Genetic Improvement of Livestock and Poultry

About the Editors

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Foreword

The Department of Animal Genetics and Breeding of this college, on the occasion of Golden Jubilee Year celebration of the University, organised a national symposium entitled " Conventional and Modern Breeding Technolgies for genetic Improvement of Livestock and Poultry in India" on October 22-23, 2010. Many distinguished animal scientists from all over the country participated in this two days national symposium and deliberated upon the issue confronting the scientists regarding faster genetic improvement of vast low producing indigenous livestock and poultry species.

The deliberations of symposium resulted into valuable recommendations which were forwarded to the concerned quarters for further consideration and incorporation of the same in policy planning for the livestock and poultry improvement. I feed delighted to know that the organisers fo the symposium decided to publish the contribution made by various delegates, in the form of a book entiitled "Genetic Improvement of Livestock and Poultry". The book comprises of two parts-Conventional Breeding Methods and Modern Breeding Technologies which supplement each other for faster multiplication and improvemnt of germplasm.

The publication of this book is a significant achievement of the symposium and I hope that it will be very useful to teachers, scientists, students and all other concerned involed in livestock and poultry improvement. The book will provide an opportunity to develop innovative and appropriate strategies for the improvement of indigenous livestock by blending conventional and modern breeding technologies.

I congratulate the editors of this book for their commendable efforts in bringing out this book.

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Preface

Livestock sector plays an important role in the national economy and in the socioeconomic development of the country. It is an integral part of the rural economy, which supplements family income and generates gainful employment in the rural sector, particularly among the small and marginal farmers, and landless labourers.

Indian has a rich and diverse repository of animal genetic resources with 34 well defined cattle breeds, 13 buffalo breeds, 23 goat breeds, 39 sheep breeds, 3 pig breeds, 8 camel breeds, 6 horse & pony breeds and 15 chicken breeds. Nearly two billion people in the world rely on livestock to supply all of their economic, social, cultural and dietary needs.

Although, we possess a large number of well-defined breeds of all domesticated animal species, yet these constitute hardly 20-25 per cent of total livestock population of the country (the rest either mixture of different breeds or non-descript). These diverse population groups are reared in small herd size of 2-3 animals mainly by small, marginal and landless labourers of different socio-economic levels under different ecologies.

India's livestock sector is one of the largest in the world. It has 56.7% of world's buffaloes, 12.5 cattle, 20.4% small ruminants, 2.4% camel, 1.4% equine, 1.5% pigs and 3.1% poultry. In 2010-11, livestock generated output worth Rs.2075 Billion (at 2004-05 prices) which comprised 4% of the GDP and 26% of the agricultural GDP. The total output worth was higher than the value of food grains. Livestock sector grew at an annual growth rate of 5.3% during 1980s, 3.9% during 1990s and 3.6% during 2000s. Despite declaration growth in livestock sector remained about 1.5 times larger than in the crop sector which implies its critical role in cushioning agricultural growth.

The average yield of milk and meat in out animals is 20-60% lower than the global average (FAOSTAT). Further, their production potential is not realized fully because of constraints related to feeding, breeding, health and management. Deficiency of feed and fodder accounts for half of the total loss, followed by the problems of breeding and reproduction (21%) and diseases (18%). Frequent outbreaks of diseases like FMD, BQ, PPR, Brucellosis, Swine fever, Avian Influenza etc. continue to reduce productivity and production. However, the available veterinary support

in terms of infrastructure (hospitals and diagnostic labs), technical manpower, is insufficient. Improving productivity in a huge population of low-producing animals is one of the major challenges. The average annual milk yield of Indian cattle is (1172 kg) which is only about 50% of the global average (FAOSTST), and much less than in New Zealand (3343 kg), Australia (5600 kg), UK (7101 kg), US (9332 kg) and Israel (10214 kg). Likewise the meat yield of most species is 20-60% lower than the world average. Crossbreeding of indigenous species with exotic stocks to enhance genetic potential of indigenous livestock has been successful only to a limited extent. After more than three decades of crossbreeding, the crossbred population is only 16.6% in cattle, 21.5% in pigs and 5.2% in sheep.

Animal Husbandry sector provides large self-employment opportunities. This sector is playing a very important role in the rural economy as a support sector to the economy. Especially, 70 million rural households primarily, small and marginal farmers and landless labourers in the country are getting employment opportunities in dairy. Dairying has become an important secondary source of income for millions of rural families.

Poultry is also another way of getting food and food security in India, Apart from food security, it provides direct employment to approximately 1.5 million people. Livestock sector not only provides essential protein and nutritious human diet through milk, eggs, meat etc., but also plays an important role in utilization of non-edible agricultural by-products. Livestock also provide raw material/by products such as hides & skin, blood, bones fat etc. to various industries to produce finished products. Livestock contribute immensely as draft power to carry out agricultural operations and dung as organic manure for better soil health. The contribution of livestock dung being used as fuel by millions of poor people also cannot be ignore.

Livestock sector provides subsidiary occupation to a large section of the society particularly to the people living in the drought prone, hilly tribal and other remote areas where crop production on its own may not be capable of engaging them fully. In the adverse climatic conditions and national calamities like drought, flood etc., animal husbandry can mitigate their adverse effect and help in sustaining the livelihood of the affected rural populace.

We all know that various conventional breeding technologies used for selection and faster multiplication of superior cattle and buffalo germplasm have contributed significantly to increase mild production. In the past, mostly livestock genetic improvement programmes were based upon the technologies developed in the areas of quantitative genetics and reproductive biology. These included methodologies for selection of females based upon their expected producing ability and young males based on the performance or progeny.

Emerging developments in the areas of molecular marker systems in animals, genome maps methods of detecting Quantitative Trait Loci (QTL) linkage. Marker Assisted Selection (MAS) etc. are latest tools to be used in breeding programmes

for enhancing the rate of genetic progress. These modern techniques could be of great help for those traits, for which the conventional technologies have limitations in their use. Therefore, integration of molecular markers with conventional breeding technologies involving pedigree and phenotypic information are probable future breeding tools for genetic improvement of livestock and poultry in India.

This book presents conventional and modern breeding technologies in the vital areas of animal breeding, to stimulate more research, and to rapidly pass such modern techniques to scientific community. The material presented in this book include*: conventional breeding methods and modern breeding technologies for a better understanding of breeding methods and technologies*.

This book is based on the conference on "Conventional and modern breeding technologies for genetic improvement of livestock and poultry in India" which was organized by the Department of Animal Genetics and Breeding. College of Veterinary and Animal Sciences, G.B.Pant University of Agriculture & Technology Pantnagar on October 22-23, 2010. The aim of the conference was to present the conventional methods and modern breeding technologies and to stimulate more research interest among scientists for genetic improvement of livestock and poultry by applying advanced methodologies and techniques. After peer- reviewed 165 research papers were accepted for presentation from all over the world later on 27 papers were selected for publication in the edited book, divided into two parts. The selected manuscripts were further improved and the edited book represents a valuable contribution to the field of animal breeding and molecular genetics.

The topic on convention breeding methods included nineteen selected papers on sustainability of indigenous cattle evaluation of sires by different sire evaluation methods, buffalo breeding research and improvement strategies, breeding policy and programme, genetic improvement of cattle and buffaloes, conservation of Bhadawari buffaloes, methods of estimation of genetic parameters and rural poultry farming, etc., (Part 1). Eight papers were selected for publication in Part II of this edited book. The modern breeding technologies as presented in the book comprises of the basic theory and recent techniques used in molecular genetic studies. The topics in part II include selected papers on integration of convention and molecular approaches, chromosome and genome analysis, molecular approaches in animal breeding, application of molecular genetics technologies, genetic resistance to mastitis, study on prolactin gene etc.

The contributors to this book deserve special thanks as it is only because of their valuable contributions due to which publication of this book could be possible. The contents of the book are as per the material provided by the contributors and the editors shall not be responsible for any controversy.

This book presents recent developments in conventional and modern breeding technologies for genetic improvement of livestock and poultry and the editors believe that the book will provide valuable information to all concerned striving to enhance production potential of indigenous livestock and poultry.

C. V. Singh
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Part – II: Modern Breeding Technologies

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PART-I

CONVENTIONAL BREEDING METHODS

1

Sustainability of Indigenous Cattle: Breeding Strategies and Future Prospects

R.S. Gandhi

India is very rich in biodiversity especially in animal genetic resources and animals have been part and parcel of agricultural heritage. There are about 30 well defined breeds of cattle found in different parts of the country. To name a few are Sahiwal, Red Sindhi, Gir, Kankrej, Deoni, Tharparkar, Hariana, Ongle, Nagori, Amritmahal and Hallikar. The cattle breeds are classified into three types i.e. dairy, dual purpose and draft/drought animals. The number of the animals of majority of indigenous breeds has declined over the years. Further, their number is very low and majority of cattle population (80%) in India is non-descript. The introduction of systematic crossbreeding program of our native cattle with exotic breeds in seventies have further led to the depletion of prized germplasm of all the indigenous breeds under farm and field conditions. However, considering the importance of indigenous cattle, some of the breed improvement programs have been initiated to conserve and multiply these breeds. The associated herd progeny testing program has been going on at NDRI Karnal for the genetic improvement of Sahiwal cattle. All India Coordinated Research Project on Hariana and Ongole cattle has been undertaken at different centres by Project Directorate on Cattle, Meerut. Lately, three more breeds namely Sahiwal, Gir and Kankarej have been included in the indigenous breed improvement program (IBP) and different centres have been identified as germplasm units and data recording units for different breeds under the program.

India has witnessed a white revolution in eighties and nineties of the last century which is largely due to manifold increase in milk production contributed largely to crossbred cows. Estimated milk production in the country was 110 million tones

during 2009. The annual growth rate in milk production of our country over the years centered around 4%. According to an estimate the milk production of our country would be 170 million tons during 2020. India has 185.18 million cattle and 97.97 million buffaloes as per the latest figures, out of which the number of breedable females is 63.39 (including 12.26 million crossbreds) and 50.28 millions, respectively. There are 24.69 million crossbred cattle, out of which 12.26 millions are breedable females. About 50 million adult buffaloes produce about 60.5 million tones of milk (55% of 110 million tones), while 63.39 million cows produce 39.5 million tones of milk (40% of total 110 million tones). Out of 40% of total milk produced by cows, 21% is produced by indigenous cows (51.13 million breedable cows) and 19% by crossbred cows (12.26 million breedable cows). It is obvious that about 19.3% of breedable crossbred cattle are producing nearly 48% of total cow milk. The impact of crossbreeding is more pronounced under field conditions in most of the states of the country. This was attributed to higher milk production of crossbred cattle as compared to local cattle and is evident from milk yield/ animal/day (6.46 versus 1.89 kg) as per the 17th Indian Livestock Census 2003. The performance of crossbreds in terms of milk yield is 2 – 3 times more than that of local cows in majority of the states. Lower production of our cattle is attributed to the poor genetic make up of majority of animals, which are non-descript.

The systematic research program on enhancing milk production through crossbreeding of European and Indian breeds of cattle was started in India with the launching of a project on "Behaviour Patterns of Zebu Crossbreds with Exotic Dairy Breeds" initiated by the ICAR during 1968 at IVRI, Izatnagar and HAU, Hisar. It involved crossbreeding of Hariana with Holstein Friesian, Brown Swiss and Jersey. The project involved four more stations namely Rahuri (Maharastra), Jabalpur (MP), Lam (AP) and Dharwar (Karnataka). The original mating plan was to produce four types of crossbreds from each of three exotic breeds - F_1, ¾ breds produced through breeding F_1 females with the same or other exotic breed, backcross to paternal breed, F_2 by *interse* mating of F_1 and three breed crosses by mating males and females from two different F_1 crosses in all six possible combinations.

Crossbreeding work done in India and other tropical countries has led to enhanced milk production by evolving new strains of crossbreds. The salient points emerged from systematic crossbreeding work in tropics are:

- The F_1 crosses expressed higher degree of heterosis in production and reproduction traits as compared to F_2 crosses.
- Crosses of temperate breeds with well-defined indigenous milch/dual purpose breeds were comparatively superior than those from other native breeds/non-descript cattle suggesting the role of improved indigenous breeds in creating new high producing dairy breeds. However, non-significant

differences of Friesian crosses with improved Zebu breeds for milk production suggested that superior indigenous breeds have not much to contribute in evolving good dairy breeds.

- Holstein crosses were superior to other crosses involving other exotic dairy breeds (Brown Swiss and Jersey) in growth and milk production, while Jersey crosses were slightly better in reproductive efficiency.
- Exotic inheritance around 50% was most ideal for growth, production and reproduction.
- Decline in milk production from F_1 to F_2 generation on account of *interse* mating amongst F_1. Higher decline in milk yield in F_2 at some of the herds was attributed to poor quality of crossbred bulls used.

Impact of Crossbreeding on Milk Production

The systematic crossbreeding during the seventies and later has contributed significantly to enhancement of milk production in our country. There are about 7 million breedable crossbred cows. The crossbreeding of indigenous cattle with exotic breed has resulted in evolving new dairy cattle strains like Karan Swiss, Karan Fries, Frieswal and Sunandini at organized farms in India. Their performance is given as under:

Table 1: Production and Reproduction parameters of Synthetic Breeds of Cattle

Breeds\ Traits	Age at Firs tCalving (Mo)	Total Lactation Milk Yield (Kg)	Lactation Length (days)	Calving Interval (days)
Karan Swiss	34.6	3075	326	412
Karan Fries	32.6	3686	321	401
Frieswal	31.9	2971	317	426

* 305-day lactation milk yield

The per lactation milk yield of crossbred cows is comparatively higher than local cows under field conditions. The performance of crossbred cows in some of the states revealed that crossbred cows produce about 2000 – 2700 kg milk per lactation. On the contrary, the local cows produce about 400 – 500 kg milk per lactation.

The latest statistics of cattle population in India is revealing clearly that the number of low and unproductive non-descript cattle especially males is declining over the years and that population of breedable females and crossbred cattle is increasing. This is a positive sign for the enhancement of milk production in India resulting from higher proportion of milk produced from crossbred cows as compared to local cows in the near future.

Performance and Genetic Improvement of Indian Cattle Breeds

The breeding policy for improving the indigenous cattle is selective breeding in well defined breeds and grading up of non-descript animals with the indigenous breeds prevalent in the area or adjoining area. The comparative performance of some important cattle breeds is given in table 2.

Table 2: Average performance of indigenous cattle

Breeds\Traits	Age at First Calving (Mo)	Total Lactation Milk Yield (Kg)	Lactation Length (days)	Calving Interval (days)
Sahiwal	38.5	1968	280	406
Red Sindhi	44.1	1476	305	496
Gir	52.9	1862	337	444
Kankrej	44.9	1836	294	446
Tharparkar	47.9	1007	179	365
Hariana	51.0	1153	189	464
Ongole	45.6	826	279	553
Deoni	51.0	943	293	466

The perusal of the table indicated that the milk production of Indian cattle breeds ranged from low to medium and there is ample scope to improve upon these breeds through selective breeding. The nondescript cattle have to be up-graded with the native available breeds in that area or adjoining area.

Constraints of Breed Improvement Programs

- Large cattle population, major chunk of cattle population is non-descript and low producing.
- Poor genetic potential of local animals.
- Deterioration of performance of crossbred cattle from inter-se mating.
- High incidence of reproductive disorders like anoestrous, repeat breeding etc. in high producing crossbred cattle. About one-third of cows are culled due to reproductive disorders. Lower breeding efficiency is another constraint.
- Lack of knowledge about scientific management of high producing cattle among farmers especially women folk like heat detection, correct time of AI, corrective measures for anoestrous and repeat breeders, proper prophylactic treatment against infectious diseases and external and internal parasites.
- Higher cost of veterinary services for high yielding crossbreds seems to be beyond the reach of the small and marginal farmers.

- Lack of breed-wise census.
- Vast difference in agro-climatic conditions in different regions of the country to implement a common breed improvement program.
- Smaller herd size at organized farms.
- Non-availability of superior bulls/semen. The use of scrub bulls hinders the genetic improvement under field conditions.
- Lower conception rate from AI and higher inter-calving interval.
- Lack of infrastructure for performance recording under field conditions.
- Data loss under field conditions hinders performance evaluation.
- Lower coverage of bovine population with AI under field conditions.
- Lesser availability of feed/fodder under field conditions. India is deficit by 10% in dry fodder, 35% in concentrate and 33% in green fodder.

Future Breeding Strategies

- Broadening the genetic base of existing crossbred population by infusing the fresh exotic germplasm as selection of crossbreds over generations seems to have led to the segregation of indigenous genes most favoured by the tropical environment due to natural selection. The semen from purebred HF/Jersey sires with higher breeding value needs to be imported.
- Rigorous selection of males and females with very high genetic merit has to be done to bring about faster genetic improvement. Proper replacement rate has to be maintained to have an optimum size of the herd.
- Culling of unproductive/surplus animals.
- To overcome the constraint of smaller herd size, there is a need of net-working the organized herds maintaining the animals of same native breed under progeny testing program. Further, performance recording of daughters of bulls under progeny testing should be extended to field conditions to facilitate the dissemination of superior germplasm in larger population. This will enhance the accuracy of selection of bulls. The genetic base of indigenous milch breeds can further be strengthened using the concept of ONBS under the breed improvement program.
- The major bottleneck for the breed improvement program is the non-availability of requisite number of semen doses of superior germplasm attributed to the lesser number of bulls available at our semen stations. As per the latest report of NPCBB, only 2711 bulls are available at 49 semen stations and 44.65 million semen doses are produced/year, which even falls short of 46.62 million semen doses required for cattle assuming 35% of the

population is covered through AI (3 AIs/conception) and 70% calving rate/ annum. Under same assumptions 36.96 million semen doses are required for buffalo population. Similarly, for covering 35% of breedable population of cattle and buffaloes, a total of about 4650 cattle and 7400 buffalo bulls are required.

- Production of bulls at Nucleus or bull mother farms using newer biotechniques like MOET and other related techniques viz. sexing and cloning.
- The selection of males and females should not be done on the milk yield alone, but also for other adaptive traits as well as higher fat and SNF percentage.
- Use of genetic markers for higher and quality milk production may be done to supplement the conventional procedure of selection. Majority of indigenous breeds have been found to have A_2 type kappa-casein, which can be used as a marker for quality cheese production.
- The native cows of well-defined breeds should not be used for crossbreeding. Rather, non-descript cattle and surplus draught/dual purpose animals should be used under crossbreeding program. Selective breeding must be done in well defined cattle and buffalo breeds. Grading up of non-descript animals with the well defined cattle and buffaloes breeds available in that area should be done.
- Different exotic germplasm should be used in different regions of the country keeping in view their adaptability to that particular environment as well as the availability of feed/fodder resources and other available infrastructure.
- The level of exotic inheritance in field should not exceed 62.5% to have optimum performance of crossbreds under field conditions under normal management practices. However, this level may exceed under intensive input – higher output system.
- Emphasis should be given to net-working and renovation of existing AI infrastructure to work under physical environment, feed resources, and prevailing disease conditions as well as to improve conception rate from AI under field conditions.
- As per the impact analysis report submitted by NABARD, overall conception rate has increased from 20% in 2000 to 35% in 2010 under the NPCBB. The coverage area under the National Project on Cattle & Buffalo Breeding has to be further increased. The requisite number of frozen semen doses has to be produced at semen stations and supplied for dissemination under field conditions. For the areas with difficult topography, where AI services could not be provided, sufficient number of superior bulls should be made available to cover the population through natural service.

- The Central Herd Registration Scheme for indigenous breeds needs to be further strengthened. Further, Breeders Associations in the breeding tract of the breeds should also be strengthened.
- Improved package of practices involving breeding, feeding, management especially reproductive management that too for different agro-climatic conditions should be evolved and the technologies based on these practices should be disseminated under field conditions.
- For different strata of farmers semen with varying genetic potential to suit the resources of the farmer should be made available i.e. 'Basket of Semen Stock' should be available at semen stations. Further, the transparency should be there in available stock of semen to allow the farmer to choose the semen of his choice for his animals. Emphasis should be given to print Sire Directory and information on availability of superior germplasm should be available to the dairy farmers.
- Enhancing awareness among farmers especially farm women about improved package of practices for breeding, feeding and management of crossbred animals through extension services including those with ICAR research Institutes and State Agriculture/Veterinary Universities. The farming community should be apprised about the latest technologies developed at research stations and demonstrations at farmer's doorstep should be organized, if possible.
- Inter-country collaboration for breed improvement program for indigenous cattle with neighboring countries having effective population size.

Conclusion

To sum up, it is beyond doubt that crossbreeding has contributed significantly towards the enhanced milk production in India and has played a vital role in white revolution as well as making our country number one in milk production. Still, there is large scope of further increasing milk production of cattle of our country by crossing/grading up about 80% non-descript cattle with exotic/indigenous breeds considering the agro-climatic conditions of different regions of the country, but assuring availability of appropriate inputs especially feed/fodder. Due attention needs to be given to reproductive problems which are a large impediment in exploiting innate potential for milk production of crossbred animals. The improvement of AI net-work under field conditions is the need of the hour to disseminate superior germplasm from indigenous/crossbred bulls at the door steps of the farmers. Simultaneously, steps should be taken to produce requisite number of doses of frozen semen from selected bulls in quantity required to meet the need of breeding vast population under field conditions.

2

Characterization and Evaluation of Hill Cattle of Uttarakhand

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The state of Uttaranchal was carved out of Uttar Pradesh on 9th November 2000 as the 27th state of the union of India and renamed as Uttarakhand. The state is located in western Himalayan region and is one of the geographically smallest states of the country. However, the state is enriched with livestock biodiversity represented by cattle, buffaloes, goats, pigs, horses, mules and poultry. The climate of the state varies from subtropical in the valleys to temperate on higher slopes with a summer monsoon. The temperature ranges from -5.4°C (Muketshwar, higher hills) to 40.2°C (Pantnagar, plains) but it drops below freezing point in many parts of high mountainous areas of the region during winter. Preponderance of hilly terrains and forestland restricts the size of the agricultural land/ holding. The average rainfall recorded in the year 2008 was 1605 mm. Higher rainfall, abundance of natural pastureland and suitable climatic conditions makes the state favorable for livestock development. The human population was 84.89 lacs with a density of 159 people per sq km during the year, 2001. The literacy rate was recorded at 71.6%. Among males it was higher (83.3%) than the females (59.6%). The economy of the state is largely based on agriculture, forestry and animal husbandry have ample opportunities for further development. Most of the farmers of the state are resource- poor due to undulated topography, rugged terrain, cold climate and lack of production and marketing facilities for livestock and crop production. Livestock sector is a source of livelihood to the majority of people.

In the state there is larger proportion of indigenous non-descript cattle, which need to be characterized on priority so as to formulate suitable breeding policy for

improvement of cattle productivity. The state possesses 21.88 lacs indigenous cattle, 12.88 lacs buffalo, 11.58 lacs goat, 2.96 lacs sheep and 19.84 lacs poultry (Livestock census 2003). In addition to this state is also having 2.28 lacs crossbred cattle. In the year 2003 there were 6.51 lacs indigenous & non-descript and 1.07 lacs crossbred breedable cows. The proportionate contribution of Uttarakhand to the country's total livestock population was 1.18% cattle, 1.25% buffaloes, 0.48% sheep, 0.93 % goat and 0.41% poultry (Livestock census, 2003). The average milk yield was 1.89 kg/day for indigenous cows, 6.69 kg for crossbred cows and 4.11 kg/day for buffalo during the year 2005-06 (Anonymous, 2006). As there was a larger proportion of non descript indigenous cattle (more than 99% in hill districts), it is the foremost and urgent need to characterize the hill cattle of the state.

To characterize the hill cattle of the state, a survey were conducted in 5 districts of the state i.e. Almora, Pithoragarh, Rudarpryag, Chamoli and Uttarkashi. Information on various management practices practised by the livestock owners in these districts and prpduction performance traits was generated by interviewing the farmers using a structured questionnaire in 32 villages of Kumanu and Garhwal regions. A total of 309 farmers were interviewed to evaluate the habitat, status, management, utility and performance of the cattle available. Farmers were interviewed for choice of breed, utility, sale and purchase of animals, animal housing, feeding, breeding, prevalent diseases in the area and performance of the breed. Performance traits like birth weight, age at maturity and calving, lactation milk yield, lactation length, dry period, service period, calving interval and draft performance were collected by conversing with the farmers from the surveyed villages. Physical characteristics were recorded on animals of different ages and sex during the survey. Eight different body measurements were also recorded on 819 animals of different ages and sex and analyzed statistically. The body measurements recorded were body length, height at withers, heart girth, paunch girth, face length, ear length, horn length and tail length without switch.

The survey revealed that there is large number of hill cattle in the state. Hill cattle are reared mainly for bullock power, milk and manure. Most of the animals were farm born. Sale and purchase of the animals were observed among the farmers. Land holding was small; about 75% farmers had less than 20 nali of land. Family size was large i.e. 4-8 members per family. The state had 628000 marginal land holdings (less than 1.0 hact), 159000 small land holdings (1.0 to 2.0 hact), semi medium and medium land holdings (1.0 to 10.0 hact) and around 1000 large land holdings (more than 10.0 hact). The most of the area was under marginal land holdings (242000 hact.) and small holdings (221000 hact). The semi medium and medium and large land holdings had 344 hact and 36 hacts area, respectively. Singh *et. al*. (2001) observed that majority of the hill farmers are small land holders and they depend on the diversification of agriculture to reduce risks and derive economic benefits from the limited resources.

Population and Trends

The total bovine population and their trends during 1997 to 2003 are presented in table 1. In the state, there were 2188182 cattle heads in the year 2003. Among them 10.40% were crossbred. 1.44% belonged to defined breeds (Hariana, Sahiwal and Red Sindhi) and a majority (89.16%) were non-defined cattle. The crossbred cattle population increased by 121.6%, indigenous cattle only by 1.76% and the total cattle by 7.83% during the period 1997 to 2003. During the same duration buffaloes increased by 12.25%. Among the crossbreds, 71% were jersey crosses, 14% Holstein Friesian and rest 15% were other crosses. The plain districts U S Nagar, Dehradun, Nanital and Haridwar had around 64.20% of total crosssbreds in the state. Among the crossbreds, theses four districts had 59.68% Jersey crossbred and 88.75% H.F. crossbreds. The maximum number of crossbred was available in U S Nagar (43.23%) followed by Dehradun (21.40%), Nanital (15.96%) and Haridwar (20.07%).

Table 1: Bovine population and trends in Uttarakhand

Category	Number	Percentage	Trends (1997-2003)
Jersey crossbreds	162705		
H.F. Crossbreds	31833		
Total crossbreds	227614	10.40	121.6
Hariana	17590		
Sahiwal	9801		
Red Sindhi	4152		
Total defined cattle	31543	1.44	
Defined and non defined cattle	1960568	89.16	1.76
Total cattle	2188182	100.00	7.83
Buffaloes	1228000		12.25
Total bovine	3417000		9.38

Source: Livestock census, Uttarakhand (2003)

The defined breeds were Hariana (17590), Sahiwal (9801) and Red Sindhi (4152). Hariana and Sahiwal heads were maximum in Haridwar districts and Red Sindhi in Tehri district. Haridwar district had 40% of Hariana cattle and 35.5% Sahiwal cattle available in the state. It was also observed that Haridwar district had the maximum number of cattle belonging to defined breeds. However the proportion of defined breeds was very low at 1.44%. The non-defined cattle were available in maximum number in Podi district (17.76%) followed by Almora (11.62%), Pithoragarh (11.40%), Chamoli (8.82%) and Nanital (7.31%). It was revealed that hill districts had more number of indigenous non-descript cattle and plain districts had higher proportion of crossbred cattle. Among indigenous cattle, only 1.44% belonged to a defined cattle breed. Hill cattle of Uttarakhand being in majority in the state necessitated its appropriate characterization.