.;
- Semen Stations may consider establishing AI delivery system for forward linkage in the delivery chain of frozen semen doses;

- Production of breeding bulls through ET and IVF;
- Collaborating with biological institutes and engineering institutes to promote R&D for evolving an indigenous technology for sex sorting of semen; and
- Incorporating robust data recording systems in the semen production facility.

Epilogue

Delivering semen doses to the farmer is the ultimate aim of producing high quality disease-free semen doses. So far, AI delivery is found to be the weakest link in the chain of breeding activity. To overcome this, semen stations may envisage establishing viable AI delivery system on the lines of breeding companies of dairy advanced countries. This will give more ownership to the semen stations in breeding activities and strengthen the delivery of AI to the farmers. It is now well explained that the need of the hour is to produce high quality disease free semen from HGM bulls. Capturing data related to semen production/ processing and its usage is very critical considering the importance of data to decide future course of action. This will also help assess the conception rate at different level like bulls, semen stations, AI service provider, inseminator etc. It will help the semen stations understand at which level more intervention and focus are required. Using high quality disease free semen through robust AI delivery system will ensure higher conception rate thereby producing more number of offsprings. Animal breeding should be considered as a linked event starting from selection/procurement of bulls from scientifically designed genetic improvement programme, quarantine and rearing of bulls, producing high quality disease free semen, delivering semen doses to the AI service provider and finally gathering data from the field. Disruption at any point of this chain of events will lead to failure of the animal breeding activity and hence development plan should be holistic considering all aspects. Semen stations should get actively involved in all other aspects of animal breeding and emerge as a complete breeding solution to Indian dairy farmers in the future.

Reference

19th Livestock Census-2012, Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries, Krishi Bhawan, New Delhi.

Annual compilation of semen production data by semen stations of India, Compiled by NDDB.

Banerjee, G.C. 1998. Artificial insemination. In: A text book of animal husbandry. 8th Ed. Oxford & IBH publishing Co. Pvt. Ltd. New Delhi. Pp. 286.

DADF website, (http://dadf.gov.in/about-us/divisions/cattle-and-dairy-development) as on August, 2016.

IASRI online e-course website (http://ecoursesonline.iasri.res.in/mod/page/view.php?id=153815) as on August, 2016

KLDB. 2004. Livestock Breeding. In: Capitalisation of Experiences in Kerala Livestock Development Board. By KLDB, Kerala. Pp. 54.

Review mission on operation Flood II activities, 1986, Commission of the European Communities/World Bank.

Acknowledgements

The authors sincerely acknowledge the encouragement given by Management of NDDB for writing this manuscript. The support of all semen stations which are owned/operated by GOI, State AH Departments/ Livestock Development Boards/Agencies, Milk Cooperatives, NDDB Dairy Services, Trusts/NGOs and Private Organizations is well acknowledged.

Dilip Rath
Chairman & Managing Director, NDDB, Anand

R. Kasiraj
General Manager (Animal Breeding), NDDB, Anand

M.U. Siddiqui
Deputy General Manager (Animal Breeding), NDDB, Anand
mus@nddb.coop