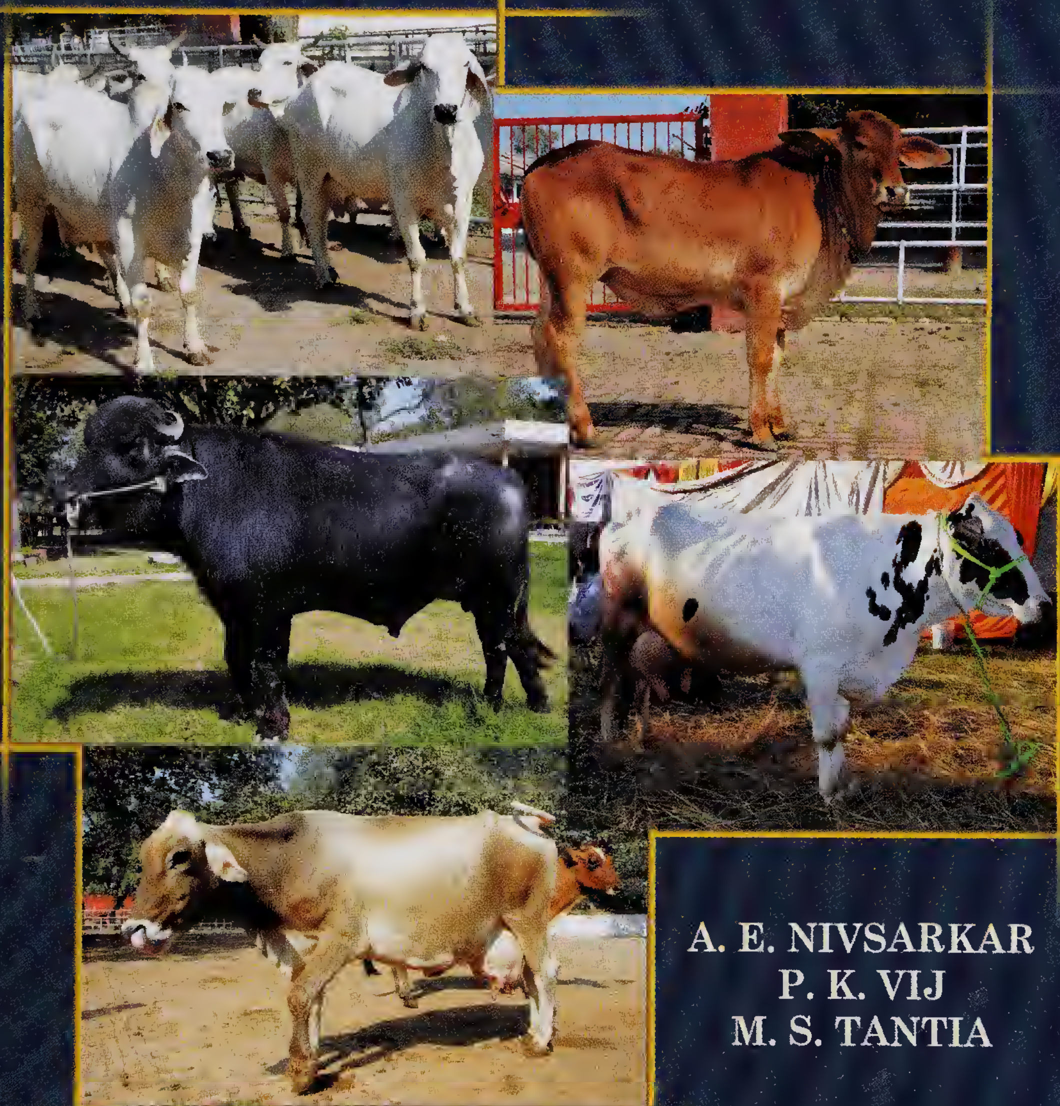
ANIMAL GENETIC RESOURCES OF INDIA

CATTLE and BUFFALO



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भाकृअनुप
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INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI

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Cattle And Buffalo

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New Delhi-110 012

Printed : March 2000
Reprinted : March 2013

Project Director (DKMA) : Dr Rameshwar Singh
Incharge (English Editorial Unit) : Dr R P Sharma
Assistant Editor : Aruna T Kumar
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Chief Production Officer : Dr V K Bharti
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ISBN : 978-81-7164-125-3

Price : Rs 700

Published by Dr Rameshwar Singh, Project Director, Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, Krishi Anusandhan Bhavan, Pusa, New Delhi and Printed at M/s Chandu Press, D-97, Shakarpur, Delhi-110092

FOREWORD

The vast diversity of animal genetic resources available in India have considerable adaptability to local environment particularly tolerance to heat and tropical diseases, and are eminently suited for economic purpose. In India, most of the cultivated land is small and fragmented, and bullocks are required for various agricultural operations. Cattle and buffaloes are therefore indispensable components of our agriculture. Buffaloes are mainly kept for milk, yet their males are extensively used in draught work, mainly traction and transport, especially in marshy areas.

There are 30 breeds of cattle and 10 breeds of buffaloes in addition to a large number of nondescripts. The total population of well-defined breeds has not been estimated. The majority of cattle breeds are small in size and have low productivity. These breeds are distributed in different agro-climatic conditions. The geographical location of each breed and marking of their main breeding areas on maps have been attempted.

In each breed, as in any population, there are gradation of morphological features or production. Many of the breeds may not be intrinsically different from one another but their distinctiveness is in respect of external conformation and appearance. It is difficult to comprehend a type of breed unless a comparative picture is available. This book presents excellent photographs of different indigenous breeds with full description of important characteristics and their habitat, and would serve as an important material for students at all levels, research workers, policy planners and common people.

The characteristics of breeds defined earlier were based on isolated studies mostly maintained in organized herds. Evaluation of breeds *in situ* is a very important component of sustainable animal production. The breed characterization procedure and evaluation strategies for different indigenous cattle and buffalo breeds described in this book will be useful in project planning and implementing animal conservation programmes.

The compilation of information on lesser-known cattle and buffalo breeds is also a very good attempt by the authors. These breeds would be considered for detailed studies in times to come and may be added to rich reservoir of already defined breeds. The data depicted in appendices provide information on these two species of livestock. The authors deserve appreciation for their valid attempt in compiling such a useful book.

(R.S. PARODA)
Secretary, DARE and Director General, ICAR

PREFACE

ANIMAL Genetic Resources contribute to a great extent to the agrarian economy of the country. The cattle and buffalo constitute major portion of domesticated animal genetic resources. They are the backbone of the agriculture and dairy industry having distinct utility in the various agro-climatic conditions. Cattle and buffalo breeds have been evolved through selective breeding by the farmers/breeders using the traditional and scientific knowledge, and today we have 30 recognized breeds of cattle and 10 of buffaloes. Cattle and buffaloes account for nearly 75% of the gross output of the livestock sector.

The breeds were initially identified and described in early 30s on the basis of a few undefined subjective parameters. Over the years mechanization of agriculture and intensification of animal husbandry have greatly changed animal genetic resources scenario. A few specialized breeds have recorded increased utility while others either due to limited use or utility have lost ground.

Identification and description of these breeds was felt necessary for conservation and judicious utilization. Information on cattle and buffalo breeds of India is very scanty. During the last five decades, cattle and buffalo husbandry has seen a sea change and the situation has completely altered due to various natural and artificial forces. Most of the students of Animal Sciences do not get a chance to see all the breeds, and find it difficult to identify and differentiate between breeds.

This book gives detailed account of the cattle and buffalo genetic resources along with distribution maps and coloured photographs. We hope, this will help in better understanding of the breed characteristics. Besides breeds, this book also deals with other important aspects like origin and distribution, breed improvement programmes, strategies for improvement and conservation, and latest statistics in cattle and buffalo genetic resources in India.

We are grateful to Dr R.S. Paroda, Secretary, DARE, Ministry of Agriculture and Co-operation and Director-General, ICAR, Krishi Bhavan, for his keen interest, encouragement and granting permission to publish this book by the Directorate of Information and Publication on Agriculture, ICAR. We are greatly indebted to Dr M. L. Madan, former Deputy Director-General (Animal Sciences), ICAR, for his constant encouragement and guidance.

We thank Shri R. R. Lokeshwar, former Chief Editor, Directorate of Information and Publications on Agriculture, ICAR for his efforts in helping us in developing the book and constructive criticism which has helped in improving the quality of the manuscript.

We acknowledge the help of Dr S.D.Sharma, Director, Dr Randhir Singh, Principal Scientist and In-charge, GIS Laboratory, and Dr Anil Rai, Scientist (Sr Scale), IASRI, New Delhi, for providing GIS facilities to prepare distribution maps.

We thank the Directors of State Animal Husbandry Departments and State Agricultural Universities, especially of Punjab, Haryana, Sikkim, Rajasthan, Uttar Pradesh, Tamil Nadu, Madhya Pradesh, Maharashtra and Gujarat, for their constant help during the surveys conducted by the NBAGR, Karnal. We thank Dr Sosamma Iype, Professor, Kerala Agricultural University, Thrissur, for providing information on Vechur; and Dr E.K. Charyulu, Retired Professor, Acharya N G Ranga Agricultural University, Hyderabad, for providing information and photographs of Punganur cattle. Thanks are also due to Dr N. Kandasami, Professor, Veterinary College, Namakkal, and Dr K. R. Tajane and Dr J. V. Solanki, Professors, Gujarat Agricultural University, for providing valuable information. We thank our colleagues Dr S.C. Gupta, Dr Neelam Gupta, Dr Goutam Sahana, Dr Anand Jain, Dr R.K. Vijh, Dr Gurmej Singh and Shri Avnish Kumar who have not only helped us in collection of information but also in the development of the manuscript. Shri Moti Ram, Photographer has been responsible for the excellent photographs in this publication. The help rendered by Smt Anita Chanda and Smt Indu Bala in the form of secretarial assistance; Shri Sanjeev Mathur in computer formatting the manuscript; and Shri Satpal, Draftsman in preparing distribution maps is duly acknowledged. Shri Subhash Chander, T-2 and other staff assisted us directly/indirectly in collecting information from the field and writing of this book.

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CONTENTS

1 INTRODUCTION

LIVESTOCK farming is an age-old tradition for millions of Indian rural households. Livestock play a pivotal role in the agrarian economy. Nearly 70 million rural households own livestock of one kind or the other, and 60 million among them own either cattle and/or buffaloes. Almost two-thirds of these families are resource poor, being small and marginal farmers or landless agricultural labourers. Livestock farming is a major source of supplementary income for 73% of rural households. There is less inequity as regards the livestock holding than the land holding. Throughout the country the average livestock holding in general and cattle and buffaloes in particular is 2-3 head per family. Each household is virtually a self-contained production system fulfilling its own requirements with no purchased inputs and in the process also generating a little income.

Animal husbandry is the most important activity in rural India next to crop production. Cattle and buffaloes form the backbone of agriculture and dairy industry in India, and have played an integral role in the cultural and socio-religious development of civilization. In addition to milk, they provide much of the draught power for farm operations and transport, meat, hides and dung throughout the Indian subcontinent.

Livestock sector has been one of the few leading growth sectors in rural India over the past five decades of post-independence and its contribution to the GDP has increased from about 5% in 1980-81 to about 10% in 1997-98, whereas agriculture as a whole has gone down in its contribution from 34 to 26% over the same period. The share of livestock in agricultural gross domestic product has risen from about 17% in 1980-81 to 26% in 1996-97 (Birthal *et al.*, 1999). This, in turn, is about 26% of the total gross domestic product (GDP) of the economy. Outputs of different livestock species have been growing at annual rate ranging from 4 to 7% and are comparable to that achieved by other important sectors of the economy. The value of output of livestock sector has grown from about Rs 58,950 million in 1950-51 to Rs 197,940 million in 1991-92 at constant (1980-81) prices. This indicates a three-fold increase in 41 years, which is at par with the growth in the agricultural sector (Kohli and Kulshreshtha, 1997). Livestock sector has also been a great source of employment and employs 8% of the labour force. Nearly 36.07 million man years were employed during 1987. This is a rural self-employment sector with a steady increase of 4.5% per annum as compared to only 1.75% in rural employment and 1.1% in agriculture (Project Report, 1997). This has another advantage as almost 90% of rural women are engaged in cattle/buffalo rearing. Investment in this sector can bring substantial prosperity to rural areas. The Government of India is providing Rs 4,000 million for animal sector annually but 90% of the amount is used for the salary of the staff.

Cattle and buffaloes are the most preponderant species among all livestock in India and they account for over 75% of the total output value of the livestock sector. In 1996 among all the farm produce, milk emerged as the single largest contributor to Indian agriculture, both in quantity and value terms. Cattle and buffaloes generated output valued at Rs 295 billion in milk, Rs 31 billion in work/draught, Rs 43 billion in dung and some Rs 40 billion in meat, hides and offal out of a total output value of Rs 470 billion for all livestock produce in 1991 (Project Report, 1997). In 1992 the country had 204 million cattle and 83.5 million buffaloes registering a growth of nearly 32% over the 1951 population in the case of cattle and almost doubling in the case of buffaloes. The annual growth between 1987 and 1992 was 0.48% in cattle and 1.91% in buffaloes.

The radical changes within the cattle population over the last two decades indicate a shift in the priority of the farming community from production of work animals to milch animals. The proportion of females in the population increased steadily with 1972 as the turning point. Between 1972 and 1982 the number of working males in the cattle population declined sharply (by 12 million); among females the proportion of adult females increased (63% in native and 61% in crossbreds). There was a gradual but steady decline in the proportion of native cows and phenomenal growth in that of crossbred cows. Crossbreds increased from 8.80 million in 1982 to 11.59 million in 1987 (+31.70%) and to 15.22 million (+31.32%) in 1992. Uttar Pradesh, Tamil Nadu, Maharashtra, Kerala and Punjab were the states with large number of crossbreds, and together they accounted for nearly 65% in the country in 1992. Northern region has a considerable population of crossbreds (40%), followed by southern region (34%) and western region (15%). Eastern region has traditional rainfed agriculture and is mainly dependent on draught animals for draught power. It has the highest proportion of native cows and lowest of crossbreds (11%).

Increase in buffalo population, particularly after 1970, indicates the preference of farmers and dairy industry for buffalo milk. Buffalo milk fetches higher price than cow milk. The percentage of female buffaloes steadily improved from 72 in 1961 to over 80 in 1991. Among them 64% were adults.

The Indian sub-continent occupies a pre-eminent position in so far as its animal genetic resources are concerned. It is endowed with a veritable gold mine of farm animals and poultry. Animal germplasm of economic utility includes numerous breeds of cattle (30), buffalo (10), sheep (40), goat (20), poultry (18), camel (4), horse (6), mule, pig, donkey, mithun and yak. India possesses 1/9th of all the recognized cattle breeds and almost all the recognized buffalo breeds of the world. Besides these, there are lots of other strains/varieties that need to be evaluated to be considered as distinct breeds.

Despite being a reservoir of vast genetic diversity, our farm animals still remain under-developed in terms of genetic improvement and production. It is indeed a strange paradox that though India possesses a vast population of farm animals which continues to increase even after being far in excess of the stocking capacity, yet the economic returns are distressingly less remunerative. Traditional and often unscientific animal husbandry practices coupled with other factors like chronic shortage of feeds and fodder, grossly inadequate health-cover and over-population of low yielders have reduced the productivity of Indian farm livestock than of their European counterparts. It would be pertinent to mention here that powerful and influential Animal Breed Associations or Societies exist in Europe and America which not only extend their patronage but also espouse the cause of breeds for development and upkeep of their genetic purity. Such bodies still do not exist in India and are needed. The Rare Breed Survival Trust of the UK and the Minor Breed Conservancy of the USA are models worthy of emulation by conservationists. Too many established Indian breeds have either lost their identity or have undergone substantial dilution and degeneration due to infusion of exotic germplasm and breed replacement. All these development efforts warrant our concern and attention.

Identification and description of the breeds were initially done in early thirties on the basis of a few undefined subjective parameters. The extent of genetic variability prevalent in native livestock breeds was not taken into consideration in the description of animals. Over the years, intensification of animal husbandry and widespread introduction of exotic breeds have completely altered Animal Genetic Resources scenario. There is perceptible increase in a limited number of specialized breeds, while several indigenous livestock and poultry breeds have suffered decline and degeneration over the years, mainly due to their being uneconomical in the present-day production system. Their admittedly low levels of production are offset by their ability to thrive on less food and food of lower quality than crossbred cattle, and thus to produce some milk or meat where the latter can not survive. Usefulness of various types of animals particularly their genetic worth has not been fully explored. In such a situation, it cannot be postulated as to which animal type would be required in future and when. Hence, the need for conservation of diverse animal types and breeds as a part of genetic security.

There is a growing realization all over the world that conservation and judicious utilization of all forms of genetic resources are of paramount importance for the continued survival of human race. Life-sustaining biological molecules, in over 4,000 million years of evolution, have undergone sea changes under the impact of forces of natural selection and to a lesser extent due to human interventions. This process bequeathed immense richness in the form of infinite varieties of species in plants and animals. We, of the present generation, are merely custodians of genetic wealth and owe it to the future and posterity to pass on this genetic diversity untampered and intact. Unfortunately, in recent past mankind has been depleting, damaging and even manipulating this wealth for short-term gains unmindful of perilous consequences.

The need for conservation of animal genetic resources has been accepted globally for sustainable development. The conservation of Animal Genetic Resources is now a multidimensional activity which encompasses not only preservation and maintenance of existing breeds but also their improvement and proper management. The overall aim is sustainable utilization, restoration and enhancement of resources so as to meet the needs of mankind at present and in future.

Earlier some efforts were made to document the information on livestock breeds in the form of books (Joshi and Phillips, 1953; Payne, 1970; ICAR, 1979; Bhat *et al.*, 1981; Singh and Moore, 1982; Basu, 1985; Bhat and Taneja, 1987; Maule, 1990; Payne and Hodges, 1997). But all these books except the one by Joshi and Phillips (1953) have very limited information on the livestock breeds in India. The emphasis, therefore, is on other aspects of livestock production. The book 'Zebu Cattle of India and Pakistan' by Joshi and Phillips (1953) was published about 45 years back. Though this served the purpose very well at that time but there are lot of changes during the last 5 decades in livestock production owing to selection pressure, both natural and artificial. Priorities of the farming community have also changed over the years. As a result of these factors, the total scenario has changed. Distribution of some of these breeds has extended to more areas while for others it has shrunk. A few of the breeds are nearly extinct and some new ones have found their way into the list during these years. Moreover, the characteristics of these breeds have also undergone considerable changes due to adaptation to agro-climatic conditions and market demand. None of the earlier books contained detailed information on their performance, maps showing distribution of breed and coloured photographs. Some publications contain only one black and white photograph of a breed. Most of the students and even the faculty of animal sciences do not get a chance to see all the breeds and find it difficult to identify and differentiate between breeds.

This book contains a detailed account of cattle and buffalo genetic resources of India along with distribution maps and colour photographs. The authors hope that this will help in better understanding of the characteristics of these breeds and differences among them. Efforts have been made to include the latest information as far as possible by conducting surveys in native tracts of these breeds. Some information is also given on the breeds which are not recognized but their names exist either in literature or are known locally. Besides breeds, this book also deals in other related aspects like origin and distribution of breeds, movement of germplasm, genetic architecture, breed improvement programmes, evaluation of breeds under field conditions, and strategies for improvement and conservation. Latest statistics on cattle and buffalo genetic resources of India are also included in this book. It is hoped that this book will be of interest to students, professionals and policy planners, and will help in understanding characteristics of different breeds and planning strategies for their improvement and conservation. □

2 ORIGIN AND DOMESTICATION

CATTLE

Evolution

DOMESTICATED cattle (in the strict sense of the word) are the descendants of a group of races of *Bos primigenius,* the **urus** or **aurochs**. Their economic significance increased as civilization advanced, and today they are the most important of all the domesticated animals as producers of meat, milk, energy and hides. It is certain that domestication was undertaken before 4000 BC, but nothing is known of its actual beginning. The aurochs are said to have been domesticated before 6000 BC (Mason, 1987). Many theories have been postulated about types of wild cattle.

Wild cattle belong to the genus *Bos*, which is different from that of the bison (*Bison*), the yak (*Poephagus*) and the gaur (*Bibos*). But these so-called genera are so closely related that they can interbreed and produce fertile progeny. Some authorities have given recognition to this by uniting all bovine cattle in one large genus *Bos*. They all belong to the sub-family Bovinae. The relationship between wild and domestic species is shown in Fig.1.

The true cattle (*Bos* in the strict sense) is most closely related to the south Asiatic gaur and banteng, from which it appears to have separated in the course of the Upper Pleiocene (Fig.2). *Bos acutifrons* has been said to occur in the Siwaliks of India. Pilgrim (1939) regarded it as the possible ancestor of the Pleistocene wild cattle, i.e. of both *Bos nomadicus* of India and *Bos primigenius* of Europe (Zeuner 1963). Some observed that separate species of wild cattle existed in South Asia, North Africa and Europe. Epistein and Mason (1984) proposed separate geographical races, viz. *Bos primigenius nomadicus* in South-West and southern Asia, *B. primigenius primigenius* in northern Asia and Europe, and *B. primigenius opisthonomus* in Egypt and northern Africa. An Asiatic origin of the group is possible, because the aurochs are rare or altogether absent in the Lower Pleistocene of Europe.

The external appearance of wild cattle is well known. The last survivor died in a Polish park in 1627. Several good descriptions of it including illustrations are available. Bulls were large, up to 1.95 m at the shoulder, and often equipped with very long horns. The best surviving picture was recorded by the British Zoologist Hamilton Smith in an Augsburg shop early in the last century (Zeuner, 1963). It must be noted, however, that it does not represent the large type of bulls which were so common in the late

Sub family	Group	Genus	Wild species	Domesticated species
Bovinae	Bovina	Bos	*Bos primigenius* Bojanus (extinct)	*Bos taurus* breeds (cattle)
				Bos indicus breeds (cattle)
		Bos (bibos)	*Bos (bibos) banteng* Wagner (benteng: tsine)	*Bos (bibos) banteng* (cattle)
			Bos (bibos) gaurus Smith (gaur: seladang)	*Bos (bibos) frontalis* (Mithun; Dulong)
			Bos (bibos) sauveli Ubain (kouprey: may be extinct)	
		Poephagus	*Poephagus mutus* Przewalski (yak)	*Poephagus grunniens* (domestic yak)
		Bison	*Bison bison* Linnaeus (American bison)	
			Bison bonasus Linnaeus (European bison)	
	Bubalina	*Bubalus*	*Bubalus arnee* Kerr (Asian wild buffalo: arnee)	*Bubalus bubalus* (all domestic breeds of river and swamp buffalo)
			Bubalus mindorensis Hende (tamarao)	
			Bubalus depressicornis Bohlken — *B.d. depressicornis* (lowland anoa) — *B.d. quarlesi* (mountain anoa)	
	Syncerina	*Syncerus*	*Syncerus caffer* Sparrman — *S.c. caffer* (black or Cape buffalo) — *S.c. nanus* (red or Congo buffalo)	

Fig. 1. Relationship between wild and domestic species of the sub-family Bovinae
Source: Payne and Hodges (1997)

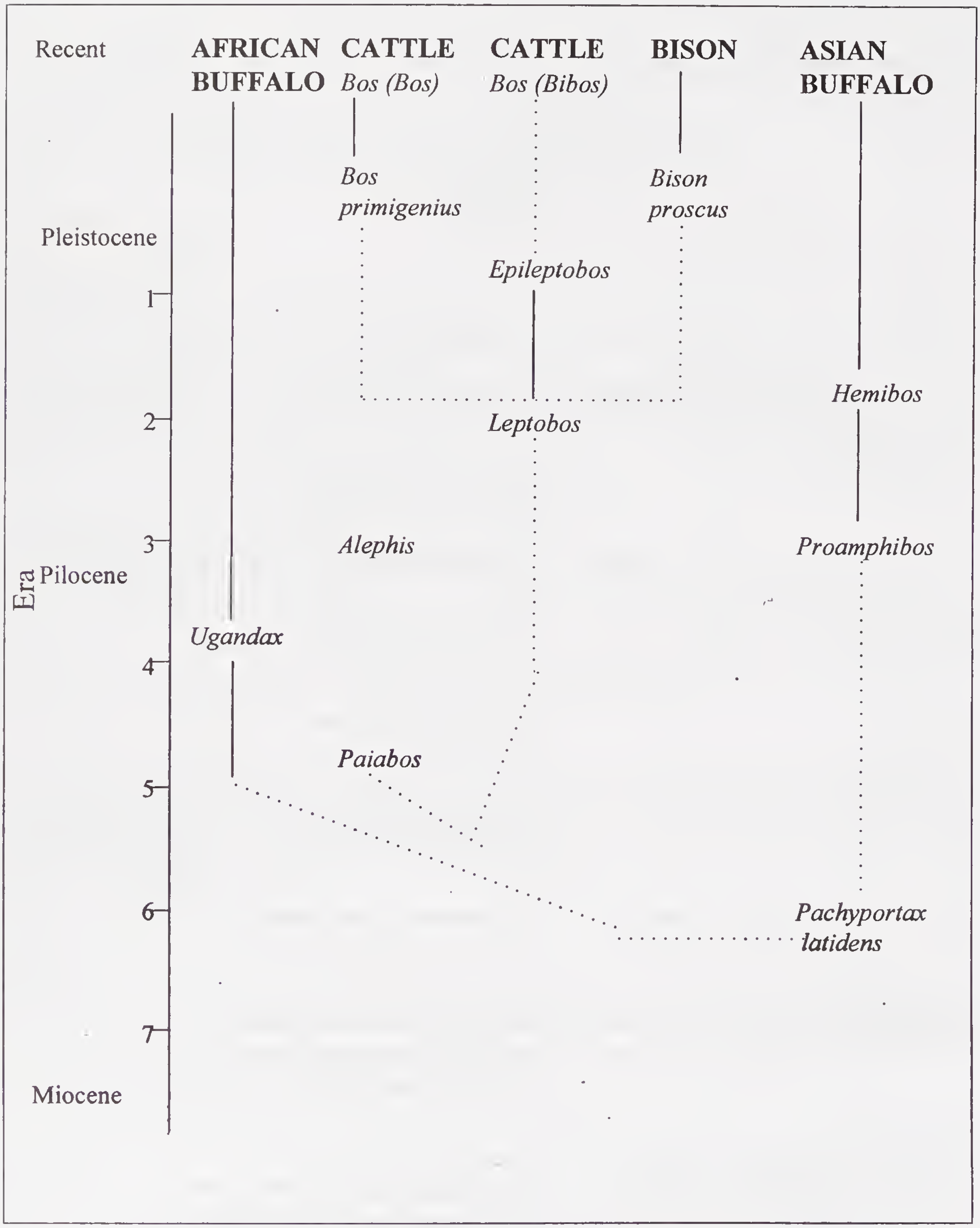


Fig. 2. Possible evolutionary paths for modern species of Bovinae
Source: Payne and Hodges (1997)

Pleistocene and the early Holocene. This type had horns which turned first outward and then forward, with the tips slightly turned upward.

The description of various characteristics of the aurochs, such as size and shape of horn, stature and coloration, are still found in certain domesticated breeds, but all these characters are not found in one breed. In 1921 an idea occurred to Lutz and Heck that it might be possible to reconstitute the aurochs by crossing breeds of cattle that exhibit certain characteristics of the wild ancestor. The attempt was remarkably successful. Heck, the Director of the Munich Zoo, crossed Hungarian, Podolian Steppe, Scottish Highland, grey and brown Alpine, piebald Friesians and Corsican cattle breeds. After some years of breeding 1 male and 1 female having the characters of aurochs were selected. These reconstituted aurochs continued to breed fairly true to type. By 1951 there were 40 oristics of these reconstituted aurochs (Heck, 1951). These aurochs not only appeared but also behaved like wild animals.

The wild cattle on the friezes in the Aurignacian cave of Lascaux in southwest France are so well drawn that they deserve close study. They are the best prehistoric pictures available of the wild ancestors of domesticated cattle, and all belong to *Bos primigenius*. In his monograph on this cave, Windels (1950) attributed certain specimens to *Bos longifrons*, thus implying that a separate wild species also existed at that time.

Domestication

The Neolithic revolution changed the economic life of the human population from hunter/gatherer to farmer/stock breeder. It was a slow and erratic revolution and there is no absolute certainty as to why and where it began (Payne and Hodges, 1997).

There are many evidences which conclude that this revolution began in Western Asia around ca 9000 BC. This region was the primary centre of domestication. Plants were domesticated before animals, and sheep and goats were the first herbivores to be domesticated. As per Payne and Hodges (1997) these were domesticated between ca 9000-8000 BC and cattle some 1,000 years later. They also suggested that apart from Western Asia domestication was also undertaken at other centres and called them copy-cat domestication centres.

As dogs, sheep and goats were already domesticated so the knowledge existed with the human beings of the advantages of domestication. Food was one of the major motives for domestication of the aurochs. The man continued to be a hunter even after the domestication of cattle. The other reason could be to save their cultivated crops from the wild animals.

The size and ferocity of the large beast must have fascinated the man and posed the challenge, and the Neolithic men might have taken up the challenge to have control over the large herbivores. Domestication might have been accidental also (Serpell, 1989). The young calf could have been kept as a pet and nourished by the man. This association might have grown and made man realize the potential of domestication.

Domestication of cattle by Neolithic men must have taken hundreds of years, and many generations of man must have contributed to this. The domesticated specimen certainly had desired characters and were more tractable in comparison to their wild ancestors. With these domesticated livestock the nomadic pastoralists migrated from Western Asia to various other parts in Europe, Central, East and South Asia, and Africa in search of grazing lands.

Zarins (1989) suggested the period ca 5000-3500 BC as migration period of pastoralists with sheep, goat and cattle.

Western Asia

The wild cattle *Bos primigenius* was first domesticated in the region between the Mediterranean and Iran, called the 'Fertile Crescent' (Fig. 3). This is the region where evidences suggest that the wild ancestors *Bos primigenius* and *Bos nomadicus* existed,

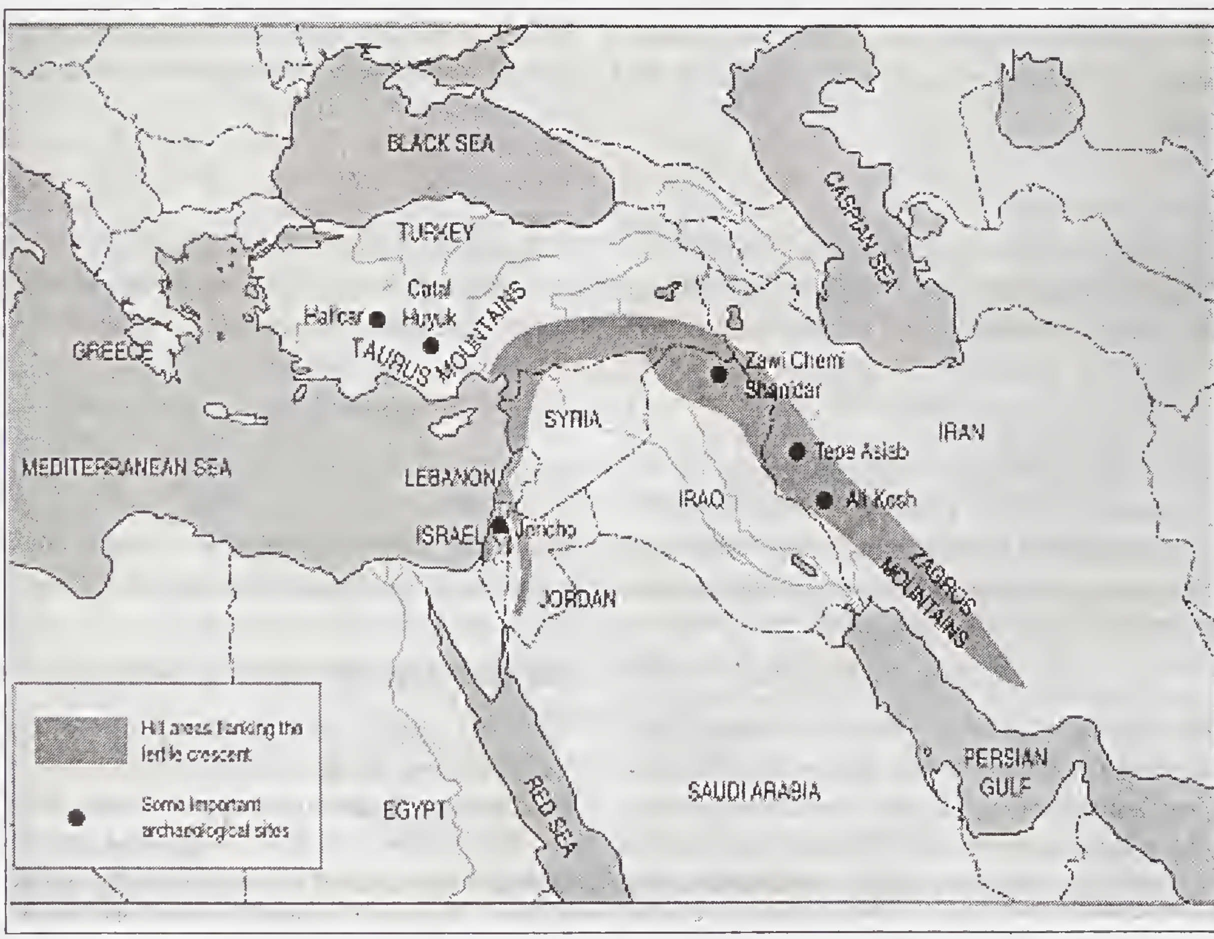


Fig. 3. Western Asia: the 'fertile cresent'

and that the Neolithic revolution was more advanced in this area than in any other part of the world. Payne and Hodges (1997) on the basis of various evidences concluded that emmer wheat and barley were grown by ca 7000 BC and cattle were domesticated by ca 6000 BC. Mixed agriculture was practised and it spread to low lands by ca 5000 BC followed by irrigated agriculture.

The earliest evidence of cattle domestication in Western Asia is from Catal Hwjuk on the Southern Anotolian plateau (ca 6400 BC) where bones of sheep and cattle were found with that of wild animals. There are other sites in the Western Asia where evidences of cattle domestication have been found.

The Western Asia is considered to be not only the primary centre for the domestication of *Bos primigenius* but also the evolution centre of 3 major types of domestic cattle, either within the region or at adjacent centres. The 3 major types of cattle breeds are the humpless long horn (*Bos taurus*), the humpless short horn (*Bos taurus*) and the humped zebu (*Bos indicus*).

The long horn type cattle by their physical characters like long, narrow head, flat forehead, and shape and position of horns resemble *Bos primigenius.* Various anatomical and archaeological evidences also support the theory that the long horn type cattle were the first domesticated ones. The nomadic pastoralists moved with these cattle herds.

Short horn type (*Bos taurus*) are medium sized, and have narrow dished forehead, and small and high set horns. Earlier authors grouped these cattle under *Bos brachyceros* (Owen, 1846; Zeuner, 1962). Hughes (1896) described it as a very small animal, probably not larger than a Kerry cow. However, the Neolithic cattle were not inferior in size to many of the modern breeds. Their small size was probably due to large number of immature specimens found in prehistoric sites. Hescheler and Kuhn (1949) pointed out that small specimens were available at most sites.

The fact that *longifrons* cattle can be distinguished from *primigenius*-derived cattle has aroused controversy. Some believe firmly that wild ancestors must have existed, while others consider *longifrons* as a descendant of the wild *Bos primigenius*. This was also supported by Zeuner (1963) considering the fact that the fossil skulls of male *primigenius* were compared with skulls of *longifrons* cows.

The archaeological evidence for the sudden appearance of a well-characterized, small, domesticated breed is, however, strongly against local domestication, and the centre of origin of the *longifrons* breed was probably outside Europe.

Domestication certainly results in reduction of size. But these breeds were not as small as the Neolithic *longifrons* of Europe. The other possibility of reduced size may be because of unhealthy conditions and starvation diet (Zeuner, 1963). It is evident that large cattle could not have easily moved from place to place, and that a population which lived in temporary settlements and practised shifting agriculture might have preferred large numbers of small-size cattle to small numbers of large-size cattle.

In some cases the *primigenius* and the *longifrons* stocks have been kept comparatively pure. The Alpine cattle, the Jersey breed, and the Shorthorn belong to *longifrons* stock. On the other hand, the Hungarian and Podolian Steppe cattle, the large-horned cattle of the Romagna in Italy, the Scottish Highland race and the fighting cattle of Spain all represent the *primigenius* stock. But crossing has been practised to such an extent that the vast majority of modern breeds must be regarded as intermediates. In Friesian cattle, for instance, it is possible to find skulls ranging from the *primigenius* type to characteristic *longifrons* type (Zeuner 1963).

Pyane and Hodges (1997) also reviewed various theories like the descent from zebu (*Bos indicus*), dwarf type of aurochs (*Bos primigenius*), and Asian urus (*Bos nomadicus*), and common ancestor with long horn type cattle. Epstein (1971) also refuted all other theories except the one of common ancestor with long horn type, and considered that this type of cattle originated in the eastern area of the Fertile Crescent in the mountainous region of Iran.

With the developments in agriculture the situation possibly changed, and smaller and lighter animals were preferred over large long horn type due to easy control. The selection for desired characters over generations led to evolution of short horn (*Bos taurus)* type of domesticated cattle. These became more prominent in Mesopotamia (ca 3000 BC) which coincides with the beginning of urban life. They also spread into Africa, Europe and Asia with migratory people.

Humped Cattle

With its hump, the zebu superficially resembles members of the *Bibos* group of wild cattle, present in India, Myanmar and the Sunda archipelago. Gaus (1915), however, pointed out that the structure of the skull is so different in *Bibos* that the zebu cannot be regarded as a domesticated descendant of this genus. The other possibility would be to assume that the *primigenius* breed of cattle was crossed with a species of *Bibos* (Zeuner, 1963). Hump of the zebu is an enlarged muscle without any support of vertebrae as in the gaur (Mason, 1972). Hump of the *Bos indicus* is different from the crest of *Bibos* spp. *Bos indicus* is more like *Bos taurus* than *Bibos* spp. in most of the body characters, especially the cranial osteology (Grigson, 1980). In spite of these findings it is yet to be explained why humped cattle are restricted to hot and dry climates. The hump is a genetically fixed character already well developed in the calf at birth.

Zeuner (1963) and Naik (1978) advocated that humped cattle existed in India and zebu has originated from *Bos nomadicus* in India. Naik (1978) opined that there were two different centres of domestication in India - one in North and the other in South. The Neolithic culture appeared in India several thousand years later than in Western Asia (Vishnu-Mittre, 1978) and probably the migrant pastoralists introduced domestic cattle. Thapar (1957) and Fairservis (1975), based on archaeological evidences, stated that humpless short horned cattle existed in southern and northern India and became extinct by 400 BC and 800 BC respectively.

There are evidences that *Bos taurus* and *Bos indicus* have been introduced from Western Asia by migrant pastoralists. *Bos taurus,* the humpless cattle, were introduced earlier but due to hot humid environment, did not last long. Meadow (1984) hypothecated that humped cattle were domesticated from Asian urus *Bos nomadicus* in Baluchistan. Payne and Hodges (1997) considered the south-eastern or north-eastern edge of 'Fertile Crescent' or the edge of Iranian desert as the possible centre for domestication of zebu cattle.

The zebu with its long face, steep horns and hump is so distinct an animal that its origin has been discussed frequently. In view of the fact that zebu and *primigenius* cattle were sharply distinguished by the Mohenjo-Daro people, a separate origin of the two is likely. That the *primigenius* breed came from temperate or western Asia is evident from the distribution of their wild ancestor in these parts. In India, however, a closely related wild cattle *Bos nomadicus* is found throughout the Pleistocene and it is conceivable that the zebu is its direct descendant.

Cytogenetic studies of various genera of Bovidae show that the fundamental number in the diploid chromosomal complement is 58 (ISCNDA, 1989). The genus *Bos* has 60 chromosomes: 58 autosomes acrocentric in morphology and 2 sex chromosomes X and Y. The X-chromosome is sub-metacentric in morphology. The difference in the morphology of Y-chromosome in *taurus* and *indicus* also show that they had different ancestors. The Y-chromosome is sub-metacentric in *taurus* and acrocentric in *indicus.* Even with various types of high resolution bandings like GTG, RBG and QFQ the idiogram of individual chromosomes could not yield any difference between zebu and *taurus* in any other chromosome. The morphological difference in the Y-chromosome was also revealed by high resolution banding. The difference in morphology may be due to pericentric inversion in the Y-chromosome. This view is held to be correct by the recent research on mitochondrial DNA which confirms that African and European cattle had an ancient separation. *Bos indicus* and *Bos taurus* have an estimated lineage divergence time of 200 000 to 1000 000 BC (Cunningham *et al.*, 1994; Meghen *et al.*, 1994; Bradley *et al.*, 1996).

Some authors have held the opinion that the zebu was introduced into India from Africa. There is no pre-historic evidence to support this, nor is there any palaeontological evidence, as no wild race of *Bos* is known from tropical Africa in the Pleistocene. One might think of southern Arabia as a possible country where zebu could have originated, but there is absolutely no evidence available for or against such a view. Its presence in very early pre-historic sites in India makes its Indian origin virtually a certainty. The Indus Valley civilization has provided abundant representations of humped cattle, especially from Mohen-jo-Daro. The zebu became popular in Egypt in New Kingdom times. There are many illustrations dating from the eighteenth dynasty. Two kinds appear to have been bred - a short horned one and one with normal sized horns.

Spread of Domestic Cattle in Indian Sub-continent

The domestic cattle appeared in the northwest region of the sub-continent from Western Asia after 3,000 years. The Harappan civilization in the Indus Valley dates from ca 2300 BC. The valley had a well-developed low-land agricultural system and extensive livestock husbandry. Fairservis (1975) predicted that the tradition of food production was derived from Iranian culture which in turn received such cultural traits from Mesopotamia. These cattle slowly spread through pastoralists to the Deccan. *Bos taurus* cattle became extinct by ca 400 BC in the Deccan also. Pastoral people herding their livestock also moved eastwards from the Indus to the valley of Ganges and came in contact with the rice-cultivating people. These cattle were introduced into Bihar and Bengal by ca 1500 BC (Payne and Hodges, 1997). According to the Rigveda, Aryans with their cattle, sheep, goats and horses invaded the Indus Valley and introduced *Bos indicus* type of cattle into India. Payne and Hodges (1997) assumed that *Bos indicus* type cattle were introduced as far south as Karnataka and as far east as Bengal by ca 1500 BC.

The cattle were used for the production of meat until the ban on cow slaughter that is considered to have been activated by Hindus about 2,000 years ago. According to Thomas (1989) cattle were also used for sacrifice, a practice that continues among non-Hindu people in the northeast region of the sub-continent. No direct evidence of dairy industry was found until ca 1300 to 1200 BC. Wheeled carts pulled by bullocks were known in pre-Harappan cultures. They were certainly common in the Harappan period, terra-cotta wheeled carts being found in Mohenjo-Daro and Harappan excavations (Allchin and Allchin, 1968).

BUFFALOES

There are two quite distinct groups of buffaloes, viz. Indian and African, classified under genera *Bubalus* and *Syncerus*. Of these the African has never been domesticated. The latter are distributed over the whole of the non-arid parts of Africa and ocurred in northwest Africa well into the Neolithic, if not later. The only African area where they appear to have been absent is Egypt.

The true Indian buffalo or arnee was originally confined to India and Sri Lanka. These large beasts lived in grass jungles near the water in which they liked to wallow. Domesticated buffaloes have retained this habit. They have changed very little, compared with their wild ancestor. Interbreeding with wild specimens is quite frequent. The Indian buffalo, given the specific name *bubalus* by Linnaeus, has a thin coat of hair which it loses with age (Cockrill, 1974). Hair is black or reddish; very rarely white specimens occur in nature. Horns are flat above and strongly ribbed, a character that distinguishes them from other members of Bovidae. They are more closely related to yak, bison, gaur and banteng than to cattle.

Domestication of the buffalo took place at an early age. Buffalo's proximity to man became possibly due to its crop destroying nature. These are known to be domesticated during Indus Valley civilization (3250 to 2750 BC) as evident from seals and recovery of bones from Mohen-jo-Daro sites which has been further confirmed from archeological finds in the Deccan plateau (Nagarcenkar, 1975).

The buffalo's westward progress has been slow and restricted, but the beast proved to be an outstanding success in the Far-East. From India its use spread to Indo-China and the Sunda archipelago. It first reached China and then Japan. In all these countries it is of real importance in connection with rice-growing. The muddy rice fields are the very environment in which buffaloes thrive. This close association may be regarded as evidence that the original domestication of the buffalo was located in the rice-growing area, and it is conceivable that it lay in Indo-China or South China rather than in India. But there is no archaeological material to support this view (Zeuner, 1963).

The domesticated buffalo is found in southern and western China, particularly in the swampy lowlands, where rice is cultivated. In such places buffaloes are considerably more resistant to diseases than cattle. In northern China they are gradually replaced by cattle of various types. Breeds are distinguished by body size, length and shape of horns, degree of hairiness and colour. It varies in height from 110 to 150 cm at the withers. Horns may be as much as 1 m long. Cross-sections of the horn often retain the triangular shape characteristic of the wild species.

The buffalo is first and foremost a beast of labour, employed in the preparation of rice fields, pulling of carts, and working of mills and wells. It is comparatively stronger than domestic cattle.

From the domesticated stocks of cattle and buffaloes various specialized breeds have been evolved according to need and climate of the region. These breeds have been developed through systematic selection for the desired traits. They are now being bred pure for these traits and are being continuously improved by artificial selection as well as natural evolution.

□

3 MOVEMENT OF GERMPLASM

In India there is vast and varied biodiversity in farm animals distributed over its large geographical area. Various breeds of different species of domestic livestock have been developed over the centuries through natural selection in different agro-ecological zones and in the process they acquired adaptation to hot climatic stress and resistance to diseases. These breeds have been exported to various tropical countries to upgrade the local livestock for improving milk production, draughtability and other animal uses. Cattle and buffaloes particularly in the neighbouring countries represent a variable mixture of several Indian breeds. These breeds were imported mainly for their hardiness, heat tolerance and tick resistance qualities as well as high butter-fat content of milk.

CATTLE

The Indian zebu cattle are now spread to various countries particularly to hot and tropical regions in Africa, Asia, North and South Americas, and Australia (Table 1). The history of the movement of Indian breeds to other countries shows that although several cattle breeds were involved only three have actually left their mark. These are Ongole, Gir and Kankrej. Brazil and southern states of the United States of America imported quite a good number of Indian zebu cattle. These cattle were also imported by Jamaica, Cuba, Trinidad and other Caribbean countries.

Indonesia, Malaysia, the Philippines, Fiji, Afghanistan, Thailand, Cambodia, Vietnam, Sri Lanka, Nepal, Korea, Iran, Iraq, Saudi Arabia in Asia; Kenya, Tunisia, Tanzania, Seychelles, Mauritius in Africa; the USA, Brazil, Cuba, and the Caribbean countries in North and South Americas; and Australia are some of the countries where Indian zebu cattle had been exported and utilized in cattle-breeding programmes.

Introduction of Indian Breeds to Different Countries

Brazil

Some zebu cattle were shipped to Brazil during 17th and 18th centuries, and were crossbred with Brazilian cattle of Iberian origin (Santiago, 1978).

The first reliable records of imports date from 1875 when a zebu bull and a cow were taken to Rio-de-Janeiro from the London Zoo. This was followed in 1881 by the import of the first Kankrej (Gujarat) bull. Systematic importations from India began at the end of the 19th century and continued until 1930, with one further importation in 1952.

The first large-scale purchase in 1906 consisted of 50 head, and included Hisar, Malvi, Mewati and Mysore cattle. Between 1918 and 1921 much larger importations

Table 1. Export of Breeds from India to Other Countries

Breed	Homeland	Exported to
Ongole (Nellore)	India	Brazil, USA, Sri Lanka, Indonesia, Fiji, Indochina,Malaysia, West Indies, Australia, Jamaica, Switzerland, Argentina, Paraguay, Mexico, Columbia, Mauritius and Philippines
Kankrej (Gujarat)	India	Brazil, Mauritius, Taiwan, from Brazil to Mexico and USA
Krishna Valley	India	Brazil and USA
Gir	India	Brazil and thence to USA, Venezuela, Mexico, Cambodia, Nepal and Myanmar (Burma)
Red Sindhi	Pakistan and India	Afghanistan, Nepal, Myanmar, Cambodia, Vietnam, Malaysia, Brunei, Bangla Desh, Thailand, Sarawak, Sri Lanka, Indonesia, Philippines, Taiwan, Korea, Iran, Iraq and Saudi Arabia in Asia; Tunis, Kenya, Tanzania, Seychelles and Mauritius in Africa; the United States of America, Brazil and Cuba in America
Sahiwal	Pakistan and India	Mauritius, Kenya, Tanzania, Sierra, Leone, Malaysia, Philippines, Vietnam, Thailand, Myanmar, Bangladesh, Sri Lanka, Nepal, Brazil, Jamaica, Trinidad, Australia and New Zealand
Mysore breeds (Kangayam, Amritmahal)	Southern India	Sri Lanka, Brazil and Malaysia

took place, mainly of the big grey-white cattle of northern India, including Kankrej, which the Brazilians called Gujarat, later changed to Gujera, Nellore (spelt Nelore in Brazil), Bhagnari, Krishna Valley, Hariana and Gir. Between 1890 and 1921 over 5,000 zebu cattle were exported to Brazil from India. In 1930, the Brazilian Government imported 192 cattle of Gir, Nellore and Gujarat, and these have been maintained in pure form since then. In 1962, Kangayam animals were also imported.

Large number of zebu cattle were exported from India to Latin America every year till there was cessation due to outbreak of the First World War. The imports to Brazil were resumed again in 1918 but were discontinued for some years since 1930 for fear of outbreak of rinderpest.

Three breeds, viz. Gujera, Nelore and Gir, have played a major part in the Brazilian cattle industry. By 1960 there were 48,500 registered zebu cattle, of which the Gir accounted for 36%, Indo-Brazilian 36%, Nelore 18% and Gujera 3%. However, today the Nelore is probably the most numerous breed. Nelore continued to increase in popularity as a beef animal because of tight sheath. Brazil has also herds of Sahiwal and Red Sindhi cattle.

Asian Countries

Amongst Asian countries, Taiwan imported Kankrej and Red Sindhi breeds during 1894 to 1945 to improve body size and draughtability of local Taiwan cattle. Majority of Taiwan draught cattle now show the influence of these two breeds, and the graded animals have been named as Taiwan Zebu. The Philippines imported 1 bull and 7 cows of Red Sindhi in 1932, and 2 bulls, 36 cows and 16 calves in October 1934, and developed a Red Sindhi purebred breeding herd at Alabang Stock Farm, Bureau of Animal Industry. In 1950 another import of 6 Sahiwal bulls, 9 cows, 71 heifers and 2 calves was made from India. In the Philippines, the Sahiwal was also used for crossbreeding with Brown Swiss in order to evolve a dairy cattle breed. During French occupation, Vietnam imported Red Sindhi, Hariana and Sahiwal. Thailand imported Tharparkar in 1980. Some South Asian countries like Indonesia, Malaysia and Thailand imported Indian zebu crossbred cattle heifers from Australia and New Zealand.

Kenya

Kenya is the third leading country with major Sahiwal cattle genetic resources primarily developed from Sahiwal cattle acquired from India and Pakistan. It serves as an important source of breeding stock and germplasm for whole of the African continent. In 1939, improvement of Kenya's local cattle through upgrading was started with import of 4 Sahiwal bulls from Pusa, India. By 1963, 60 bulls and 12 cows of Sahiwal cattle from India and Pakistan were imported. A national Sahiwal herd has been established at Naivasha for futher improving and utilizing its germplasm for propagation, upgrading and crossbreeding with temperate cattle breeds.

Ongoles

Ongoles are our mute ambassadors to several countries. South American countries keep pure Ongoles (Nath, 1981). The United States of America imported the Ongole but mixed it with other Indian breeds to develop Brahman. South America developed Indu-Brazil by mixing Ongole with Gir and Kankrej. The last shipment of Nellore bulls into Jamaica was in 1921. Until mid-1920s, most of the zebu cattle in the USA were of Nellore type.

Brazil imported Ongoles first in 1875. In 1906, a large contingent of 200 Ongole cows and bulls was brought to Uberaba in Brazil. During 1961-62 Brazilians purchased 107 Ongole cows and a few bulls. Between 1890 and 1921, more than 5,000 zebu cattle were taken from India to Brazil (Sreemannarayana, 1981). While early Indian cattle taken to Brazil were of Mysore type, after 1900 many Nellores were also imported.

The first import of an Indian bull and cow into the USA was in 1854. In 1878 the USA imported 4 bulls and 1 cow. In 1885, it imported 2 Nellore bulls. Again in 1890, 1 Ongole bull and 1 cow were imported. Most of these bulls and the 3 cows were of Ongole breed. Of the 9 Indian breeds, viz. Sindhi, Sahiwal, Gir, Kankrej, Ongole, Hallikar, Kaṇgayam, Hisar and Krishna Valley, introduced into other countries Ongoles were in largest numbers and are the most widely distributed (Nath, 1993). Traits of hardiness, disease resistance and capacity to thrive on scanty and dry fodder by Nellore and Ongole breeds have been quite successfully exploited for improving and upgrading the local stock of European origin.

Ongoles have been imported by the USA for beef, Brazil for beef and milk, Sri Lanka, Fiji and Jamaica for draught, Australia for heat tolerance and beef, and Switzerland for disease resistance. Ongoles have been imported by many other countries like Argentina, Paraguay, Mexico, Columbia, Mauritius, Indonesia, the Philippines and Malaysia (Rao, 1995).

Contribution of Indian Cattle to the Development of Synthetic Cattle Strains

Different Indian cattle breeds exported to foreign countries have been maintained as purebreds in some cases, but were mainly used for crossbreeding with cattle breeds of temperate countries and upgrading the native cattle of these countries. Crossbreeding for combining characteristic features of hardiness, adaptation to climatic stress and resistance to tick-borne diseases of Indian zebu cattle with high milk and beef productivity of cattle breeds of temperate countries resulted in creating various internationally reputed synthetic crossbred cattle breeds. Some of these are described in the following pages.

American Brahman cattle

Brahmans are like Indian humped zebu cattle. They had been developed in the Gulf area of the South-West USA between the years 1854 and 1926. Different cattle breeds of Indian origin, viz. Kankrej, Ongole, Gir, Krishna Valley, Hariana and Bhagnari, are considered to be used as constituents of Brahman cattle. The foundation stock of Indian cattle were either imported directly into the USA or indirectly through Brazil and Mexico. Brahman cattle normally have very light grey coat colour but red, or black coat-coloured animals are also found. This breed has been developed essentially for beef production.

In the USA and many other countries, it has been widely used for crossbreeding purpose, particularly to produce zebu × temperate beef cattle breeds that are well adapted to tropical and sub-tropical environment. Brahman, as zebu cattle breed, had also been used in crossbreeding the Aberdeen Angus, Hereford and Charolais resulting in Brangus (Brahman × Angus), Brayford (Brahman × Hereford) and Charbray. Santa Gertrudis, another crossbred cattle breed with 3/8 zebu cattle and 5/8 shorthorn cattle, was developed in Texas, USA.

Jamaica Hope

This cattle breed has been developed from a herd established in Jamaica in 1910. Different temperate region cattle breeds, viz. Holstein-Friesian, Jersey, Ayrshire and Red Pole, were introduced to the originally stocked Criollo cows. Indian cattle inheritance was introduced in the formation of Jamaica Hope in 1920 through 2 Sahiwal bulls imported from Sahiwal herd at Pusa, India. The Jamaica Hope cattle breed constitutes about 70 to 75% of Jersey and about 20% of Sahiwal and small fraction of Criollo cattle. The Jamaica Hope resemble more to Jersey. They are now widely distributed throughout Jamaica and have been exported to other Caribbean and Central and South American countries.

Indu-Brazilian Crossbred Cattle

In Brazil various types of Indian cattle had been maintained as separate cattle breed herds. Some were interbred resulting in the formation of Indu-Brazilian crossbred cattle breed. This breed was developed through indiscriminate crossbreeding between Indian cattle breeds, mainly Kankrej, Gir and Ongole, with Brazilian cattle. In initial stages Brazilian cattle were crossed with Kankrej and later on with Gir. The Indu-Brazilian breed development started mainly during the decade of 1920 because of ban on importing Indian cattle from 1921 to 1930. The modern Indu-Brazilian cattle have morphological characteristics resembling those of Gir cattle and have also similarity with American Brahman. This breed has been developed for beef production.

Mpwapwa (Indo-African Zebu Cattle Breed)

In East African countries, the development of Mpwapwa cattle breed for both milk and beef production was started in 1958. The average genetic composition of the foundation cattle stock of this breed was 32% Red Sindhi, 30% Sahiwal, 19% Tanzanian short-horned zebu, 10% Boran, 9% European breeds (mainly Ayrshire) and Shorthorn.

Australian-Friesian Sahiwal (AFS)

Sahiwal bulls were crossed with Holstein-Friesian cows in early sixties in Australia in order to combine resistance to *Boophilus microplus* exhibited by the Sahiwal cattle with milk production ability of Holstein-Friesian. As a result of this crossing, a tick-resistant dairy cattle breed was developed. Further progeny-testing programme on young AFS bulls for tick resistance was also started. In Queensland, milk and fat yields of AFS were found to be about 75 and 82 % of those of Holstein-Friesian cows, and similar to other *Bos taurus* breeds. However, data from humid tropics of Northern territories indicated AFS cows outyielding Holstein-Friesian and other *Bos taurus* cows. There is further scope for spread of such synthetic cattle germplasm to wet tropics of Southeast Asian and Central Asian countries. Sahiwal × *Bos taurus* crossbred calves from Australia and New Zealand have been imported to Malaysia.

Australian Milking Zebu (AMZ)

Another crossbred synthetic cattle strain was developed in Australia incorporating Red Sindhi and Sahiwal zebu cattle inheritance. In the first stage of breed development, Sahiwal and Red Sindhi males were crossed with Jersey females, and were *inter-se* mated up to F_3. The Red Sindhi and Sahiwal crossbreds were kept separate. The second stage was based on progeny testing of young bulls from meritorious dams and mated to top 10% elite cows of each co-operating herd for production of young bulls for future testing. The young bulls under testing were further exposed to two screening tests, viz. (i) artificial climatic stress and (ii) infestation of cattle ticks. In the third stage, only sons of progeny-tested sires and high-yielding dams were subjected to screening and progeny testing. The ultimate aim was to develop animals containing between 3/8 and 1/2 of *Bos indicus* inheritance, and select for milk production, tolerance to climatic stress and resistance to ticks.

BUFFALOES

The river buffalo seems to have originated from the Indus Valley and the Indo-Gangetic plains in the Indian subcontinent, and from there it spread to other parts of Asia and the world. The river buffaloes are now found in all the continents and in about 40 countries spread from South China to Taiwan, the Philippines, Thailand, Indonesia, all the Indo-China States, the Far-East and Australia. Recently, buffaloes have multiplied surprisingly very fast in some of the countries, especially Trinidad and Tobago, Peru, Surinam, Guyana, Venezuela, Columbia, Bolivia, Brazil and Australia. Originally, the buffaloes were introduced from South East Asia into some of these countries as a draft animal for sugarcane cultivation by European settlers. Subsequent introductions have taken place from time to time of river type buffaloes from the Indian Peninsula (Rao and Nagarcenkar, 1977).

Records are not available for the export of animals prior to 1895. However, migration of river buffaloes occurred from time to time along with invaders, pilgrims and crusaders (Table 2). Brazil seems to be the first country to purchase buffaloes from

India in 1895. After that various countries like Trinidad, the Philippines, China, Bulgaria, Thailand, Uganda, former USSR, Vietnam and Nepal have imported river buffaloes from India. Thailand, Bulgaria and the Philippines have also imported frozen semen doses from India.

Among the buffalo breeds imported by various countries from India, Murrah seems to be the most preferred one, followed by Nili-Ravi. A few animals of Jaffarabadi and Surti breeds have also been exported.

In India, Rohtak and Jind districts of Haryana state, the native tract of Murrah buffaloes, are the main trading centres. Large number of buffaloes are purchased from this area and sent to other parts of the country and abroad. This trade in Haryana accounts for a turnover of about Rs 70 million. Movement of cryopreserved germplasm in the form of semen and embryos is easy, and is on the increase. Murrah is considered to be the best milch breed of buffaloes and is being preferred over other breeds all over the world.

Table 2. Export of Buffalo Breeds from India to Other Countries

Sr. No.	Exported to	Year	No. & type of animals or semen doses	How movement of animals occurred
1	2	3	4	5
1.	Mesopotamia Iraq, Iran, USSR	500 BC	Variable no.of river buffaloes	Along with early invaders and followers of Alexander
2.	Egypt	Mid 700 AD	Variable no.of river buffaloes	Along with Arab invaders
3.	Bulgaria	800	Variable no.of river buffaloes	Along with pilgrims and crusaders from Mesopotamia
		1979	1,000 doses of frozen semen of Nili-Ravi	As germplasm exchange
		1961, 1970	Murrah, Nili-Ravi, Surti, Jaffarabadi	As germplasm exchange
4.	Italy	Between 475 and 900	Murrah, Nili-Ravi, Surti, Jaffarabadi	As germplasm exchange
5.	European countries like Hungary, Romania, former Yugoslavia, Greece	1000	Murrah, Nili-Ravi, Surti, Jaffarabadi	Along with pilgrims and crusaders from the holy land

Table 2. Concluded

1	2	3	4	5
6.	Brazil	1895	Murrah, Nili-Ravi, Surti, Jaffarabadi	Through purchase and shipment
7.	Trinidad	1903-1906	Variable No. of Nili/Ravi, Jaffarabadi, Surti, Nagpuri, Bhadawari buffaloes	Along with migrants
		1948	6 Murrah bulls	Along with migrants
8.	The Philippines	1917	57 river buffaloes	Through purchase and shipment
		1918	57 river buffaloes	Through purchase and shipment
		1947	85 river (Nili/Ravi buffaloes)	Through purchase and shipment
		1947	50 Murrah	Through purchase and shipment
		1950	119 Murrah (3 males, 116 females)	Through purchase and shipment
		1953	100 Murrah males	Through purchase and shipment
		1955	323 Murrah	Through purchase and shipment
		1956	98 Murrah females	Through purchase and shipment
		1982	1,000 doses of frozen semen of Murrah	As germplasm exchange
		1984	1,000 doses of frozen semen of Murrah	As germplasm exchange
		1985	1,000 doses of frozen semen of Murrah	As germplasm exchange
9.	China	1957	55 Murrah	As germplasm exchange
10.	Thailand	1962	Murrah (variable no.)	Migration with Indian peoples' relative
		1979	100 Murrah	Government purchase as a germplasm exchange
		1979	1,000 doses of frozen semen of Murrah	Donation by Government of India
11.	Uganda	1969	13 Murrah (12 females, 1 male)	Through purchase and shipment
12.	Former USSR	1970's	Murrah	Government purchase as a germplasm exchange
13.	Vietnam	Late 1970's and early 1980's	Murrah	Government purchase as a germplasm exchange
14.	Nepal	Late 1970's	Murrah	Government purchase as a germplasm exchange

Source: Balaine (1988). □

4 CLASSIFICATION OF BREEDS

CATTLE

India has several breeds or types of cattle. These breeds have been evolved over centuries to suit to the agro-climatic conditions of the region where they are bred and reared. Many of these breeds have been named after their place of origin. Some of the breeds are completely different from each other in respect of morphological characteristics, whereas the others have some common characteristics. Many researchers tried to classify the breeds into different groups according to their place of origin, type and physical characteristics especially horn shape and size, and coat colour. The major types identified are humpless (*Bos taurus*), humped (*Bos indicus*) and crossbreds between these two. Olver (1938) was, perhaps, the first to classify zebu cattle of the Indian sub-continent into 6 groups on the basis of similarities in some physical characteristics. Ware (1942) agreed to this classification with some modifications. Phillips (1944) assigned appropriate breeds to these groups. Joshi and Phillips (1953) summarized these groups.

CLASSIFICATION BY JOSHI AND PHILIPS (1953)

Group I

Breeds of this group are lyre-horned grey cattle with wide forehead, prominent orbital arches, and thin, flat or dished face. Kankrej, Malvi, Kenkatha, Kherigarh and Tharparkar belong to this group. Tharparkar breed seems to be intermediate between groups I and II and it can be included in group II also.

Group II

Short-horned white or light grey cattle with long coffin-shaped skulls but not so prominent orbital arches and slightly convex face are included in this group. Hariana, Ongole, Mewati, Gaolao, Krishna Valley, Nagori, Rath and Bachaur breeds belong to this group. Hariana and Ongole breeds are distinct and important types of this group. The Krishna Valley breed seems to carry Ongole blood whereas all the remaining breeds of this group seem to have evolved from a Hariana base.

Group III

This group comprises animals of heavy type having pendulous dewlap and sheath, prominent forehead, and lateral and often curled horns. They are spotted either red and white or completely red or brown. The Gir is the most important breed of this group and seems to have influenced all other breeds of this group. Other breeds of this group are Red Sindhi, Sahiwal, Dangi, Deoni and Nimari.

Group IV

Cattle of this group are medium sized, compact animals having powerful quarters and tight sheaths. Forehead is prominent. Horns emerge from the top of poll fairly close together in an upward and backward direction ending in pointed tips. Colour varies from almost white to steel grey or black. The 'Mysore typ' cattle, viz. Amritmahal, Hallikar, Kangayam, Khillari and Bargur breeds, are included in this group.

Group V

This group includes cattle of mixed type. They are small, black, red or dun cattle often with large patches of white markings. Poll and hump are covered with coarse hair. Horns are small or sometimes slightly lyre-horned. These animals are found mostly in hills. Ponwar and Siri belong to this group. In almost all breeds of this group, the position of hump may be described as cervico-thoracic, but in Siri cattle it is thoracic. Ware (1942) and Payne (1970) reported that Siri breed has cervico-thoracic hump. During a survey, the authors of this book observed that hump is slightly forward in Siri as compared to that in other Indian breeds.

Group VI

This group is represented by Dhanni breed of cattle from the part of Punjab, now in Pakistan. These animals are medium sized, compact and active. Dewlap and sheath are tight. Colour varies from almost white with evenly scattered black or red spots over the whole body to black or red with spots on certain parts.

Payne (1970) listed following difficulties in completely accepting this classification: (i) this classification is not complete as *Bos (Bibos)* spp. and their crossbreds are excluded; (ii) in some groups there are important exceptions to the conformational characteristics used for classification; (iii) the Dhanni breed is placed in a separate group although it has obvious conformational and other similarities with group IV breeds; and (iv) the Siri which possesses a cervico-thoracic hump, is classified with group V breeds that are said to possess thoracic humps.

He further suggested that any classification of breeds in Indian sub-continent should include *Bos (Bibos)* spp. and crossbreds between these and humped cattle, and that within humped type there should be a more rational classification. He classified these breeds as:

1. *Short-horned zebu with white or light grey coat, non-prominent orbital arch and long coffin-shaped skull.* The Hariana and Ongole are the 2 most distinct and

important breeds. Bachaur, Nagori and Rathi breeds are probably related to the Hariana breed while the Gaolao breed appears to be related to Ongole breed and should be included in this group. The Mewati breed demonstrating the influence of the lyre-horned cattle, the Gir and the Krishna Valley, a breed of recent origin demonstrating even more mixed ancestry, should also be included in this group.

2. *Lateral-horned zebu with curved horns.* The Gir is the most important breed in this group. The Dangi, Deoni and Nimari breeds are of more recent origin, but should be included in this group. The Dhanni breed classified by Joshi and Phillips (1953) in a separate group may also be included. Although the Red Sindhi and Sahiwal breeds are undoubtedly related to the hill cattle breeds, they also appear to possess Gir blood; they are tentatively classified in this group though they do not possess true lateral horns.
3. *Lyre-horned zebu with grey coat and prominent orbital arches.* The Kankrej and Malvi are the two most important breeds. The Tharparkar breed should be included in this group though it could equally be classified in group 1 (Joshi and Phillips, 1953). The Hisar breed is of minor importance.
4. *Long-horned zebu with grey coats.* The horn is very distinctive and these cattle are known as 'Mysore type'. The major breeds included in this group are the Amritmahal, Hallikar, Kangayam and Khillari. The Bargur and Alambadi breeds are minor breeds.
5. *Small short-horned or lyre-horned zebu found in the hills and peripheral areas.* Major breeds are the Lohani, Ponwar and Sinhala. The Kumauni, Shahabadi and Punganoor are minor breeds. The Lohani breed is in Pakistan while Sinhala is in Sri Lanka.

It was also suggested that the Siri should not be classifed as a zebu but as a stabilized indigenous crossbred as it possesses a cervico-thoracic hump and is in many ways similar to other breeds of this type found in Southeast Asia. The classification for cattle of the Indian sub-continent and Sri Lanka is suggested as follows:

CLASSIFICATION OF CATTLE OF INDIAN SUB-CONTINENT AND SRI LANKA

Humped cattle

1. *Short-horned zebu* (Bachaur, Gaolao, Hariana, Krishna Valley, Mewati, Nagori, Ongole, Rathi)
2. *Lateral-horned zebu* (Gir, Dangi, Deoni, Nimari, Dhanni, Red Sindhi, Sahiwal)
3. *Lyre-horned zebu* (Kankrej, Malvi, Tharparkar, Hisar)
4. *Long-horned zebu* (Amritmahal, Hallikar, Kangayam, Khillari, Bargur, Alambadi)
5. *Small short-horned or lyre-horned zebu* (Kumauni, Lohani, Ponwar, Shahabadi, Punganoor, Sinhala)

Humpless × Humped Cattle
1. *Stabilized indigenous* (Siri)
2. *Recent* (Taylor)

***Bos (Bibos)* spp**
1. (Gaur)

***Bos (Bibos)* spp × humpless and/or humped cattle**
1. *Intermediate* (Gayal)

CLASSIFICATION BY ACHARYA AND BHAT (1984)

Acharya and Bhat (1984) conducted studies on breed classification and divided the grey-white cattle of India into two groups as follows:

1. The broad-faced, lyre-horned, grey-white cattle of western India. The Kankrej breed is the representative breed and appears to have followed the route taken by Rig Vedic Aryans after entering India through northern passes, turned west, north of Aravalli range to reach Sind, Gujarat and southern Rajasthan. These are related to bulls depicted in Mohenjo-Daro seals.
2. The white, narrow-faced, stumpy-horned breeds, e.g. Hariana, Rathi, Gaolao and Ongole breeds. These are located along the route taken by the Rig Vedic Aryans from northern passes through central India to the South.

CLASSIFICATION BY MAULE (1990)

Maule (1990) classified typical cattle under 5 groups with zebu (thoracic humped) cattle in group I and Sanga (cervico-thoracic humped) cattle in group II. Group III comprises humpless cattle, group IV crosses between humped and humpless cattle, and group V *Bos bibos* and crosses. Cattle breeds under group I comprising Indo-Pakistan region has been classified into 6 subgroups based on physical characteristics such as horn shape, coat colour and body size. These subgroups are :

1. *Lyre-horned grey*	Kankrej, Tharparkar, Malvi, Kenkatha, Kherigarh
2. *Short-horned, white or grey, coffin-shaped skull*	Hariana, Krishna Valley, Mewati, Nagori, Ongole, Rath, Bachaur
3. *Lateral-horned, red, red and white or black and white*	Sahiwal, Red Sindhi, Gir, Nimari, Deoni, Dangi

4. *'Mysore' breeds; grey, long backward pointing horns*	Alambadi, Amritmahal, Hallikar, Khillari, Kangayan, Bargur
5. *Small hill cattle*	Lohani, Ponwar, Siri, Terai
6. *Cattle of Sri Lanka*	Sinhala, Tamakaduwa

CLASSIFICATION BY PAYNE AND HODGES (1997)

Payne and Hodges (1997) classified humped cattle of the Indian sub-continent according to their utility and not by horn type as was done by Payne (1970). They recognized the major breed types of Indian sub-continent as humped (*Bos indicus*) and those resulting from crossing between *Bos taurus* and *Bos indicus,* and gave the following classification:

Humped Cattle

a. Dairy type
Red Sindhi and Sahiwal

b. Dairy/draught type
Gir and Tharparkar

c. Draught/dairy type
Deoni, Gaolao, Hariana, Kankrej, Krishna Valley, Ongole, Punganur and Rathi

d. Draught type
Amritmahal, Bachaur, Bargur, Bengali, Dangi, Hallikar, Jellicut, Kangayam, Khillari, Kumauni, Ladakhi, Malvi, Mewati, Nagori, Nimari and Ponwar

Cattle of Crossbred Origin

a. Stabilized indigenous
Siri

b. Intermediate
No indigenous breeds in this category

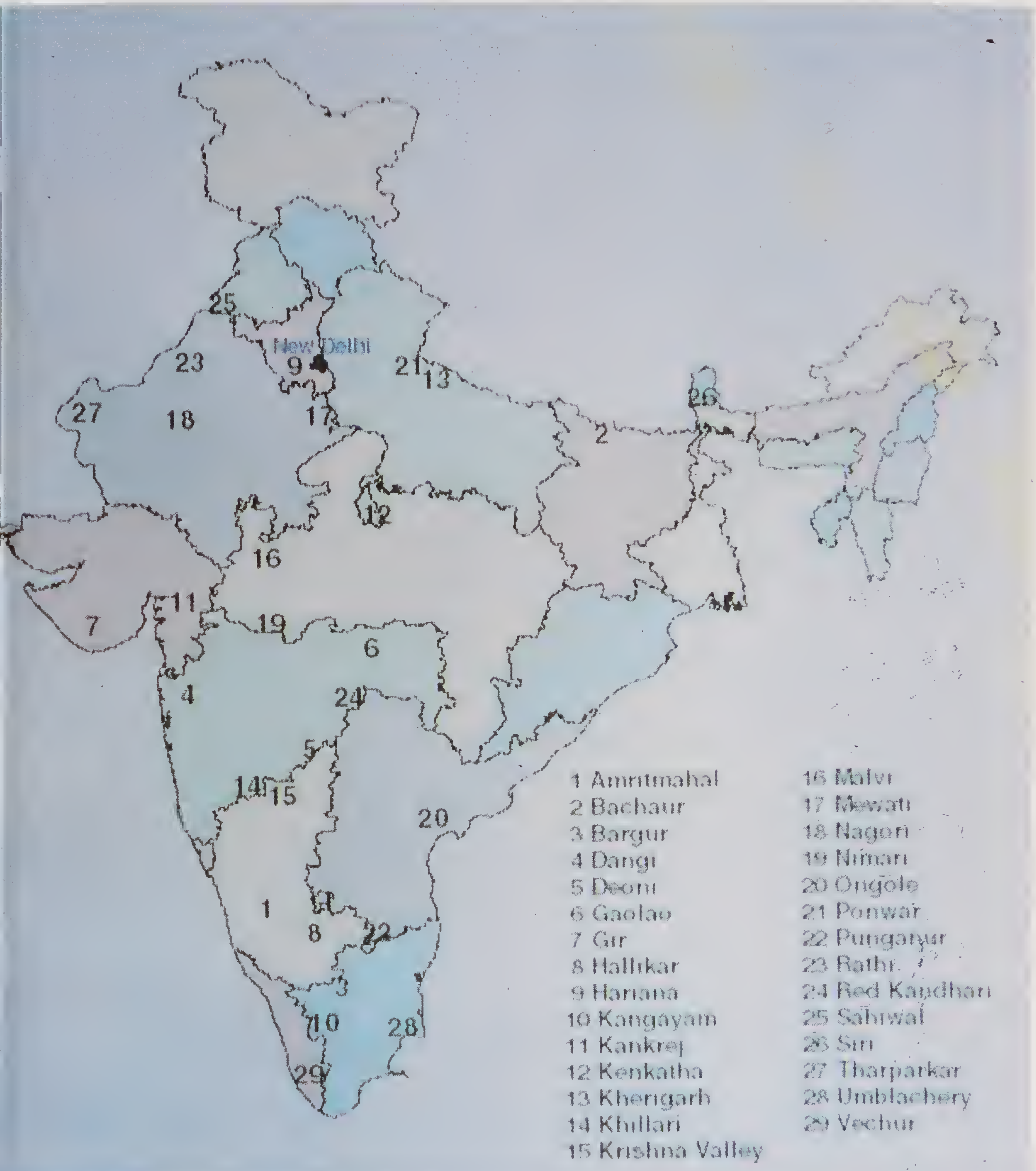
c. Recent
Karan Fries, Karan Swiss, Sunạndini and Taylor.

Presently there are 30 recognized breeds of cattle in India. These breeds can be broadly classified according to their utility under the following 3 categories.

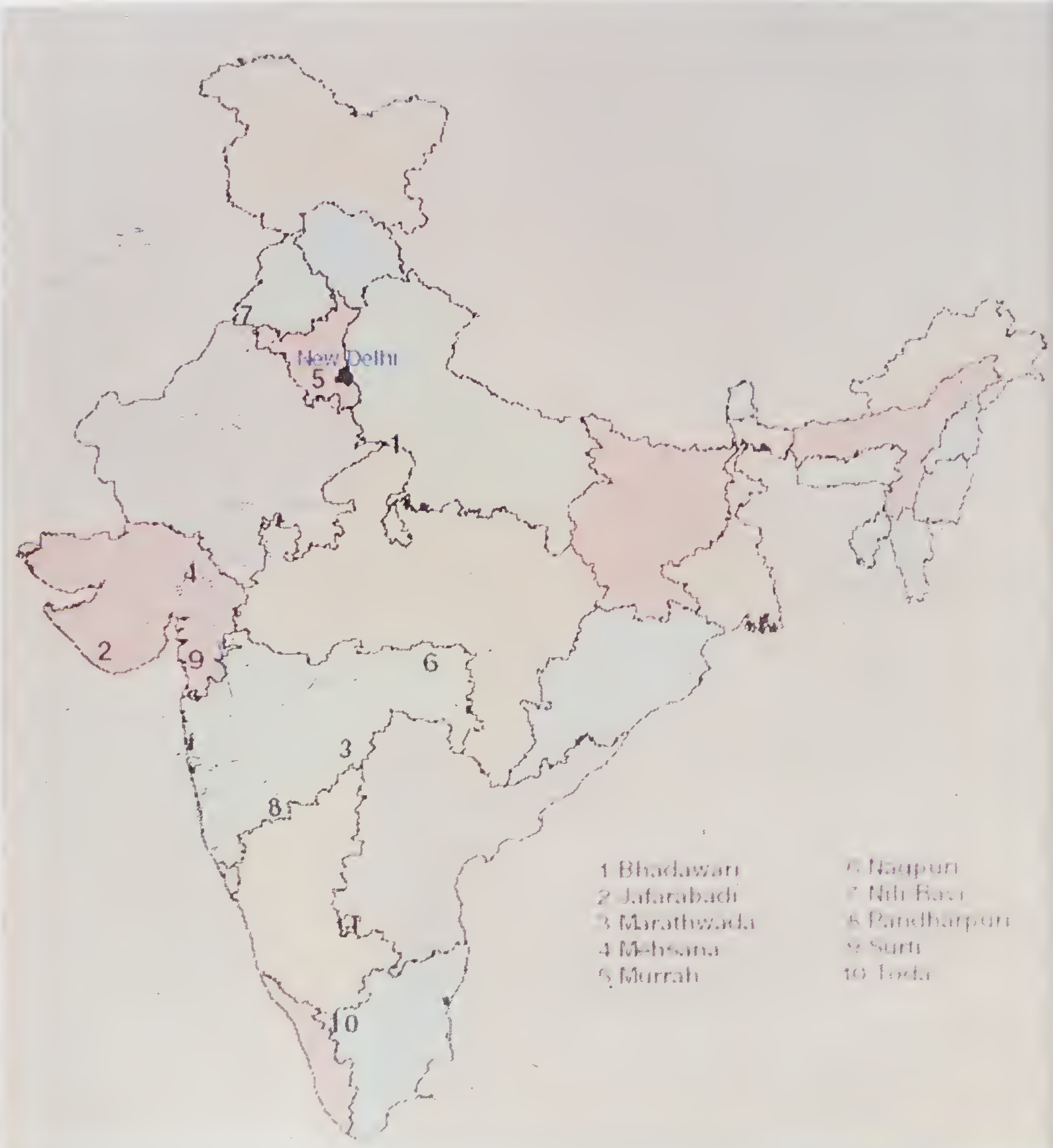
CLASSIFICATION BASED ON UTILITY

Dairy Breeds

Cows of these breeds are high milk producers, but bullocks are of poor draught quality. These animals are generally ponderous in build, and have pendulous dewlap and sheath. Skin is loose. Dairy type breeds are Sahiwal, Red Sindhi, Gir and Rathi.



Distribution of cattle breeds in India



Distribution of buffalo breeds in India

Draught Breeds

The majority of the indigenous breeds belong to this group. Cows produce little amount of milk but are reared only to produce bullocks. Bullocks are powerful and good draught animals. Proportioned body, strong limbs, long barrel, tight sheath, tight skin, fast gait and alertness are the chief characteristics of this group. Amritmahal, Bachaur, Bargur, Dangi, Hallikar, Kangayam, Kenkatha, Kherigarh, Khillari, Malvi, Nagori, Nimari, Ponwar, Red Kandhari and Siri breeds belong to this group. Siri is a humped cattle as has been proved by cytogenetic studies (Tantia *et al.*, 1996). It should be grouped with *Bos indicus,* and not as of crossbred origin as was suggested by Payne (1970) and Payne and Hodges (1997).

Dual-purpose Breeds

Cows of this group are fairly good milkers and bullocks provide good draught power. This group includes Deoni, Gaolao, Hariana, Kankrej, Krishna Valley, Mewati, Ongole and Tharparkar breeds.

CHARACTERISTICS OF ZEBU CATTLE

Zebu cattle have certain specific characteristics and belong to *Bos indicus* group. These characteristics are described below.

Physical Characteristics

The most obvious feature is the presence of a hump. Its position distinguishes zebu cattle from the closely related Sanga cattle. In zebu cattle, hump is thoracic, i.e. situated over the withers, whereas it is cervico-thoracic in Sanga cattle, i.e. it is further forward than in zebu cattle.

Zebu cattle have a narrower body, longer legs and a well-developed dewlap than the *Bos taurus* which have deep body, short legs and a small dewlap. Backline is uneven, slopes behind the hump, rises to peak between hip bones and then drops sharply to the tail head. Skin of zebu cattle is generally much looser than that of *Bos taurus*. Dewlap and sheath are very pendulous.

Fitness Characters

Zebu cattle are adapted to harsh agro-climatic conditions because of their low metabolic rate at high temperature than temperate breeds. They can survive and produce on less feed and fodder and that too of poor quality. They are more resistant to tropical diseases as compared to European breeds. They have a long breeding life up to 10-12 years. Bullocks provide excellent draught power for agricultural operations.

Genetic Characters

The karyotype of *Bos taurus* and *Bos indicus* are similar except for the difference in the Y-chromosome. The Y-chromosome is sub-metacentric (non-acrocentric) in *Bos taurus* and acrocentric in *Bos indicus* (Gupta *et al.*, 1974; Benjamin and Bhat, 1977).

BUFFALO

Macgregor (1939) named black dairy type buffaloes having curled or sickle-shaped horns as river buffaloes. These differ from Swamp buffaloes in colour, conformation and use. The Indian sub-continent has most of the important buffalo breeds, among which a few are the best in the world. Cockrill (1974) classified Indian breeds into the following 5 groups:

Group	Breeds
1. Murrah	Murrah and Nili-Ravi
2. Gujarat	Jaffarabadi, Mehsana and Surti
3. Uttar Pradesh	Bhadawari and Tarai
4. Central India	Jerangi, Kalahandi, Manda, Nagpuri, Pandharpuri and Sambalpur
5. Southern India	South Kanara and Toda

Acharya and Bhat (1984) also classified domesticated buffaloes into 2 main categories, viz. swamp and river buffaloes. They belong to the same species but have very different habits. Swamp buffalo is more or less a permanent denizen of marshy lands, where it wallows in mud and feeds on coarse marsh grass. They classified Nagpuri/ Pandharpuri, Toda and Marathwada buffalo as swamp type. The river buffaloes are found throughout India where clean water of rivers, irrigation canals and ponds are available to wallow. This type was specially developed for milk production with high fat percentage. It is docile. Important breeds of milch buffalo, viz. Murrah, Nili-Ravi, Surti, Mehsana, Jaffarabadi and Bhadawari, are from this group.

Cytogenetic studies have proved that Nagpuri, Pandharpuri, Toda and Marathwada breeds also belong to riverine group (Nair *et al.*, 1986) along with Bhadawari, Jaffarabadi, Mehsana, Murrah, Nili-Ravi and Surti. Buffaloes in coastal districts and Paralakhemundi area of Orissa posses 2n = 48 chromosomes (Rao, 1981; Bidhar, 1985) and are classified as swamp buffaloes.

Khanna (1973) reported genetic differentiation between various buffalo breeds using blood protein variants and blood group data. Various Murrah herds located in different agro-climatic regions were shown to diverge from the base population of Hisar herd and were genetically closely inter-related. Nili-Ravi was having less genetic distance from Murrah. Marathwada and Pandharpuri were reported to have closer genetic relationship. These two are reported to be strains of same variety and nearer to Nagpuri breed. Surti was reported as a distinct genetic identity. These results agreed with the physical and geographical relations between the buffalo breeds. □

5

CATTLE BREEDS

AMRITMAHAL

Origin and Distribution

THE Amritmahal breed is found in Hassan, Chikmagalur and Chitradurga districts of Karnataka state in southern India. It is a famous draught breed known for its power and endurance. Animals are fiery and active. Bullocks are especially suited for trotting and quick transportion. Cows are poor milkers.

The Amritmahal originated from a herd established by the rulers of Mysore State between 1572 and 1636 AD. They reared these cattle to supply milk and milk products to the palace, and to produce bullocks to be utilized for movement of army equipments. These cattle consisted of 3 distinct strains: Hallikar, Hagalvadi and Chitaldoorg. Thus the foundation cattle from which the breed was developed were of the Hallikar and closely related types. Between 1572 and 1617 AD Vijaynagar dynasty brought a group of Hallikar cows to Srirangapatnam, which was later taken over by the Wodeyars of Mysore. From these cattle, royal families of Mysore (Shri Chamaraja Wodeyar) established Amritmahal kavals between 1617 and 1636 AD. These herds were further strengthened by Shri Kanteerava Narasaraja Wodeyar between 1638 and 1658 AD and by Sri Chikka Devaraja Wodeyar between 1672 and 1704 AD. Nawab Hyder Ali Khan (1704 to 1799 AD) kept around 60,000 bullocks for movement of army equipage. Nawab Tipu Sultan trained

Breeding tract

these males and classified them as gun, pack and plough bullocks. He used these bullocks successfully in wars against the British. He also changed the name of these cattle to Amritmahal which literally means department of milk.

Location and Topography

The breeding tract lies between latitude 11° 36' and 15° north, and longitude 74° 4' and 78°4' east. The area is an undulating table land much broken by chains of rocky hills and scores of deep rivers. Its form is that of a triangle with the apex to the south at the point where the Western and Eastern Ghat ranges of the hills converge in the group of Nilgiri hills of the south. The altitude ranges fromt 540 to 900 m above msl.

Soil

Soils in the east are red loam or clay loam. These are generally deficient in phosphorus. Stony and widespread pasture grounds in the central parts of the region represent very poor soil with coarse grasses. The plains in the north are of black soil and are used for crops such as cotton and millets. Tracts in the south and west are irrigated by channels drawn from rivers. Sugarcane and rice are grown here.

Climate

The climate is pleasant throughout the year. Temperature ranges from 14° to 35°C. The tract gets rains from both southwest as well as northeast monsoons. The rainy season begins in early June and continues with some intervals in August and September to the middle of November, closing with heavy rains of the northwest monsoon. These later rains are very useful for pastures. Annual rainfall ranges from 70 to 90 cm. Then the mild cold season begins, which is dry and lasts until the end of February. The hot season then sets in and increases in intensity to the end of May with occasional relief owing to thunderstorms.

Management Practices

This breed is purely used for draught purpose. Calves are not weaned. Bull calves are allowed to suck all milk from their dams. Calves of very poor milkers are sometimes given extra quantity of milk. After 3 months calves are allowed to graze. Amritmahal cattle are reared mostly in small numbers. They are owned by well-to-do cultivators and large breeders who maintain herds in the vicinity of hills where good grazing is available. Breeders sell calves to cultivators, who after training them for yoke sell them at the cattle fairs. These animals are kept in the open all the time and trees are the only source of protection from rain and sun. This weeds out the weaklings automatically. Bull calves are castrated at the age of 18 months but under village conditions this age may be as high as 4 years. Depending on the soil and irrigation facilities, various crops are grown. In black cotton soil in the north, cotton, millets,

Amritmahal bull

Amritmahal cow


Amritmahal calf

sorghum and oilseeds are extensively grown. In the south sugarcane and paddy are grown. Grasses commonly observed are *Andropogon* sp., *Aristida*, *C. dactylon*, etc.

Physical Characteristics

Amritmahals are grey cattle but their shade varies from almost white to nearly black. In some animals white-grey markings are present on face and dewlap. Muzzle, face and tail switch are usually black but in older animals the colour looks lighter. Cows are white, bullocks slightly white and bulls dark, rusty white and even interlace to some extent. Typical characteristics of this breed are head shape and horns. Head is long and tapering towards muzzle. Forehead is narrow, bulging out with a furrow in the middle. Horns are long and emerge from the top of the poll fairly close together in backward and upward direction, turn in and end in sharp black points. Sometimes the long, sharp points touch each other and appear like torch light. Eyes are bright. Ears are small, horizontal and taper to a point. Hump is well developed and is carried slightly forward. Dewlap is fine and does not extend very far. Sheath and navel flap are very small and close to the body. Legs are medium in length and well proportioned. Hooves are hard, close together and small. Skin is thin, smooth, tight and jet black with short glossy hair. Udder is small, and compact with hard and small teats.

Morphometric and Performance Parameters

Body length, height and heart girth average 130, 150 and 170 cm, respectively, in males, and 130, 150 and 150 cm, respectively, in females. An adult male weighs around 500 kg and female around 318 kg. Age at first calving is 1,337.6±115.52 days and milk yield is 572±24 kg. Calving interval is 577.6±24.32 days and lactation length 299±10 days.

Breeding Farms

1. Cattle Breeding Station, Ajjampura, Karnataka
2. Composite Livestock Farm, Hessarghatta, Bangalore, Karnataka

Amritmahal herd

Contact Agencies

1. State Animal Husbandry Department, Karnataka
2. BAIF, Pune, Maharashtra
3. University of Agricultural Sciences, Bangalore, Karnataka
4. People's Trust, Bangalore, Karnataka

BACHAUR

Synonym: Sitamarhi

Origin and Distribution

This breed was found in Sitamari and some parts of Madhubani, Darbhanga, Samastipur and Muzaffarpur districts of Bihar but a recent survey has revealed that the original breeding tract has shrunken and the Bachaur cattle are now concentrated in the areas adjoining Nepal border comprising Bachaur and Koilpur subdivisions of Sitamarhi district. It is known for its draught qualities and ability to thrive on poor fodder resources. This breed has very close similarity to the Hariana breed. A pair of bullocks fetches around Rs 5,000 to 35,000.

Location and Topography

The breeding tract is situated in the north-central part of Bihar, lying approximately between 26° and 26°6' north latitude, and 85° and 85°6' east longitude.

Breeding tract

Soil

The area consists of low-lying alluvial plain traversed at intervals by ridges of high ground. Beds of nodular limestone are occasionally found in the tract. Major portion of the area is fertile with high cropping intensity.

Climate

The climate of the area is hot and humid. Maximum temperature in summer is about 45°C and in winter about 21°C. Minimum temperature during winter is about 9°C. Average rainfall of the area is 125-140 cm. Humidity ranges from 66 to 90%.

Paddy, barley, wheat, chickpea, mustard, lentils and sugarcane are the most important crops. No special fodder crops are grown in the area for cattle except *Lathyrus sativus* in paddy fields and mustard sown with high seed rate as a winter crop and then gradually thinned and used as green fodder.

Bachaur bullocks

Bachaur cow


Bachaur calf

Management Practices

The Bachaur breed is maintained by the Koir and Ahir communities. Majority of them have few animals but a few have large herds. Cattle are grazed in the nearby grassland areas. Cow having male calf is not milked at all and the calf is allowed to take all the milk. Males are castrated at the time of eruption of horns, i.e. at about 1 to 1½ years of age.

The males produced in the village area are valuable and traded everyday in small 'Hatia' being arranged privately or by the government. These practices are being followed for many centuries. Small and marginal farmers buy Bachaur bullocks from these trade centres for various agricultural operations.

Physical Characteristics

The cattle are of grey colour, compact with straight back, well rounded barrel, short neck and muscular shoulders. Muzzle is either black or brown. Eyelids are black for animals having black muzzle and white for animals having brown muzzle. Face is short, forehead broad and flat or slightly convex.

Poll is almost absent. Eyes are large and prominent. Horns are medium sized, stumpy curving outward and upward. Ears are small and drooping. Hump is compact, firm and medium sized. Legs are short and thin. Sheath and navel flap are light and close to the body. Dewlap is medium sized. Tail is short and thick, and usually does not go far beyond the hock. Tail switch is either black or white. Udder is small, trough shaped with cylindrical teats having rounded tips. Colour of skin is black.

Morphometric and Performance Parameters

Length of a bull is around 110-120 cm, height 110-125 cm and heart girth 140-170 cm. Length, height and heart girth of females are around 95-115, 100-120 and 135-165 cm respectively. Adult body weight is around 385 kg in males and 318 kg in females. Average age at first calving is 1,453.24±21.75 days. Cows are poor milkers and produce around 540 kg of milk (range 495 to 605 kg) in a lactation of 254.34±2.49 days. Average calving interval is 487.8±5.92 days. Bullocks can work for about 8 hours without any break.

Bachaur herd

Breeding Farms

1. The Bachaur Cattle Breeding Farm, Pusa, Bihar

Contact Agencies

1. State Animal Husbandry Department, Bihar

BARGUR

Origin and Distribution

BARGUR is a draught breed found around Bargur hills in Bhavani taluk of Erode district of Tamil Nadu, and are bred extensively by Lingaiys and Lambadis of that area. This area was earlier a part of Coimbatore district. Animals are of Mysore-type, but smaller and more compact. They are very restive and fiery in disposition, and are difficult to train. They are light in built and are developed mainly for carrying out agricultural operations in the uneven and hilly terrain. Cattle of this breed are unsurpassed in speed and endurance in trotting.

Location and Topography

The breeding tract lies between 11°40' and 12° north latitude, and between 77°20' and 77°70' east longitude.

Soil

Mostly red sandy followed by black and alkaline. Soil is shallow in depth and texture ranges from sandy to gravel.

Breeding tract

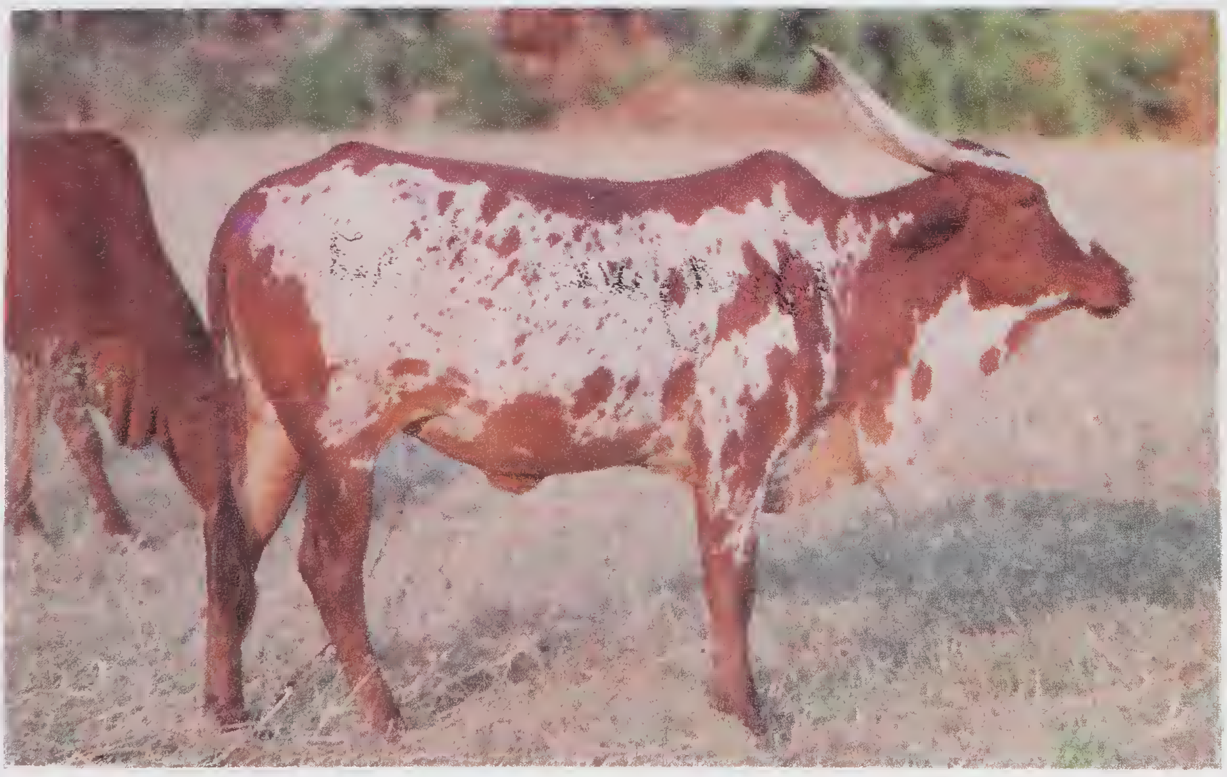
Climate

Climate is usually hot. Maximum temperature varies from 30° to 38° C and minimum from 19° to 26° C. Annual rainfall is about 65 cm and mean relative humidity varies from 53 to 77%.

Management Practices

These cattle are mainly reared in the forest area in semi-wild conditions and penned in enclosures called *pattys*. They are tended by hired local tribal labourers called Lingaiys. Each *patty* has 50 to 200 heads of cattle. For most part of the year, these cattle remain in the interior of forest and graze on the existing vegetation. They are brought back to villages for harvest operations and sent back to forest area after the next sowing is over. All these cattle are driven to salt licks about 43 km north of Bar-

Bargur bullock



Bargur cow

gur by about January for a few days and then driven to forest again. Cows are not usually milked. Calves remain with their dams throughout.

Physical Characteristics

Bargur cattle are of brown colour with white markings. Some white or dark brown animals are also seen. Calves are generally brown in colour. Colour does not change with age as in Kangayam and Umblachery breeds. Animals are well built, compact and medium in size. Head is brownish, well shaped, long and tapering towards the muzzle. Forehead is slightly prominent and has a deep furrow between the roots of horns. Muzzle is moderate and black in colour. Eyes are prominent and bright. Ears are moderately long and erect. Horns are of light brown colour, moderate length, closer at the roots, inclining backward, outward and upward with a forward curve and sharp at the tip. Neck is fairly long and thin. Hump is moderately developed in females and well developed in males. Dewlap is thin and short extending up to sternum only. Navel flap is present in many animals. Sheath is tucked up. These cattle have thin and bony limbs. Thighs are well developed. Hindquarters are well developed and slightly dropping. Tail is well set, fairly long (below hocks) and thin, tapering to a good brownish switch. Tail length is 85 to 105 cm. Cows have small udders applied close to the body. Teats are small and well set apart. Skin is loose, mellow with fine short hair.

Bargur calves

Bargur herd

Morphometric and Performance Parameters

Average body length of cows is 120.5 cm (range 98 to 147 cm), and of bulls 176.6 cm (range 172 to 201 cm). Average height is 121.6 cm in cows and 125.6 cm in bulls. Average heart girth in cows is 123.8 cm (range 120 to 148 cm) and 156.2 cm in bulls (range 140 to 169 cm). Average length and width of face are 43.5 and 26.8 cm, respectively, in cows and 46.5 and 34.8 cm, respectively, in bulls. Average horn length is 30.8 cm in cows, 33.5 cm in bulls and 35.8 cm in bullocks. Thickness of horns at base is 18.7, 20.1 and 30.9 cm in cows, bulls and bullocks respectively. Average birth weight in males and females is 18.9 and 18.1 kg respectively, and adult weight is around 340 kg in males and 295 kg in females. Cows are poor milkers, and produce 250 to 1,300 kg of milk in a lactation period of 270 to 310 days. Mostly cows calve once in 16 to 18 months and sometimes once in a year also.

Breeding Farm

1. Agricultural Research Station, Bhavanisagar, Tamil Nadu

Contact Agencies

1. State Animal Husbandry Department, Tamil Nadu

DANGI

Synonyms: Kanada, Konkani and Ghauti

Origin and Distribution

Dangi is a draught breed found in a small area of Nasik and Ahmednagar districts in Maharashtra state including an area in the Western Ghats known as Dangs from which the breed takes its name. They are well known for their excellent working qualities in heavy rainfall areas, rice fields and hilly tracts.

Location and Topography

The approximate latitudinal position of the tract is between 20° and 22° north while the longitudinal position is between 73° and 74° east. The whole area is hilly, broken by deep ravines. Towards the centre and west there are dense forests while to the east there are larger clearings. It is a hilly tract with heavy rainfall and poor agricultural production. These hills run north to south, with spurs on the eastern side. Though the average altitude of this region is about 600 m, the highest elevation rises to 1,350 m above msl.

Breeding tract

Soil

In the valleys and depressions good black soil exists, whereas on the slopes and uplands the soil is red or black with boulders.

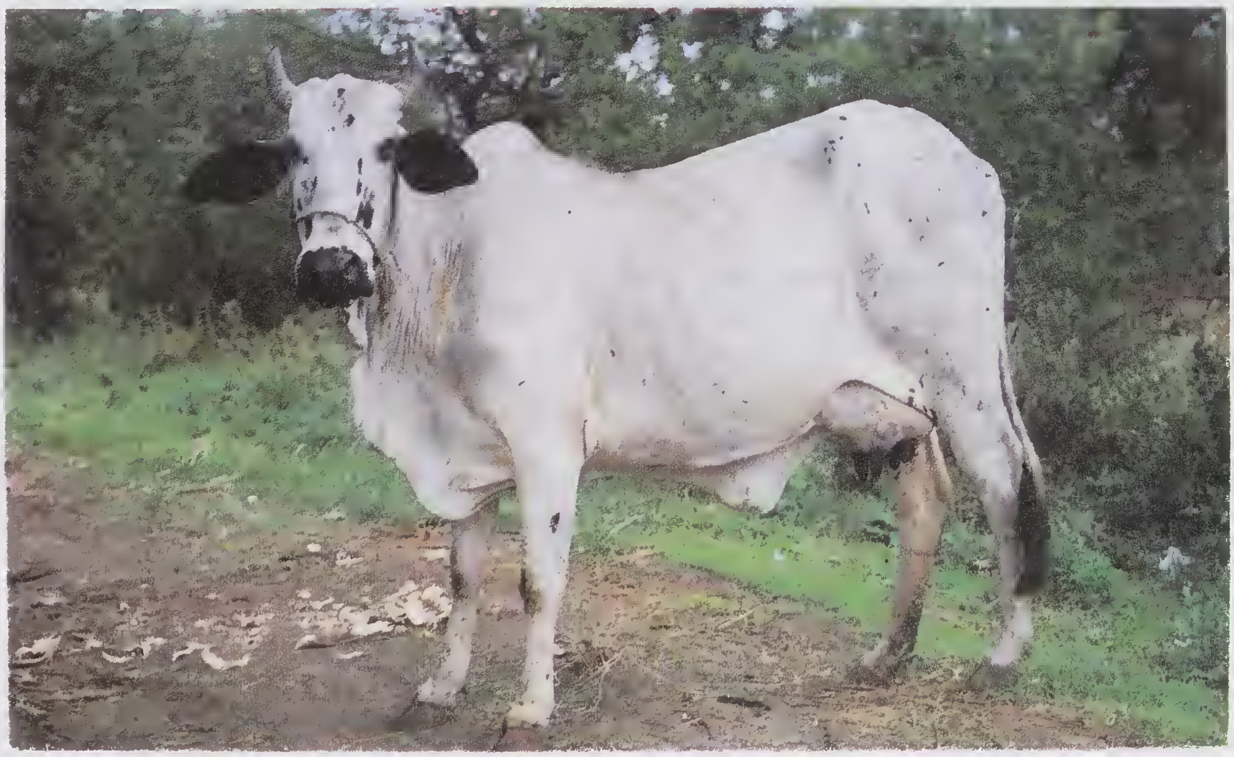
Climate

The climate on the whole is pleasant. Average maximum temperature ranges from 28° to 38°C and minimum from 11° to 31°C. The cold season lasts from November to February and is dry. Average rainfall in the area may be about 250 cm. The Dangi breed has adapted very well to these agro-climatological conditions.

Management Practices

Dangi breeders are semi-nomadic.

Daṅgi bull



Dangi cow

Dangi calf

They belong to Kanadi, Mahadeo Koli, Thakar and Maratha communities, who practice seasonal migration and remain away from their villages for about 9 months in a year (January to September). During the hot and dry season, the breeders migrate towards coastal areas where grass, tree fodder and water are available to some extent. During the period of heavy rainfall, they settle down at the foothills for protection from the cold draught. Green grasses are available in forest areas during July to September. Paddy and *Eleusine coracana* are extensively grown in the area. Byproducts from these crops are used for feeding cattle. Only breeding bulls are fed with concentrates.

Physical Characteristics

Dangi cattle have distinct white coat colour with red or black spots distributed unevenly over the body. Animals are medium in size with deep bodies. Head is usually small with a slightly protruding forehead. Muzzle is large. Horns are short and thick. Ears are small. Dewlap is slightly pendulous. Hump is firm and medium in size. Hooves are black, flint-like and exceptionally hardy. Skin exudes an oily secretion which protects the animals from heavy rain. Coat is shiny.

Morphometric and Performance Parameters

Body length, height and heart girth average 140, 130 and 150 cm, respectively, in males. Average birth weight is around 18.4 kg in male and 17.5 kg in female calves. An adult male weighs around 363 kg.

Milk yield averages 530 kg (range 32 to 1,228 kg) in an average lactation period of 269 days (range 100 to 396 days). Average fat% in milk is 4.3. Average dry period is 190 days (range 0 to 934 days). Average ages at first oestrus, at first fertile service and at first calving are 1,107, 1,154 and 1,351 days respectively. Average service period and calving interval are 185.6±9.7 and 474.1±10.2 days respectively. Gestation period is around 285 days. Conception rate is around 60.45% and the number of services per conception is around 1.65. Postpartum oestrus interval is 159.2 ± 8.1 days. Dangi cattle are extensively used for ploughing, harrowing and other field operations, and also for carting timber from the forest areas.

Dangi herd

Breeding Farms

1. Dangi Cattle Breeding Farm, Igatpuri, Maharashtra

Contact Agencies

1. State Animal Husbandry Department, Maharashtra
2. Mahatama Phule Krishi Vidyapeeth, Rahuri, Maharashtra

DEONI

Synonyms: Dongerpati, Dongari, Wannera, Waghyd, Balankya, Shevera

Origin and Distribution

THE Deoni is a very popular dual purpose breed of cattle of Marathwada region of Maharashtra state and adjoining parts of Karnataka and Andhra Pradesh states. Its breeding tract lies in the Balaghat range of Sahyadri hills. The actual place of origin is Deoni, Udgir and Ahmadpur taluks of Latur district. It is also found in Parbhani, Nanded and Osmanabad districts of Maharashtra and Bidar district of Karnataka.

Deoni cattle is believed to have been developed from Gir cattle about 280-300 years back. The tribes Rabaris, Bharwadas, Charans, Maldars, Ahirs etc. used to move with their cattle from Gujarat in search of fodder during scarcity period towards the southern parts of the country. During these periods, Gir herds also come from Gujarat state to Marathwada region. The migration of Girs to Marathwada led to the increasing admixture of Gir blood with local herds, contributing to the development of Deoni cattle. This breed has derived its name from the habitat i.e. Deoni taluk of Latur district. The estimated population of Deoni breed in 1998 was 119,000. Breedable females, breeding bulls and bullocks constituted 33.6, 1.5 and 41.1 % respectively.

Breeding tract

Location and Topography

Breeding tract of Deoni cattle covers an area of about 11,240 km This area lies between 17°35' and 20°01' north, and 75°16' and 78°15' east. The whole area is hilly with an average altitude of 409 and 455 m above msl. 2 major rivers, viz. Manjra and Mnyad, flow through this area.

Soil

Soils are deep black and heavy varying from medium light to black cotton.

Climate

Climate is generally hot throughout

Deoni bull

Deoni cow

Deoni calf

the year except some winter months. Mean maximum temperature ranges from 29° to 44°C while mean minimum temperature varies from 9° to 27°C. The average rainfall is 75 to 89 cm with maximum precipitation from mid of July to end of September. Average relative humidity ranges from 49 to 54%.

The entire area is open with very scanty vegetation and poor grass cover. Grazing facilities as such are scanty. Sorghum, pearlmillet, pigeonpea, groundnut, sunflower, cotton, blackgram and green pea are the major *kharif* crops, and *rabi* sorghum, wheat, Bengal gram are the major *rabi* crops.

Management Practices

Herd size is small, mainly of 1 or 2 cows, a pair of bullocks and some young stock. Deoni cattle are maintained under semi-intensive system. Animals are housed mostly in open houses. Most of the animals are given individual care. Calves are not weaned. Male calves are nursed better and longer as compared to female calves. Animals are taken to pastures during day time. Generally animals are maintained on grazing only. Common grasses are marvel (*Dicanthium annulatum*), kuntha (*Teachninusum pilosum*), dongri (*Heteropogan contratus*) and pawana (*Sahima nurvestum*). Bullocks, bull calves and milking cows are offered some crop residues, viz. sorghum (*kadbi*), wheat straw, gram and groundnut, and some concentrates like groundnut-cake, cotton seed, chickpea and millets. Males are castrated at about 30 months of age and used for transportation from about 3 years of age.

Physical Characteristics

Body colour is usually spotted black and white. This breed has 3 strains, viz. (i) complete white animals without any spot on the body (*balankya)*, (ii) complete white animals with partial black face (*wannera*), and (iii) black and white spotted animals (*weghyd* or *Shevera*). Ears are grey-white, or complete white with black pinna. Ears are drooping like in the Gir. In some animals ear tip is slightly curved. Forehead is prominent and slightly bulged similar to that of the Gir. Horns emerge from the side of the poll behind and above the eyes in outward and upward direction, slightly backward and again curving upward. Horns tips are blunt. Eyes are prominent and bright, with black eyebrows and black eyelashes. Hump is massive and well developed in males but not so in females. Limbs are clean, straight and powerful. Hooves are black and symmetrically placed. Dewlap and sheath are of medium size. Switch of the tail is black and white reaching below hock joint. Skin is thick, loosely attached with the body. Udder is moderately developed. Teats are black, cylindrical with rounded tips, and are squarely placed. Animals are docile and calm. Albinism, pendulous dewlap, heavy sheath, loose skin, legginess, narrow and long-drawn mouth with slightly roman arched face are some undesirable characteristics.

Morphometric and Performance Parameters

Length, height and heart girth range from 105 to 150, 127 to 164 and 152 to 201 cm, respectively, in males, and 110 to 139, 116 to 132 and 145 to 165 cm, respectively, in females. Birth weight averages 23.4±2.48 kg (range 20 to 25 kg). Adult body weight ranges from 620 to 680 kg in males and from 432 to 485 kg in females. Age at first calving ranges from 894 to 1,540 days with an average of 1,391±26.74 days. Milk yield in Deoni cows ranges from 636 to 1,230 kg with an average of 940 kg. Lactation length ranges from 169 to 475 days with an average of 299.0±7.83 days. Calving interval averages 447 days. Milk contains 4.3% fat, 9.69% SNF and 13.99 % total solids. Deoni bullocks are preferred for heavy work. A pair of Deoni bullocks can pull 10 to 11 q of load using wooden heavy cart with wooden wheels on *kutcha* roads and 28 to 30 q using

Deoni herd

light steel cart with tyre wheels on tar roads. These can plough 594 m^2 and harrow 1,615 m^2 of land per hour. Deoni bullocks reach the maximum potential around 5 to 6 years of age and maintain it effectively up to 12 years of age.

Breeding Farms

1. Deoni Cattle Breeding Farm, Gudaripalli, Andhra Pradesh
2. Cattle Breeding Farm: Kampasagar; Zahirabad, Andhra Pradesh
3. Deoni Cattle Breeding Farm, Bidar, Karnataka
4. University of Agricultural Sciences, Dharwad, Karnataka
5. Cattle Breeding Farm, Udgir, Maharashtra
6. Agriculture College-cum-Dairy Farm, Parbhani, Maharashtra

Contact Agencies

1. Marathwada Agricultural University, Parbhani, Maharashtra
2. State Animal Husbandry Department, Maharashtra

GAOLAO

Synonyms: Arvi, Gaulgani

Origin and Distribution

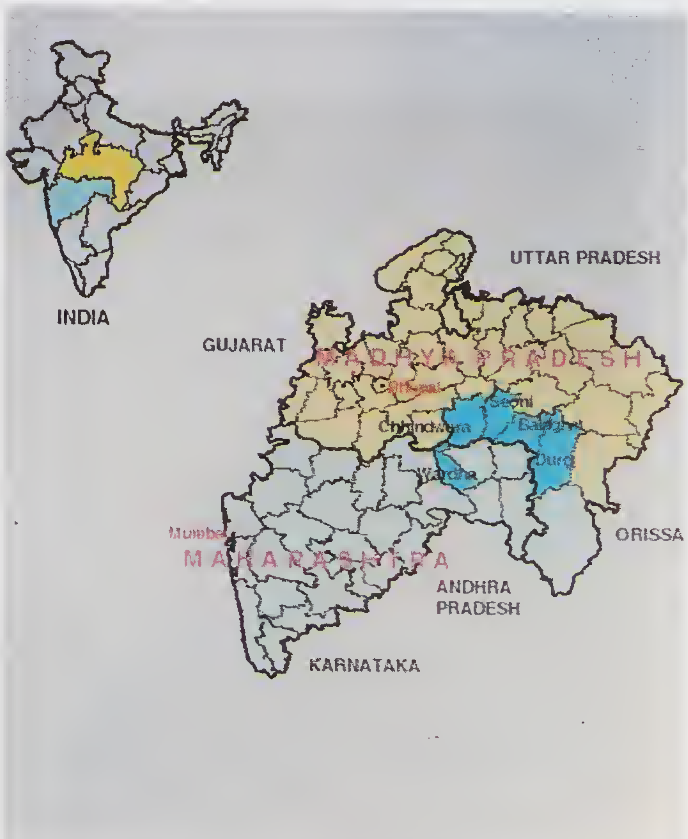
THE Gaolao is a dual-purpose breed reared for draught (mainly fast transportation) and milk production. This breed is found in Wardha district of Maharashtra; and Balaghat, Chhindwara, Durg, Rajnandgaon (earlier part of Durg) and Seoni districts of Madhya Pradesh. There is a close similarity between the Ongole and the Gaolao except that the latter is much lighter with greater agility. In the eighteenth century the Marathas developed this breed as a fast trotting type suitable for quick army transport in hills.

Location and Topography

The breeding tract lies between 20°25' and 22°45' north latitude, and between 78°20' and 82°5' east longitude. Most of the areas in the breeding tract is hilly and consists of a long strip of land extending from northwest to southeast. The average altitude is about 600 m above msl.

Soil

The whole area consists of a thin covering of black or brown soil over a sheet of trap rock. Shallow brown soil mixed with sand is found in the hilly regions.



Breeding tract

Climate

Climatic environment is sub-tropical. Summer becomes oppressive, particularly during April to July. Winters are very mild. Temperature varies from 10° to 39°C.

Management Practices

Herd size is normally 6 to 8 but some farmers have large herds. Animals are grazed in the grasslands preserved by the forest department. Grazing is usually available from middle of July to the end of October. Sorghum is the principal crop of the area. Grains are

Gaolao bull

Gaolao cow

used for human consumption while the stover is fed to cattle. Cows and young stock are usually undernourished but bullocks and young male calves ready for sale are well fed. Cotton seed, linseed or groundnut are given as concentrates. Bullocks are particularly trained to run fast.

Physical Characteristics

Gaolao animals are white or light grey. Males are generally grey over the neck, hump and quarters, medium sized, light built, narrow and long. Head is markedly long and narrow usually tapering towards the muzzle. Forehead is usually flat, though it appears to recede at the top, giving a slightly convex appearance. Eyes are almond shaped and placed slightly at angles. Ears are of medium size and carried high. Horns are short and stumpy, blunt at the points and curve slightly backward. Hump is well developed, loose and hangs on one side. Dewlap is voluminous but the sheath is moderately developed. Tail is short, reaching just below hocks.

Morphometric and Performance Parameters

Average length, height and heart girth of a Gaolao animal is around 118, 143 and 180 cm, respectively, in males, and 108, 125 and 173 cm, respectively, in females. Average body weight is around 430 kg in males and 340 kg in females. Average age at first calving is around 1,300 days. Milk production is about 600 kg (range 470 to 725

Gaolao calves

Gaolao herd

kg) in a lactation of about 240 days. Fat is about 5.5%. Average service period is around 93 days and calving interval around 387 days.

Breeding Farms

1. Central Breeding Institute, Hetikundi, Wardha, Maharashtra
2. Cattle Breeding Farm: Hetikundi; Pohara; Yeotmal, Maharashtra

Contact Agencies

1. State Animal Husbandry Department, Maharashtra
2. State Animal Husbandry Department, Madhya Pradesh

GIR

Synonyms: Bhodali, Desan, Gujarati, Kathiawari, Sorthi, Surati

Origin and Distribution

THE Gir is a very good milch breed and is found in the Gir hills and forests of Kathiawar comprising Junagarh, Bhavnagar and Amreli districts of Gujarat.

The Gir is a world-renowned breed known for its tolerance to stress conditions. Having faced scarcity for a number of years, it has the capacity for yielding more milk with less feeding and is resistant to various tropical diseases. The Gir has proved its utility not only for milk but also for draught. Though very lethargic due to its pendulous sheath and heavy built, Gir bullocks can drag heavy loads on all kinds of soils, be it sandy, black or rocky. It is a hardy animal, and can survive and produce in difficult environment. It has been imported by Brazil, the USA, Venezuela and Mexico and bred there successfully.

Location and Topography

The native tract covers around 6,000-7,000 km², and lies between 20°5' and 22°6' north. The longitudinal position is approximately between 70° and 72° east. Surface of the area is for most part undulating. Altitude varies from 125 to 600 m above msl. Some of the low-lying valleys between Gir ranges are liable to floods. Gir forest is extensively used for pasture purpose.

Breeding tract

Soil

Gir hills being volcanic in origin, consist of trap and basalt. There is much variety in the texture, quality and depth of soil habited by the breed. Soil is generally black with scattered tracts of the lighter kind of soil. Soils of the Gir forests and adjacent areas are either light coloured or red. Black soil is supposed to be very fertile but the lighter coloured red soils respond well to irrigation.

Gir bull

Gir cow

Climate

Climate in general is monsoon tropical. Maximum temperature varies from 30° to 36°C. Rainfall ranges from 50 to 100 cm. It is usually dry and hot or dry and pleasant in winter. In Junagarh area it is hot and humid in monsoon, humid and moderate in winter, and hot, humid and windy in summer.

Gir calf

Management Practices

Gir cattle are largely bred by professional breeders known as Rabaris, Bharwads, Maldharis, Ahirs and Charans. They lead a nomadic life moving their cattle from place to place in search of grazing. Good pasture is available from July to December; there after the pastures are scanty and migration of herd begins to adjoining districts. Calves are allowed to suck for 8 to 12 months. Milking cows are usually retained in the village while dry cows and young stock are sent for grazing. Concentrate mixture is prepared from wheat bran, crushed pulses, grain husk, oilcakes, cotton seed etc. and is fed to bullocks and milking cows only. Shelter is provided only to milking cows, bullocks and young calves. Animals are herded in a field for 3 or 4 nights by the farmers as it provides manure in the form of dung and urine.

Physical Characteristics

Colour pattern of the Gir is very distinctive. Basic colour of skin is white with patches of red or sometimes black. Most of the Gir animals seen today are purely red though some are speckled red. The typical characteristics of the Gir breed are: A broad convex forehead like a bony shield. It narrows sharply and bends down at an angle on the nasal bone to end in a broad muzzle and large nostrils. This broad bony forehead overhangs eyes such that they appear to be partially closed giving the animals a sloppy appearance. Long and pendulous ears are folded like a leaf with a notch at the tip. Their inside faces forward and always remains hanging from the base.

Horns are peculiarly curved. Starting at the base of the crown they take a downward and backward curve and again incline a little upward and forward taking a spiral inward sweep, finally ending in a fine taper - thus giving a half moon appearance.

Gir herd

Dewlap is moderately developed. Sheath in males is usually large and pendulous. Tail is long and whip like. Skin is loose and pliable. Hair is short and glossy. Hooves are of medium size and black.

Morphometric and Performance Parameters

Length, height and heart girth average 150, 140 and 180 cm, respectively, in males. The corresponding figures in females are 125.5, 121.2 and 160.4 cm. Birth weight averages 23.9 kg with a range of 20 to 27 kg. Adult body weight averages 544 kg in males and 310 kg in females. Age at first calving ranges from 1,200 to 1,800 days with an average of about 1,552 days. Gir cows are very good milkers. Milk yield averages 2,110 kg (range 800 to 3,300 kg) in a lactation of about 308 days (range 250 and 375 days). Calving interval ranges between 400 and 600 days with an average of 516 days. Fat averages 4.4%.

Breeding Farms

1. Cattle Breeding Farm, Copardem, Goa
2. Akshar Purushottam Mandir Gaushala, Gondal, Gujarat
3. Bochasanwasi Shree Akshar Purushottam Gaushala Trust, Bochasan, Gujarat
4. Lok Bharti Gaushala, Sanosara, Gujarat
5. Sabarmati Ashram Gaushala, Bidaj, Gujarat

6. Gujarat Agricultural University, Junagarh, Gujarat
7. Cattle Breeding Farm: Bhuttwad, Rajkot; Dhoraji, Gujarat
8. BAIF Magazari Farm, Zamp, Gujarat
9. Kasturba Krishi Khetra, Indore, Madhya Pradesh
10. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh
11. Bombay Pinjrapole, Mumbai
12. Mumbai Gou-Rakshak Mandali, Mumbai
13. Pinjrapole Sanstha Sangli, Sangli, Maharashtra
14. Shree Nasik Panchvati Pinjrapole, Nasik, Maharashtra
15. Cattle Breeding Farm: Kopargaon; Jath, Maharashtra
16. Cattle Breeding Farm, Dag, Jhalawar, Rajasthan

Contact Agencies

1. State Animal Husbandry Department, Gujarat
2. Gujarat Agricultural University, Anand, Gujarat
3. State Animal Husbandry Department, Rajasthan

HALLIKAR

Origin and distribution

THE Hallikar is a typical Mysore type breed of cattle found mainly in Mysore, Mandya, Bangalore, Kolar, Tumkur, Hassan and Chitradurga districts of Karnataka state. It is one of the best draught breeds of southern India. Most of the present-day South Indian breeds have originated from the Hallikar.

Location and Topography

The breeding tract lies between 12° and 14°31' north latitude, and between 75°5' and 78°15' east longitude. The native tract of the Hallikar in general is undulating with an average altitude of 800 m above msl. On the western side, there are Western Ghats known as Malnad. Towards the east, the area is at a slightly lower level. In the west and south, there are extensive pasture areas. The east is intensely cultivated. Rice, pulses, oilseeds, sugarcane and coffee are the major crops.

Breeding tract

Soil

Soil in the depression of undulations is composed of rich red sedimentary deposits and red laterite on the grass-covered hills. There are extensive tracts with gravelly sandy soil, particularly on the top of rising grounds. Most of the soils in the east are deficient in nitrogen.

Climate

The temperature of the area is moderate throughout the year. The mean maximum temperature varies from 26° to 35°C and mean minimum temperature from 15° to 21°C. Humidity ranges from 68 to 81 %. Average rainfall is around 80 cm.

Management Practices

Hallikar cattle are bred both by professional breeders and cultivators. A few families in each village have been breeding these cattle for generations.

Hallikar bull

Hallikar cow

Hallikar females being used for ploughing

They maintain their own stud bulls and also provide service to others for a nominal fee. A couple of decades back cows were not milked and were kept only for production of bullocks. However, with the change in the economic scenario, cows are generally milked. Milk yield is 1.5 to 2.5 kg. In the entire tract bullocks are given special attention. Females are being used for all kinds of farm operations. They can also work in water logged fields and contribute to the farming system.

They are fed in verandahs by the owners with their own hands. Mostly fingermillet, grass, sorghum or pearlmillet are offered as green fodder. Animals are loosely tied in sheds and fed simultaneously. Such practices do not exist for females. Price of each bullock ranges from Rs 5,500 to Rs 10,000. This is probably the only consideration for personal attention in the feeding and management of the males.

Physical Characteristics

Colour is grey to dark grey with deep shadings on the fore- and hind-quarters. Frequently, there are light grey markings on the face, dewlap and under the body. Hallikar cattle are medium sized, compact and muscular in appearance.

The forehead is prominent giving a slight bulgy appearance and is farrowed in the middle. The face is long and tapers towards the muzzle, which is usually grey to black. Horns emerge near each other from the top of poll and are carried backward, each in a straight line for nearly half their length and then with a gentle and graceful sweep bend forward and slightly inward toward the tips which are black and sharp. Horns almost touch the neck in front of hump when the animal is feeding with its head downward. Eyes are small and clear. Ears are small tapering to a point. Dewlap is thin and moderately developed. Sheath is very small and is tucked up with the body. Tail is fine with a black switch which reaches little below hocks.


Hallikar calf

Morphometric and Performance Parameters

The length, height and heart girth range from 190 to 200, 132 to 140 and 170 to 200 cm, respectively, in males. In females, these average around 170, 118 and 150 cm respectively. Adult males and females weigh around 340 and 227 kg respectively. Age at first calving ranges from 915 to 1,800 days with an average of about 1,370 days. Lactation milk yield is around 540 kg ranging from 227 to 1,134 kg. Lactation length ranges from 210 to 310 days averaging of about 285 days. Fat is about 5.7%. Average calving interval is 598.9±27.36 days.

Males are castrated when they are 3 to 4 years of age and are then gradually broken to yoke. A pair of bullocks can pull continuously a maximum draught of 13 to 16% of their body weight for 6 hr. The average speed and power under average load and climatic conditions are 3 km/hr and 0.91 hp/pair.

Breeding Farms

1. Composite Livestock Farm and Research Station, Hessarghatta, Karnataka
2. Cattle Breeding Farm: Kunikenahalli, Tumkur; Koila, Karnataka

Contact Agencies

1. State Animal Husbandry Department, Karnataka
2. University of Agricultural Sciences, Dharwar, Karnataka

HARIANA

Origin and Distribution

THE Hariana, a prominent dual-purpose breed of northern India, was primarily reared for bullock production. Its native breeding tract encompasses large parts of Rohtak, Hisar, Jind and Gurgaon districts of Haryana.

These animals are also reared in Jodhpur, Alwar, Loharu and Bharatpur districts of Rajasthan. Meerut, Bulandshahar and Aligarh districts of western Uttar Pradesh also have sizable population of this breed. This is one of the most widely spread breed in the Indo-Gangetic plains. According to some reports the purebred Hariana cattle were abundant in Jhajjar, Beri and Jahajgarh pockets of Rohtak district.

It is difficult to speculate the origin and ancestry of this breed. Hariana cattle take their name from the region known as Haryana in the erstwhile east Punjab. There were two strains of cattle - Hisar and Hansi, known after the names of their native towns. Hariana cattle seems to have originated from these strains. Harianas are somewhat similar to the Gaolao, Mewati and Ongole breeds. Shahabadi and Gangatiri are closely related types.

Breeding tract

No systematic scientific studies have been made to evaluate the work efficiency of our well-known draught animals. Therefore, the Indian Council of Agricultural Research has initiated a progeny testing scheme for the conservation of Hariana breed, and improvement of its draughtability and milk yield. The scheme is run by the Project Directorate on Cattle, Meerut, and Haryana Agricultural University, Hisar, in collaboration with the Government Livestock Farm, Hisar, 4 livestock farms in Uttar Pradesh and one in Bharatpur (Rajasthan). The 6 co-operating herds number about 900 breedable females, for which, allowing for infertility and mortality, it is expected to produce annually 200 male and 200 female progeny. Young males (bullocks) from selected sires are being tested for known measures of draught capacity.

Location and Topography

The native breeding tract lies between 28°30' and 30° north latitude, and 75°45' and 76°80' east longitude. This area is irregular in shape, with its long axis lying northwest and southeast. On the northwest it is bound by the Ghaggar valley; and on the west, southwest and south by the Bagar and Dhaundauti or sandy tracts which are a continuation of the Rajasthan desert. On the east it is bound by the Yamuna river. The average altitude of the area is about 200 m above msl.

Soil

Soils in the breeding belt fall into two groups, viz. arid soils and entisoils. They are light textured, sandy and loamy sand. Soils are deficient in organic carbon, and medium to high in phosphorus and potassium contents. In Rohtak district, soil is mostly light coloured alluvial loam. In Hisar, soft loam with reddish tinge is interspersed with sand and clay. In some parts sand hills are present. In low-lying parts clay is hard. Calcareous limestone is also found in some parts of the area. All soils give excellent crop returns with sufficient rains but, unless irrigated, fail entirely in times of drought, though sandy soils as are prevalent in this area can yield good crops even with less rain. Salinity is not uncommon where the drainage lines have been obstructed. The average water level is quite deep, ranging from 18 to 30 m, except in land of canal areas where the water-table is 9 or 12 m deep.

Climate

The climatic environment is sub-tropical and semi-arid. This tract has a relatively dry climate. The southwest monsoon brings rains during July and August, contributing 80 to 85 % of the total annual rainfall. The annual rainfall ranges from 30 cm in arid zone to 50 cm in semi-arid areas. The weather remains almost dry from October to mid-April. Temperature ranges from 0°C in winter to 46°C in summer. Important rainfed crops are pearlmillet, sorghum and clusterbean during *kharif* season, and gram, mustard and barley during *rabi* season. In areas under irrigation, major crops grown are rice, wheat, barley, lucerne, maize and mustard.

Management Practices

Land holding size in the breeding tract has decreased from 8-10 ha during fifties to 1.52 ha in 1994 along with a reduction in the number of Hariana cattle from 6.8 to 0.43 per household. Cattle are traditionally reared mainly by grazing on common pasture lands of the village and along the banks of canals and roadsides with little supplementary feeding of crop residues like wheat *bhusa*, stalks of pearlmillet, sorghum, millet, straws from pulse crops, weeds and grasses. Calves are not weaned. Since Hariana cows are mainly reared for producing bullocks, greater attention is paid to rearing of male calves than of female calves. High-yielding cows, bullocks and young males are

Hariana bull

Hariana cow

Hariana calves

given green fodder and concentrate in addition to grazing. Animals are tied in the open or under the shade of trees. Housing is provided during extreme weather conditions. Animal houses have mostly *kutcha* floor and good drainage facilities, and are separate from human dwellings. This region has a good network of AI and this is the common method used to breed the animals. However, breeding bulls are also available in villages. Males are usually castrated at about 3 years of age. Bullocks are used for ploughing, transportation etc.

Physical Characteristics

Hariana animals are white or light-grey in colour. In bulls, colour in between fore- and hind-quarters is relatively dark or dark grey. Skin is black. Hariana cattle have compact and proportionately built body. They are characterized by a long and narrow face, flat forehead and a well marked bony prominence at the centre of the poll. They have small horns. Muzzle is usually black. Eyes are large and prominent. Typical animals have black eyelashes. Head is carried high and gives them a graceful appearance. Hump is of medium size in cows and large in males. Legs are moderately long and lean with small, hard and well shaped feet. Sheath is small. Udder is capacious and extends well forward with a well-developed milk-vein. Teats are well developed, proportionate and medium sized. Tail is rather short, thin and tapering. There is a black switch reaching just below hocks. A coat colour other than white or grey as well

Hariana herd

as white switch of tail is considered a marked deviation from the typical attributes and a disqualification from the stand point of breed registration.

Morphometric and Performance Parameters

Body length, height and heart girth measure 136, 144 and 160 cm, respectively, in males, and 137.5, 135 and 155.6 cm, respectively, in females. Birth weight averages 23.34 kg for male calves (range 20 to 25 kg), 21.73 kg for female calves (range 17 to 24 kg) with an overall average of 22.46 kg (range 17 to 25 kg). Adult body weight is around 499 and 325 kg in males and females respectively. Age at first calving ranges from 1,067 to 1,809 days with an average of 1,567 days. Average milk yield is around 997 kg with a range of 692 to 1,754 kg. Lactation length is about 272 days ranging from 238 to 330 days. Average service period is 232 days (range 126 to 305 days), dry period 255 days (range 133 to 571 days) and calving interval 483 days (range 415 to 561 days). Fat ranges from 4.3 to 5.3%, with an average of about 4.5%; SNF is around 9.1%.

Breeding Farms

1. State Livestock Farm: Barpeta, Kamrup; Guwahati; Jagduar, Sibsagar; Khanikar, Dibrugarh; Manja; Pachmile, Darrang; Lumbajang, Darrang, Assam
2. Cattle Breeding Farm: Dumraon, Shahbad; Sairakela, Singhbhum; Purnea, Bihar
3. Birsa Agricultural University, Ranchi, Bihar

Hariana bullocks

4. Shri Gaushala, Bhagalpur, Bihar
5. Government Livestock Farm, Hisar, Haryana
6. Choudhary Charan Singh Haryana Agricultural University, Hisar, Haryana
7. Shri Gaushala Society, Panipat, Haryana
8. Cattle Breeding Farm: Minora, Tikamgarh; Kiratpur, Itarsi; Imlikhera; Pakaria, Madhya Pradesh
9. Cattle Breeding Farm: Hetikundi; Kopergaon, Maharashtra
10. Bull Rearing Centre, Nagpur, Maharashtra
11. Panjabrao Krishi Vidayapeeth, Warud, Maharashtra
12. Livestock Breeding and Dairy Farm, Bhojanagar, Ganjam, Orissa
13. Cattle Breeding Farm: Bolangir; Boudh; Chiplima; Keonjhar, Orissa
14. Cattle Breeding Farm, Kumher, Bharatpur, Rajasthan
15. Regional Exotic Cattle Breeding Farm, Agartala, Tripura
16. State Livestock-cum-Agricultural Farm: Niblet, Barabanki; Hastinapur, Meerut; Babugarh, Ghaziabad; Neelgaon, Sitapur; Saidpur, Lalitpur, Uttar Pradesh
17. Mathura Brindavan Hasanand Gochar Bhumi Trust, Mathura, Uttar Pradesh
18. Central Research-cum-Breeding Centre, Haringhatta, Nadia, West Bengal

Contact Agencies

1. Choudhary Charan Singh Haryana Agricultural University, Hisar, Haryana
2. State Animal Husbandry Department, Haryana

KANGAYAM

Synonyms: Kanganad, Kongu

Origin and Distribution

THE Kangayam, a draught breed of cattle, is distributed in Kangayam, Dharapuram, Perundurai, Erode, Bhavani and part of Gobichettipalayam taluks of Erode district, Palani, Vedasandur and part of Dindikgul taluks of Dindigul district; Karur and Aravakurichi taluks of Karur district; Udumalpet, part of Avinashi and Tirupur taluks of Coimbatore district; and Tiruchengodu and part of Sankaridrug taluks of Namakkal district of Tamil Nadu. Animals true to type are seen in Kangayam, Dharapuram and Karur taluks. Kangayam cattle have extended into areas other than the original breeding tract, viz. Tiruchengodu and parts of Sankaridrug taluks of Namakkal district. On the other hand, replacement of Kangayam cattle by exotic crosses is high in Udumalpet, Pollachi, Palladam and Tirupur taluks of Coimbatore district, and Erode taluk of Erode district. These districts were earlier considered as part of main breeding tract. This breed derives its name from its habitat, Kangayam taluk of Coimbatore district.

Breeding tract

The Kangayam breed was developed by the efforts of the late Pattogar of Palayakottai, Sri Rai Bahadur N. Nallathambi Sarkaria Manradiar. This breed is most closely related to the Umblachery breed of cattle. Kangayam animals are well built and heavier than Umblachery cattle and are found in drier climate, whereas Umblachery are found in the hot humid tract. The estimated total population in the breeding tract is 479,200. Bulls, bullocks and breedable females constitute about 0.15, 22.79 and 43.52 % of the population respectively.

Location and Topography

The Kangayam breeding tract lies approximately between 10°12' and 11°48' north latitude, and 77°12' and 78°12 east longitude. Total area is approximately 17,000 km². The area is on a plateau with undulation. Average altitude is about 400 m above msl. Though two major rivers, viz. Bhavani and Amaravathi, are flowing through this area, water is a major constraint for agricultural production.

Soil

Soil type is predominantly red followed by black soil. Red soil is shallow in depth with texture ranging from sandy to gravel with a calcareous sub-soil.

Climate

Climate of the tract is generally hot throughout the year except during rainy season. Winters are mild and summers not excessively warm. Mean maximum temperature varies from 30° to 38°C and mean minimum temperature from 19° to 26°C. Rainfall is spread throughout the year averaging around 65 cm/annum. The tract receives maximum rainfall during northeast monsoon (September to December). Mean relative humidity varies from 53 to 77 %.

Cereals are the main cultivated crops in the breeding tract. Cereal crops grown are sorghum (*Sorghum vulgare*), pearlmillet (*Pennisetum typhoides*), paddy (*Oryza sativa*) and fingermillet (*Eleusine coracana*). Other main cultivated crops are groundnut (*Arachis hypogoea*), sugarcane (*Saccharum officinarum*) and cotton (*Gossypium hirsutum*) in addition to certain pulses.

Management Practices

Kangayam cattle are maintained under semi-intensive system of management. They are traditionally reared on grazing in dry lands kept as pasture land by farmers for cattle and sheep in the breeding tract. The pasture land is divided into many paddocks by live fencing. A thorny shrub *mullukiuvai* (*Balsamodendron berryi*) is grown as fence. Within the grazing area, facility for drinking water is provided by keeping small cement water trough.

The predominant grass on the pasture in this tract is *kolukkattai* grass (*Cenchrus ciliaris* and *Cenchrus setigerus*). This grass with bulbous root stock can maintain its vitality through the severest drought. Seeds are freely shed and rain at any time causes their rapid germination, resulting in lush green pasture which grows to 30 cm or more in height within a few weeks time. A system of rotational and priority grazing is being adopted. *Velvaelam* trees (*Acacia leucocephala*) are also seen extensively in grazing areas. They provide shade to animals in rest during grazing.

Calves are allowed to suck as much milk from their dams as they require up to first 6 weeks. Later green grass is provided to the calves and in due course they are allowed to go for grazing along with their dams. Suckling is gradually reduced as calves grow. However, weaning is never practised and calves are allowed to suck throughout lactation.

Males which are not selected for breeding are castrated usually between 18 and 30

Kangayam bull

Kangayam cow

months of age and trained for ploughing. Bullocks at the age of above 4 years are used for load hauling. Young stock and adults are allowed for grazing from 7.00 AM to 5.00 PM. They are brought back from the pasture in the evening and mostly housed in the open during night near owners' residence. Average herd size is 3.5.

Besides grazing, animals are also fed with dry fodder like sorghum and pearlmillet stovers, groundnut haulms and paddy straw. The quantity of dry fodder fed depends on the availability of green grass in grazing field. During dry seasons when grazing is scarce, concentrate feed consisting of rice bran, groundnut-cake, soaked cotton seed, and ground sorghum and pearlmillet are fed only to cows in milk and working animals. Palmyra leaves (*Borassus flabellifer*) are also fed with other fodder during drought. Kangayam young stock and adult are able to utilize poor quality roughages efficiently.

Physical Characteristics

Coat is red at birth, but changes to grey at about 6 months of age. Bulls are grey with dark colour in hump, fore- and hind-quarters, face and legs. Bullocks are grey. Cows are grey or white and grey. However, animals with red, black, fawn and broken colour are also observed. Such animals comprise approximately 1 to 2 % of the total population. Horns, muzzle, eyelids, tail switch and hooves are black. Skin is also black.

Animals are strong and active with compact body. Legs are short and stout with strong hooves. Forehead is broad and level with a groove at the centre. Face is straight.

Colour variation among Kangayam calves

Ears are short, erect and pointed. Eyes are prominent with dark rings around them and are elliptical. Horns are long and strong, taking backward, outward and upward sweep, and then curving inward with tips tending to meet each other thus nearly completing a circle. Hump is large in males and medium in females. Dewlap and navel flap are small. Penis sheath is small and tucked up with body. Tail is broad at the base and tapered towards the end with a black switch which extends well below the hock. Udder is small, mostly tucked up. Teats are small and cylindrical with rounded tips.

Morphometric and Performance Parameters

Averages of body length, height and heart girth are 144.9±0.87, 140.1±0.97 and 176.5±1.65 cm, respectively, in males, and 131.4±0.76, 124.9±0.58 and 156.1±0.85 cm, respectively, in females. Birth weight is around 21 kg. Adult body weight averages 640 kg in males and 380 kg in females. Age at first calving is around 1,330 days (range 1,100 to 1,500 days). Milk yield ranges from 600 to 800 kg with an average of about 540 kg in a lactation of about 270 days. Average dry period is about 175 days. Averages of fat and SNF are 3.88±0.07 and 6.96±0.05 % respectively. Calving interval is around 498 days (range 365 to 670 days).

Bullocks are used for all agricultural operations like ploughing, threshing and carting. Bullocks have a good capacity for work. They are capable of carting with load even on a sunny cloudless summer day with ambient temperature of 30° to 35°C. Usually the cart owners start at about 6.00 AM in the morning. Double animal two-wheeled carts of a specified design are made with strong wood and steel frame and pneumatic tyres similar to those used for heavy vehicles. A pair of bullocks is able to pull 3,644±69 kg (including cart weight), i.e. 3.82 times of their body weight, over a distance of 10 to 21 km without rest. Bullocks usually take 4 to 6 hr to cover 18 to 21 km distance with load. The travelling time for a single trip, i.e. with load to mill and back with empty cart, varies from 7 to 11 hours.

Bullocks reach the maximum potential for this type of work at about 6 years and maintain it effectively till 11 years of age. Kangayam bullocks alone are used for sugarcane load hauling, though different draught type Mysore breeds, viz. Hallikar and Alambadi, are available in this area. This quality of Kangayam bullocks facilitates the cart owners to earn their livelihood solely on transportation of sugarcane in and around the sugar mill.

Breeding Farms

1. Cattle Farm, South Arcot, Tamil Nadu
2. Livestock Research Station, Hosur, Tamil Nadu

Contact Agencies

1. State Animal Husbandry Department, Tamil Nadu
2. Tamil Nadu Veterinary and Animal Sciences University, Chennai

KANKREJ

Synonyms: Wadad or Waged, Vagadia, Talabda, Nagar and Bonnai

Origin and Distribution

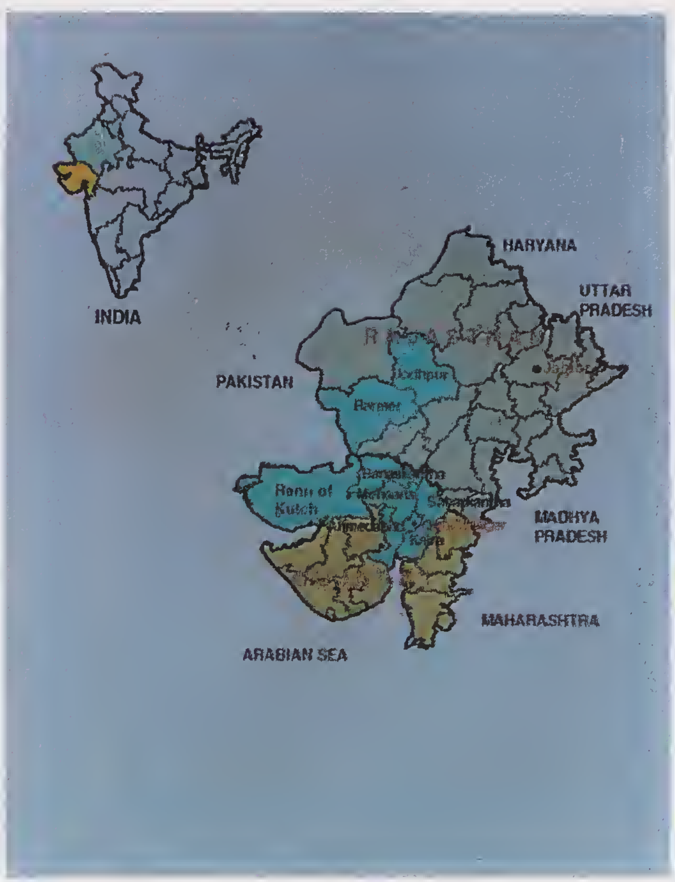
THE Kankrej is one of the heaviest breeds of cattle in India and is found in southeast Rann of Kutch comprising Mehsana, Kutch, Ahmedabad, Kaira, Sabarkantha and Banaskantha districts of Gujarat, and Barmer and Jodhpur districts of Rajasthan. It takes its name from the name of a geographical area in north Gujarat.

Location and Topography

The area covered by this breed is roughly 18,000 km^2 and lies between 21° and 24° north latitude, and between 71° and 74° east longitude. The Kankrej breeding tract is low-lying and dry. Most parts of the area are sandy, treeless plains with some sand hills and valleys of black clay between them.

Soil

In the southwestern part of the region the soils are sandy loam and heavy black, whereas on the eastern side they are mostly sandy with some sandy loam areas. In some areas, the soil is whitish-grey clay loam. The sub-soil is yellowish white. Usually in black soils rice, wheat, millets, sorghum and sugarcane are grown. In light soils pulses, oilseeds, sorghum and millets are extensively grown.



Breeding tract

Climate

Climate is tropical to sub-tropical and dry varying greatly with the distance from the sea. Average rainfall is 50 to 76 cm and is usually concentrated during July to October. Temperature varies from 4°C in winter to 49°C in summer.

Management Practices

Pastures are seasonal. These are available from July to October. No

Kankrej bull

Kankrej cow

Kankrej calf

fodder crops are grown as such. Only stovers and straws are fed to cattle. Cottonseed and oilcakes are widely used as concentrates. The Rabaris, the Maldharis, the Bharwads, the Ahirs and the Charans are the main communities associated with breeding of the Kankrej.

Kankrej cattle have a very important role to play in the economy of the region. Agricultural operations and road transport in village areas are carried out mainly by bullocks of this breed. Animals are not tied. They are kept in paddocks of thorny bushes near human dwellings. Animals are taken out for grazing. They cover long distances during scarcity periods but during rainy season when pastures are available, they graze in nearby areas. Calves are not weaned. Male calves are cared better than female calves. Castor, rapeseed and sesamum are common among the oilseeds. Clusterbean (*Cyamopsis psoraloides* or *C. tetragonoloba)* seed is used as a cattle feed. Cottonseed and oilcake are used as concentrate.

Physical Characteristics

Colour of the animal varies from silver-grey to iron-grey or steel-black. In males, forequarters, hindquarters and hump are slightly darker than the rest of the body. Forehead is broad and slightly dished in the centre. Face is short and nose slightly upturned. Ears are large, pendulous and open – characteristic of this breed. Horns are strong, and curved outward and upward in a lyre-shaped fashion. They are covered with skin to a longer distance as compared to other breeds. Polls, forequarters and hindquarters are rusty red in newborn calves, but the colour disappears later on. Hump is well developed. Dewlap is thin and pendulous; sheath is pendulous.

The gait of Kankrej is peculiar to the breed; the action is smooth, there is hardly any movement of the body, the head is held noticeably high, the stride is long and even, and the hind hoof is placed well ahead of the impression of fore hoof. This gait is called 1¼ paces (*sawai chal*) by the breeders.

Morphometric and Performance Parameters

Body length, height and heart girth average 148, 158 and 194 cm, respectively, in

Kankrej herd

males, and 113.6, 133.6 and 166.2 cm, respectively, in females. Average birth weight is 23 kg (range 21-26 kg). Adult body weight is 500 - 550 kg in males and 325 - 400 kg in females.

Average age at first calving is 1,438.1±10.95 days (range 1,030 to 1,700 days). Average milk yield is around 1,746 kg (range 1,097 to 3,194 kg). Lactation length averages 294 days (range 275 to 350 days) and calving interval is around 490 days (range 407 to 639 days). Fat is around 4.8% (range 4.66 to 4.99%).

Breeding Farms

1. Cattle Breeding Farm: Bhuj; Mandvi; Thara, Gujarat
2. Gujarat Agricultural University, Anand, Gujarat
3. BAIF, Magazari Farm, Zamp, Gujarat
4. Bidda Pinjrapole and Gaushala, Mandvi, Gujarat
5. Bochasenwari Shri Akshar Purushottam Gaushala Trust, Bochasan, Gujarat
6. Mansa Gaushala Trust, Vijapur, Gujarat

Contact Agencies

1. State Animal Husbandry Department, Gujarat
2. Gujarat Agricultural University, Sardar Krushinagar, Gujarat

KENKATHA

Synonym: Kenwaria

Origin and Distribution

THE Kenkatha cattle take their name from the River Ken, for they are bred along the banks of this small river in the area of Bundelkhand comprising Lalitpur, Hamirpur and Banda districts of Uttar Pradesh, and Tikamgarh district of Madhya Pradesh. This breed is similar to the Malvi breed.

Location and Topography

The area where the breed is prevalent lies approximately between the Tropic of Cancer and 26° north latitude, and between 78°5' and 81°6' east longitude. It is a rugged area traversed by ranges of the Vindhya Hills, which never rise above 600 m msl.

Soil

Three types of soils are commonly found in the area. One type is reddish brown, and is very coarse-grained. It is shallow in depth, poor in plant nutrients and usually found on high-lying areas where it produces very poor crops. The second type is brown with greater depth, and is usually underlaid with a zone of calcium carbonate accumulation. It is suitable for cultivation provided manuring and irrigation facilities are available. The third type is dark brown to black, and is the most fertile soil of the locality.

Climate

The maximum temperature during summer exceeds 45°C during May and June. Winters are comparatively mild. Air movement throughout the year is rapid. The average rainfall of the area is 90 to 100 cm. Most of the rainfall is concentrated during July and August.

Breeding tract

Kenkatha bull

Kenkatha cow

Kenkatha herd

The growing season of the grasses is thus short and they become coarse very quickly. Millets are grown extensively in this area.

Management Practices

Kenkatha animals are very popular for light draught on the road and for cultivation. The animals of this breed are no more preferred as Hariana and Tharparkar graded animals are becoming popular. They have strong feet and are well adapted to the agro-climatic conditions of this region as they have to cover long distances in search of grazing pastures. They thrive on poor feed and fodder resources. Straws and husks from crops are utilized as cattle feeds. Only a few animals are maintained by each cultivator. Cows and young stock are maintained on grazing only. Pasture is scanty and generally consists of coarse grasses of low nutritive value. Bullocks are usually fed good-quality straws. All the animals of one village are taken by villagers turn by turn.

Physical Characteristics

The Kenkatha cattle are small, sturdy and fairly powerful, varying in colour from grey on the barrel to dark grey on the rest of the body. Head is short and broad. Forehead is dished. Horns emerge from the outer angles of poll in a markedly forward direction and terminate in sharp points. Ears are sharply pointed and do not droop. Body is short, deep and compact. Hump is well-developed. Sheath is somewhat pendulous and ends with a black tip. Dewlap is moderately heavy. Tail grows beyond hocks.

Morphometric and Performance Parameters

Body length, height and heart girth average 119.4, 127.0 and 177.8 cm, respectively, in males, and 114.3, 132.1 and 167.6 cm, respectively, in females. An adult male weighs around 350 kg, whereas an adult female weighs around 300 kg.

Contact Agencies

1. State Animal Husbandry Department, Uttar Pradesh

KHERIGARH

Synonyms: Kheri, Kharigarh, Khari

Origin and Distribution

THE Kherigarh breed is closely allied to the Malvi breed. This breed is mostly found in the Lakhimpur-Kheri district of Uttar Pradesh, but some animals are also found in the adjoining Pilibhit district. This breed has been named after the area. The local people, however, do not know anything about its name and just call it as *desi*. Population of Kherigarh breed has decreased considerably over the last few years because of large-scale deforestation for crop production. The grazing areas are now restricted to road-sides and canal banks only.

Location and Topography

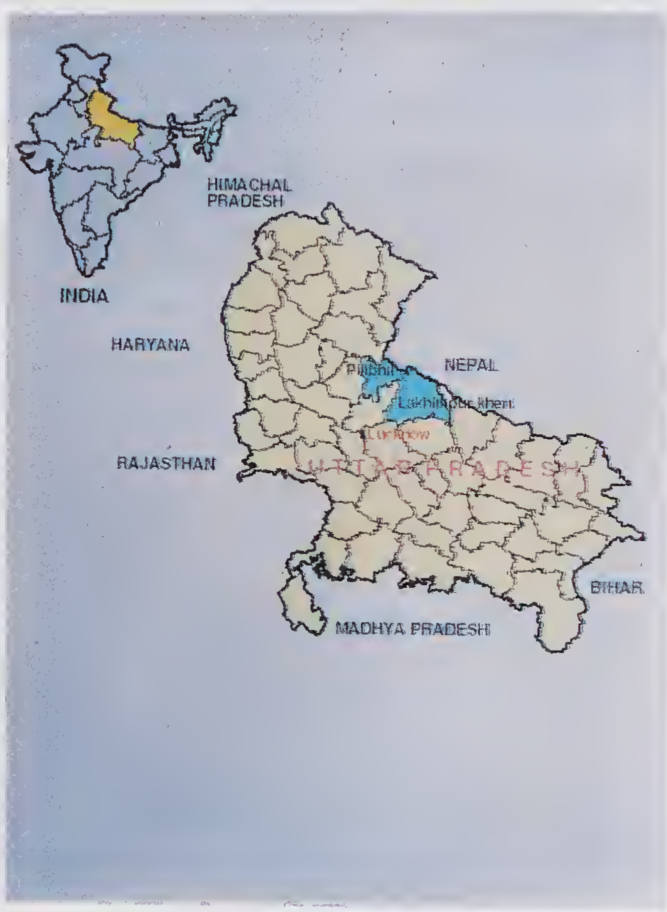
The Kheri district of Uttar Pradesh is located between 27°4' and 28°4' north latitude and between 80°2' and 81°2' east longitude. Kheri is divided by the rivers which flow through the area into different tracts of varying conditions. There are many small lakes and swamps in the district.

Soil

The southwest region between the rivers Sukheta and Gomti consists of fertile loam soils. The area between rivers Gomti and Kathna is sandy, and is called Parehar tract; here the best Kherigarh cattle are bred. The most fertile part of the district is along the banks of the River Sarda in the northern region. The predominant soil consists of deep alluvium with occasional nodular limestone.

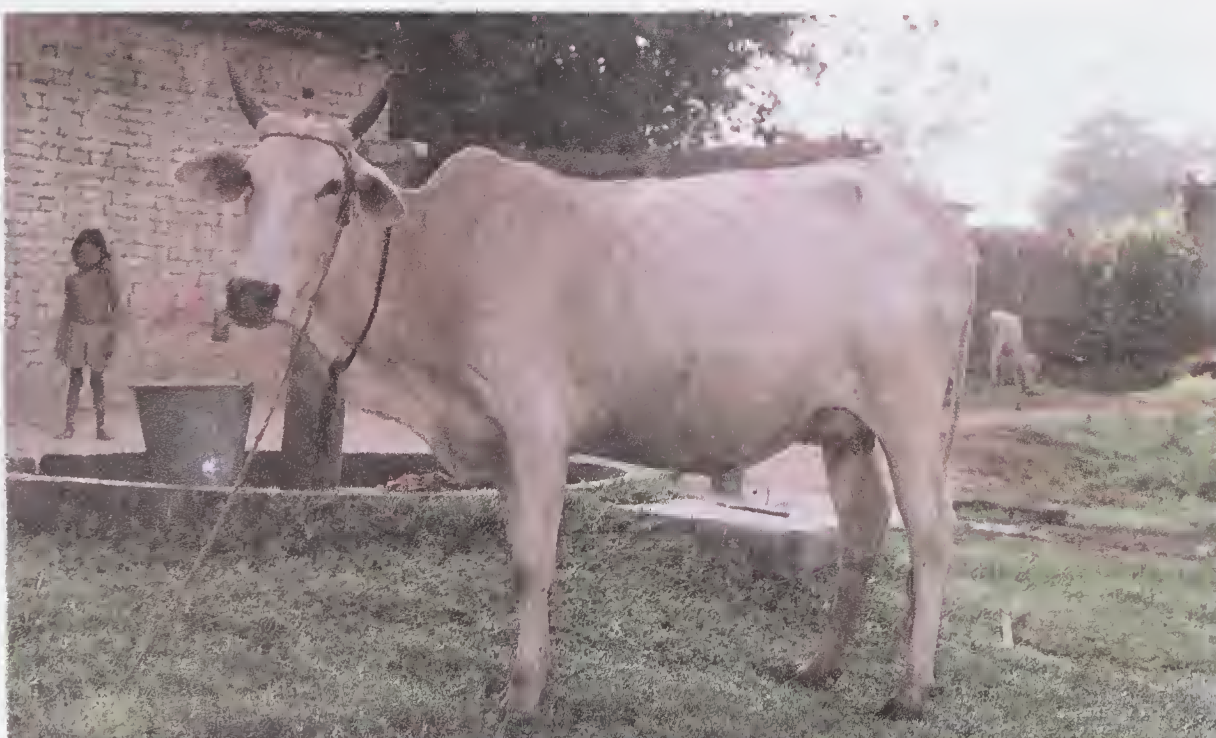
Climate

The climatic environment might be defined as sub-tropical medium altitude with a relatively good rainfall. It is a submontane area having high humidity. During summer the maximum day temperature may go as high as 45° C.



Breeding tract

Kherigarh bull



Kherigarh cow

During winter months the minimum temperature rarely goes below 20°C. The mean annual temperature is around 25°C. Annual rainfall is 115 to 165 cm. Rainfall is heavier in the northeast part of the area.


Kherigarh calf

Management Practices

Animals are maintained on grazing only. No additional fodder or concentrate is provided. Housing is also not provided. They are tied in the open area. Males are castrated at about 3-3½ years of age and used for work. Uncastrated males are used both for breeding and work purposes. No separate breeding bulls are maintained. Animals are resistant to diseases and the expenditure on treatment is almost nil.

Sugarcane is grown extensively. Among other field crops rice, maize, wheat, barley, chickpea, lentils and oilseeds such as mustard and rape are largely grown. The region has an abundance of coarse grasses and most of the cattle are maintained on grazing. Calves are reared mostly on milk. In some cases cow is not at all milked.

Physical Characteristics

Kherigarh cattle have white coat colour. Some animals have grey colour distributed all over body especially on face. The grey colour might have appeared due to interbreeding among different breeds.

These are small-sized, very active animals, reared mainly for draught purpose. Face is small. Forehead is flat and broad. Eyes are large, bulging and bright. Horns are medium (about 15 cm) and upstanding, curving outward and upward. These are thick at the base. Horn formation is typical of the lyre-horned Malvi type. Animals of this breed are much lighter in general appearance than the Malvis. Ears are small and horizontal. Muzzle is black. Neck is short. Hump is small in females and medium sized in males. Dewlap is thin and pendulous, starts from right under the chin and continues up to brisket. Sheath is small. Legs are light and straight. Hooves are small and black. Tail is long almost touching the ground and ending in a black switch. Some animals have white switch also. Udder is small and tightly attached with the body. Teats are small and cylindrical. Skin is slightly loose and black. Bullocks are very good for draught purposes. They run very fast.

Kherigarh herd

Morphometric and Performance Parameters

Average body length, height and heart girth are around 130, 120 and 180 cm, respectively, in males, and 130, 130 and 150 cm, respectively, in females. Adult body weight is around 476 kg in males and 318 kg in females.

Cows are poor milkers. They produce about 1 to 1.5 litres of milk in a day and for about 1 year. Age at first calving is 1,100 to 1,300 days. Service period is around 150 days and calving interval 420 to 450 days. Bulls mature at an age of about 3 years and start servicing.

An animal fair is held every Friday at Dhubagha, Lakhimpur-Kheri for the trade of Kheri type of animals. Only males are brought for sale/purchase. A bullock, 2 to 2½ years old, fetches about Rs 1,000 to 1,200. There are no purchasers for the females. A large number of animals are marketed through this fair during August and September.

Contact Agencies

1. State Animal Husbandry Department, Uttar Pradesh

KHILLARI

Synonyms: Mandeshi, Shikari

Origin and Distribution

THE Khillari breed of cattle is known for the quick draught capabilities of its bullocks. This breed is found in Kolhapur, Solapur, Sangli and Satara districts of Maharashtra, and Belgaum, Bijapur and Dharwad districts of Karnataka. This breed seems to have originated from Hallikar or Amritmahal breed of cattle. Unlike most of the Indian breeds, it does not take its name from a geographical area. Khillar means a herd of cattle and the herdsman is known as Khillari or Thillari. Four types of Khillaris are prevalent in different parts of the breeding tract: Atpadi Mahal in southern Maharashtra, Mhaswad in Solapur and Satara areas, Thillari in Satpura range of hills and Nakali in the adjoining areas ot these regions.

Location and Topography

This area lies approximately between latitude 16° and 22°2' north, and longitude 70°25' and 76°24' east. The altitude of the area is around 510 to 600 m above msl.

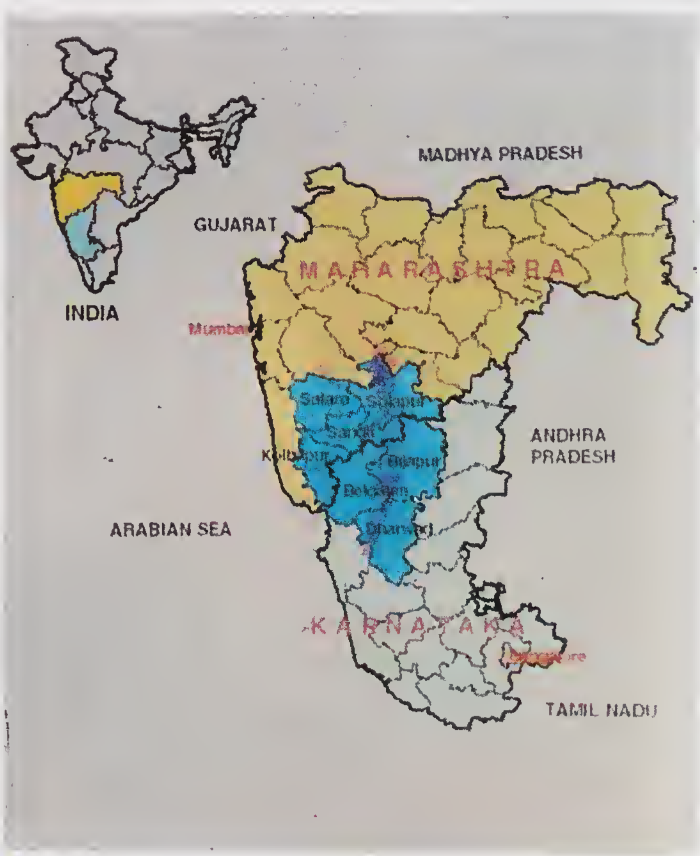
Soil

Soil type is light shallow in some parts and deep rich loam having black to deep black hue suited for cotton in other parts. Light soils mixed with gravels are good for growing millets, groundnut and sorghum.

Climate

The climate is tropical and dry. Day temperature may go as high as 40°C during summer but the nights are pleasant. Minimum temperature during winter is around 12°C. The area has scanty rainfall and famines are quite frequent.

Annual rainfall is about 150 cm spreading mostly over 3 months from June to August. Average wind velocity



Breeding tract

Khillari bull

Khillari cow

is 6.8 km/hr. Average humidity is 85% in the morning and 50% in the evening.

Management Practices

Breeders pay more attention to male calves as compared to female calves because of their draught qualities. Usually the male calf is allowed to suck all the milk it can take until the dam goes dry. Cow is partially milked if it has a female calf. Males are castrated at about 5- 5½ years of age. *Sorghum vulgare* and *Pennisetum typhoideum* are extensively grown in the area. Grains are used for human consumption while stalks are fed to cattle. Maize and some varieties of sorghum are also grown as fodder crops.

Khillari calf

Physical Characteristics

Khillaris of the Deccan plateau, the Mhaswad and the Atpadi Mahal types are greyish-white. Males are dark over the forequarters and hind quarters, with peculiar grey and white mottled markings on the face. The Tapti Khillari is white with carroty nose and carroty hooves. The Nakali Khillari is grey with tawny or brick dust colour over the forequarters. Newborn calves have rusty red polls, but this colour disappears within a couple of months.

A typical Khillari animal is compact and tight skinned, with clean cut features. Appearance is like a compact cylinder with stout, strongly set limbs. There is a slight rise in the level of the back towards the hook bones. Forehead is long and narrow with a gradual convex bulge backward toward the horns. A distinct groove runs in the centre of the forehead from the nasal bridge to the centre of the poll. Face is lean and long with smooth, tightly drawn skin. Nasal bridge is sharp and prominent. Muzzle is frequently mottled in colour. Pink muzzle is not liked by some breeders. Eyes are set in elongated fashion and are rather small, though prominent and a little bulging. Thick, wavy skin folds around the eyes give them a dull appearance. Ears are small, pointed and always held sideways. Horns are long and pointed, and follow the backward curve of the forehead. They are placed close together at the root, grow backwards for half the length and then turn upwards in a smooth bow shape peculiar to this breed. The horns are thick at the base and taper to a fine point.

Dewlap is light with very few folds. Hump in males is firm, fleshy and of moderate

Khillari herd

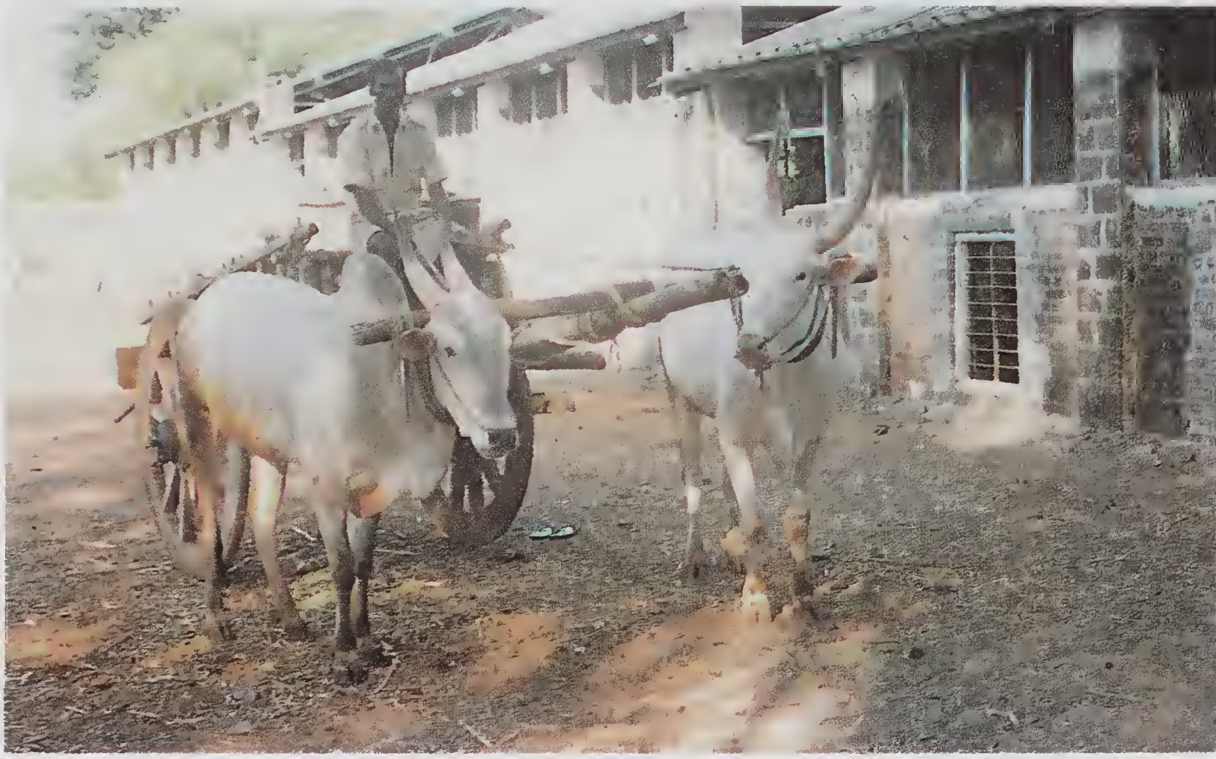
size. Hooves are black with digits closely set. Navel flap and sheath are tight and tucked. up with the body. Tail just touches the hock joint and has a black switch. Skin is soft and pliable though tightly drawn over the body. Hair are fine, short and glossy.

Morphometric and Performance Parameters

Body length, height and heart girth range from 125 to 150, 130 to 145 and 185 to 210 cm, respectively, in males, and from 100 to 125, 115 to 140 and 150 to 200 cm, respectively, in females. Birth weight ranges from 17 to 20 kg in female calves and 18 to 21 kg in male calves. Adult body weight ranges from 450 to 625 kg in males and from 300 to 350 kg in females.

Average age at first calving is 1,428 days (range 1,050 to 1,930 days). Lactation milk yield averages 384 kg (range 240 to 515 kg). However, cows producing up to 1,200 kg milk per lactation have been found in Pandharpur area of Maharashtra. Average lactation length is 228 days (range 190 to 275 days). Average calving interval is 450 days. Bulls mature at about 2 to 2½ years of age.

Khillari bullocks are highly valued as fast powerful draught cattle, for they can travel miles without showing any signs of fatigue. Bullock pair is very popular and fetches very good price. The cost of a pair of bullocks varies from Rs 10,000 to Rs 30,000. Cattle of this breed have been exported to north-western Sri Lanka to improve the draught qualities of Sinhala breed. Female stocks produce very little milk. However, they nurse calves satisfactorily.



Khillari bullocks

Breeding Farms

1. Cattle Breeding Farm: Junoni, Solapur; Hingoli; Jath, Maharashtra
2. Cattle Breeding Station, Bankapur, Dharwar, Karnataka

Contact Agencies

1. State Animal Husbandry Department, Maharashtra

KRISHNA VALLEY

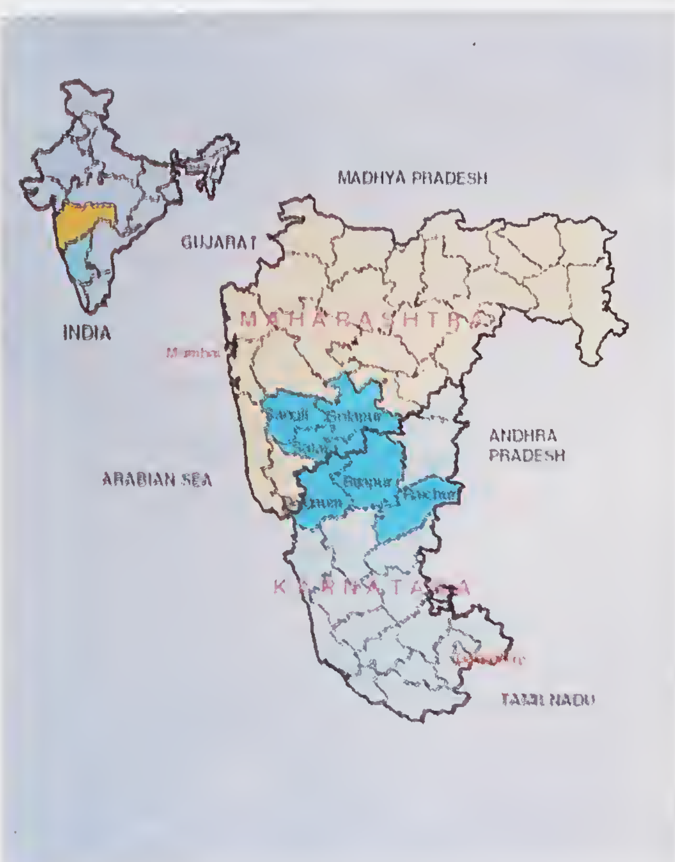
Synonym: Kistna Valley

Origin and Distribution

THE Krishna Valley breed of cattle is a heavy draught breed and is used exclusively in the black cotton soil of the watershed of the River Krishna. It is mainly found in Solapur, Sangli and Satara districts of Maharashtra, and Belgaum, Bijapur and Raichur districts of Karnataka. It is understood that Gir cattle from Kathiawar, Ongole cattle from Andhra Pradesh, Kankrej cattle from Gujarat, and local cattle having Mysore-type blood in them have contributed to the origin of the Krishna Valley breed.

Location and Topography

The home tract of this breed lies approximately between 15°8' and 17°8' north latitude, and 74° and 78° east longitude. The whole area is on a plateau east of the Sahyadri range of hills, also known as Western Ghats. The average altitude of the area ranges from 540 to 750 m above MSL.



Breeding tract

Soil

Soil belongs to 3 main classes: red in the hills, black near the river banks, and a third type of light grey colour and full of gravel. Black soil is widely distributed in the Krishna Valley.

Climate

The climate is generally mild and dry. During April and May there is considerable heat during the day, but nights are pleasant and cool. Even during summer months there are occasional showers of rain with thunder, causing a considerable decrease in temperature. Temperature varies from 15° to 35°C. Annual rainfall ranges from 125 cm in the west to approximately 75 cm in the east.

Management Practices

Grazing lands in the area are

Krishna Valley bull

Krishna Valley cow

Krishna Valley calves

extremely limited. Cattle are usually allowed to graze only after the grasses have been harvested for hay making. All animals are stall-fed throughout the year. Sorghum, maize, beans and grasses are fed as green fodder. Concentrates are fed to milking cows and bullocks.

Shevri (*Sesbania aegyptiaca*) is grown extensively along the banks of rivers; the plant remains green throughout the summer. Loppings are used for feeding cattle. Cotton is extensively grown in this area. Sugarcane, tobacco, betelvines and various garden crops are grown where irrigation facilities exist.

Male calves are allowed to suck 2 teats and female calves 1 teat. At 2½ years of age, young males are broken into work, and at 3 to 4 years they are castrated and sold as bullocks.

Physical Characteristics

Large variation exists in the physical characteristics of this breed because of contribution from at least 3 distinct breeds, i.e. Gir, Ongole and local Mysore type cattle, to its development. The common colour is grey-white with a darker shade on fore-quarters and hind-quarters in males. Adult females are more whitish in appearance. Brown and white, black and white, and mottled colours are often seen. Animals are large, having a massive frame with deep, loosely built short body, and large barrel. Forehead has a distinct bulge surmounted by small curved horns which usually emerge

Krishna Valley bullocks

in an outward direction from the outer angles of the poll and curve slightly upward and inward. Dewlap is well-developed and pendulous. Sheath is also slightly pendulous. Ears are small and pointed; breeders prefer them not to droop too much. Tail almost reaches the ground.

Morphometric and Performance Parameters

Average body length, height and heart girth measure 153.4, 144.8 and 195.8 cm, respectively, in males, and 132.1, 121.9 and 167.6 cm, respectively, in females. Body weight of an adult male is 550 kg and that of an adult female 325 kg. Average age at first calving is 1,400 to 1,500 days. Bullocks of this breed have been exported to Brazil and the United States of America.

Contact Agencies

1. State Animal Husbandry Department, Maharashtra
2. State Animal Husbandry Department, Karnataka

MALVI

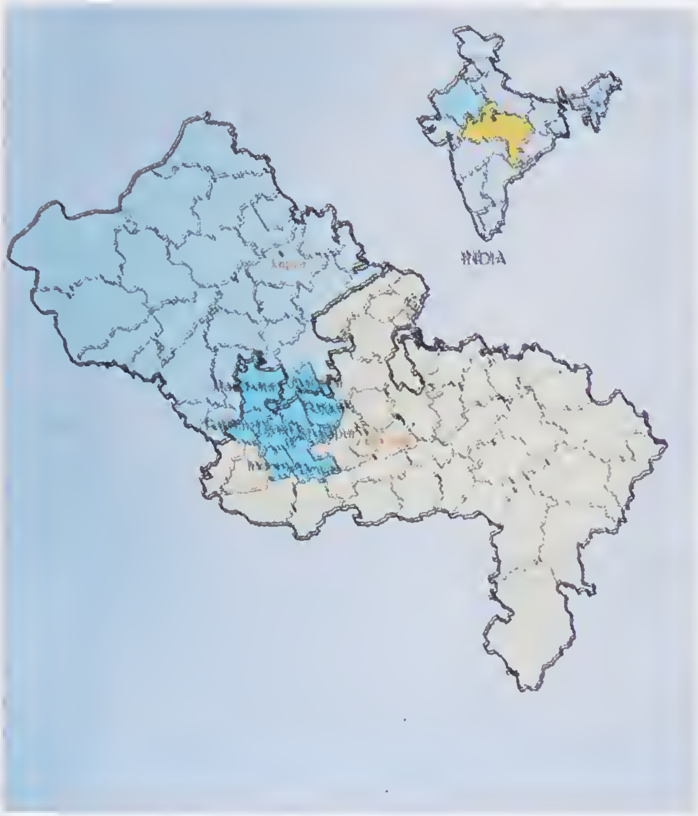
Synonyms: Mahadeopuri, Manthani

Origin and Distribution

THE Malvi is primarily a draught breed found in a large area comprising Indore, Dewas, Ujjain, Shajapur, Mandsaur, Ratlam, and Rajgarh districts of Madhya Pradesh, and Jhalawar district of Rajasthan. There are 3 strains of Malvi breed: light, medium and heavy. The Umatwara strain bred in Rajgarh and Narsingarh is a heavy type animal; the Saugar strain in the Malwa tract of Madhya Pradesh is a lighter type. In the west adjoining Rajasthan the breed is larger, while in Madhya Pradesh it is smaller. Malvi bullocks are well known for quick transportation, endurance and ability to carry heavy loads on rough roads.

Location and Topography

The breeding tract of Malvis lies between 22°4' and 25°9' north latitude, and 74°3' and 78°5' east latitude. The average altitude is about 480 m above msl.



Breeding tract

Soil

Majority of the area has black cotton soil of heavy loam type. Lighter soils with greater sand proportions are also prevalent.

Climate

Climate is dry and moderate. Maximum temperature during summer is around 40°C. Nights are cool and pleasant.

Management Practices

Plenty of grasses are available for grazing. Cattle owners take their cattle to grazing areas during day time and bring them back in the evening. Wherever irrigation facilities exist fodder crops such as sorghum and maize are grown. Concentrate is given only to bullocks.

Malvi bull

Malvi cow

Malvi calf

Physical Characteristics

Malvi cattle are grey- darker in males, with neck, shoulders, hump and quarters almost black. Cows and bullocks become nearly pure white with age. Malvi cattle have short, deep and compact body. Legs are short but powerful, and hooves are strong and black. Dewlap is well developed and the sheath is pendulous. Head is short and broad with dished forehead. Muzzle is dark and slightly upturned. Horns are strong and pointed, and emerge from the outer angles of poll in an outward and upward direction. Tail switch is black.

Morphometric and Performance Parameters

Average body length, height and heart girth are about 150, 140 and 200 cm, respectively, in males, and 140, 130 and 170 cm, respectively, in females. Average birth

Malvi herd

weight of the calf is around 20 kg, male calves being slightly heavier (21 kg) than female calves (19 kg). Adult male weighs 499 kg and adult female 340 kg. Average age at first calving is 1,432 days (range 1,175 to 2,009 days). Average milk yield is 1,074 kg (range 627 to 1,227 kg). Average lactation length is 306 days (range 275 to 320 days). Average calving interval is 419 days (range 411 and 530 days). Average dry period is 180 days (range 125 and 265 days) and service period 178 days.

Breeding Farms

1. Cattle Breeding Farm, Agar, Shajapur, Madhya Pradesh
2. Cattle Breeding Farm, Dag, Jhalawar, Rajasthan

Contact Agencies

1. State Animal Husbandry Department, Madhya Pradesh
2. State Animal Husbandry Department, Rajasthan

MEWATI

Synonyms: Kosi, Mehwati

Origin and Distribution

THE Mewati breed of cattle is found in the tract known as Mewat, comprising Alwar and Bharatpur districts of Rajasthan. These cattle are also found around Mathura and Kosi in western Uttar Pradesh, and Faridabad and Gurgaon districts of Hariana. The breed is sometimes spoken of as Kosi, on account of the sale of large number of cattle of this breed at the Kosi market. Presently this market has become buffalo dominated and few cows are being brought for sale. Mewati cattle are similar in type to the Hariana but there are traces of influence of the Gir, Kankrej and Malvi breeds.

Location and Topography

The breeding tract lies between 27°15' and 27°55' north latitude, and 76°35' and 77°4' east latitude. The area in the breeding tract is flat, rocky and sandy, and is intersected by the lower ranges of the Aravali hills.

Breeding tract

Soil

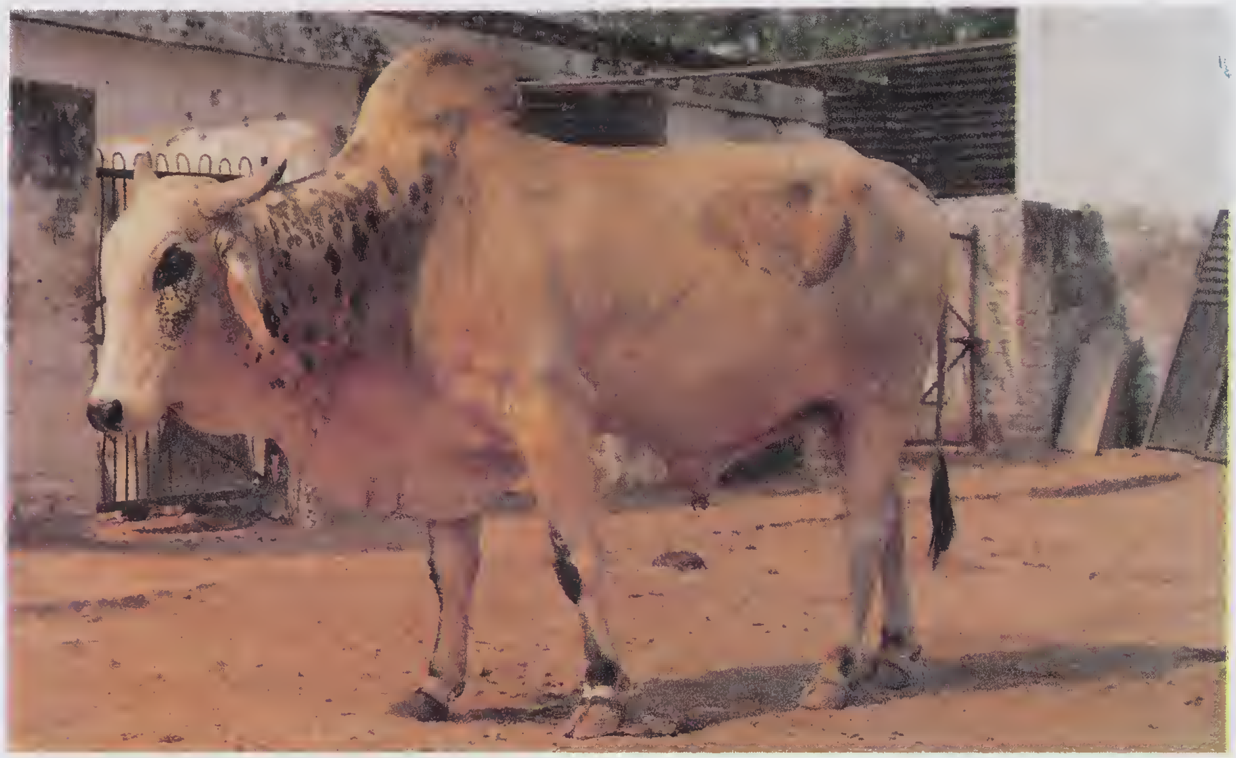
Soils of this region may be divided into 3 classes: a stiffish clay; loamy soil, easier to work but requiring heavy manuring; very fertile sandy type, found at the foot of hills and along the banks of streams, being only suitable for lighter crops.

Climate

The climate is sub-tropical and dry throughout the year except during July, August and September when it is hot and humid. Maximum temperature may go as high as 47°C during May and June. Average annual rainfall of the area is about 55 to 65 cm.

Management Practices

Very little grazing is available only for a limited period of about 2 months in



Mewati bull

Mewati cow

Mewati calf

August and September, otherwise they are stall-fed. Cattle depend mostly on the byproducts of cereals, sorghum, millets, *Cajanus cajan, Phaseolus radiatus, P. mungo*, wheat, barley, chickpeas, etc. Concentrates such as oilcakes and crushed grains are given to bullocks only. Calves are not weaned. Male calves receive greater attention than female calves since the breed is basically reared for draught purposes. Males are castrated at 3 years of age.

Physical Characteristics

Mewati cattle are usually white with neck, shoulders and quarters of a darker shade. Face is long and narrow with forehead slightly bulging. Horns emerge from the outer angles of poll and are inclined to turn backward at the points. Eyes are prominent and surrounded by a very dark rim. Muzzle is wide and square. Upper lip is thick and overhanging, giving the upper part of the nose a contracted appearance. Muzzle is pitch black. Ears are pendulous but not so long. Dewlap, though hanging, is not very loose. Sheath also is loose but not pendulous. Tail is long, the tuft nearly reaching the heels. Cows usually have well-developed udders.

Morphometric and Performance Parameters

Average body length, height and heart girth are 155, 152 and 188 cm, respectively, in bulls, and 122, 122 and 152 cm, respectively, in cows. Bull weighs around 385 kg and mature cow 325 kg.

Mewati cattle are powerful and docile, and are useful for heavy ploughing, carting and drawing water from deep wells.

Contact Agencies

1. State Animal Husbandry Department, Rajasthan

NAGORI

Origin and Distribution

THE Nagori is a reputed breed. It is primarily reared for draught quality of its bullocks. Its home tract lies in the Nagaur district of Rajasthan in western India. A sizable population of the breed is also found in the adjoining Jodhpur district and Nokha tehsil of Bikaner district. The traditional breeding tract covers an area of 17,718 km².

Population statistics of the Nagori breed is not available as such. However, as the breed is largely confined to Nagaur district of Rajasthan, overall cattle population of this district can provide a basis for making logical deductions. Approximately 35% of the indigenous cattle in this district are true to Nagori breed and there may be around 0.173 million Nagori animals in Nagaur district on the basis of livestock census conducted in 1992. Although the population appears to be quite impressive, yet the actual position in the field presents a dismal picture. Since the demand for bullocks is decreasing day by day due to mechanization of agriculture and transport means, its population is decreasing at a considerable rate. The economy of this region depends heavily on the livestock resources and Nagori cattle forms a major component of their farm animal wealth. The decline in population of these locally adapted animal breeds of this desert region may have serious effects on its eocnomy.

Location and Topography

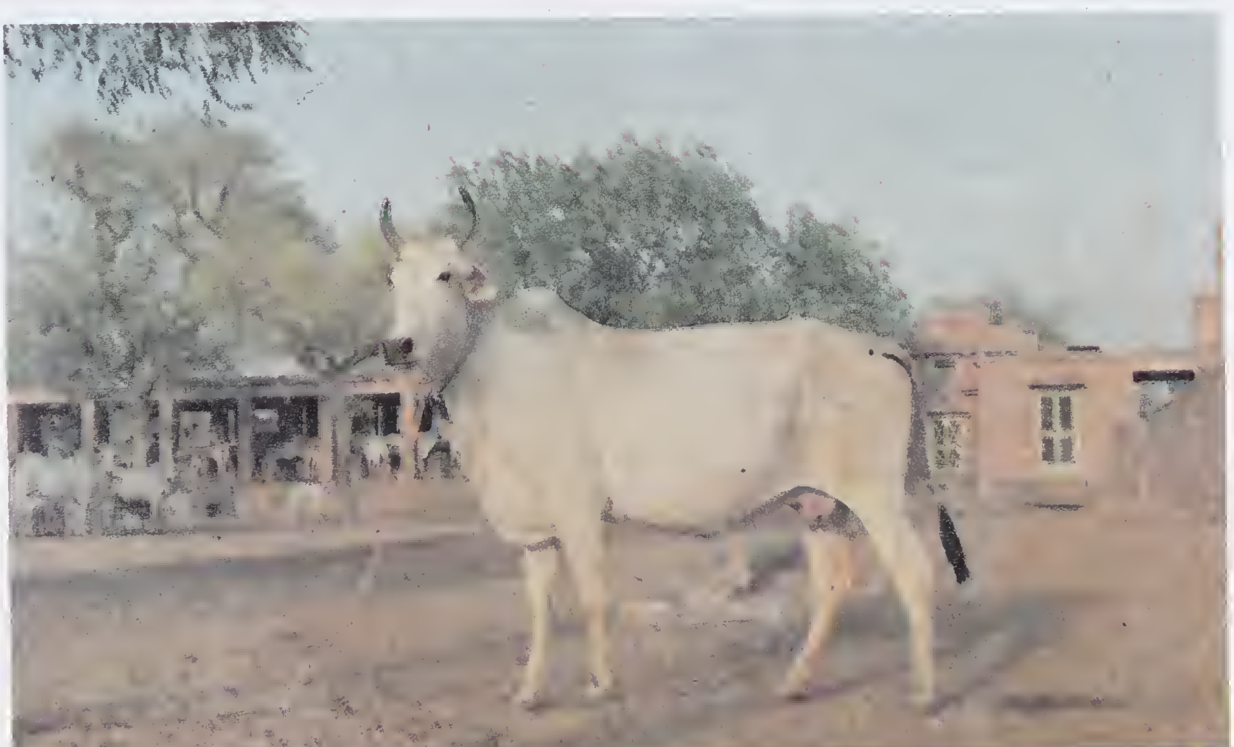
The latitudinal position of the area lies approximately between 24°37' and 26°37' in the north; the longitudinal position is between 63°05' and 75°22' in the east. Major part of the breeding tract of Nagori cattle lies in the sandy plain at an average altitude of 215 m above msl. Extremely meagre rainfall and inadequate irrigation facilities are great constraints in agricultural production.

Soil

Most of the area covered by the tract is sandy plains, except towards the

Breeding tract

Nagori bull



Nagori cow

west nearing the ranges of Aravali hills, where the soil in the foothills is sandy loam. The scanty vegetation is semi-arid, comprising mainly of tall bushes and some trees.


Nagori calf

Climate

Being an arid desert, the climate of the region remains dry even in the monsoon period. It is also characterized by extreme variation in temperature. The maximum temperature ranging between 47° and 49°C is not uncommon during the peak summer season. The average annual rainfall is around 32 cm. Winds blow at great velocity during April to June and during this period sand storms occur very frequently.

Management Practices

Farmers generally maintain mixed herds of Nagori and Rathi cattle. Animal feed resources including water are scarce. Main fodders available in the area are some trees like *khejri*, *kabli keekar, jal, aakh* and *sewan* grass. Animals are taken out for grazing and they cover long distances in search of fodder. Bullocks are usually stall-fed. Animals are kept in open areas fenced either by bushes or by small mud-walls. These are located in the close vicinity or even within the human dwellings. During extreme weather conditions a temporary shelter of thatched roof is provided. Milk letdown is through suckling, and calves are allowed to suck milk as long as their dams give milk. In case of female calves, milk feeding is reduced to half within a month. Male calves are nursed longer and fed better as compared to female calves. Males are castrated at about 6 months of age. Natural mating is generally practised in the field and there is very little of artificial insemination.

Physical Characteristics

Nagori animals are fine, upstanding, very alert and agile, and generally white or light grey. In some cases head, face and shoulder are slightly greyish. Eyelids are white or light grey. Muzzle, hooves and horns are black. Skin is tight and black. Forehead is flat and not so prominent. Face is long and narrow like that of horse. Eyelids are heavy and overhanging, whereas eyes are small, clear and bright. Ears are

Nagori herd

medium in size with pinkish inside. Poll is very small and is almost absent in animals true to the breed. Horns are of medium size emerging from the outer angles of poll. They extend in an outward direction and are carried upwards with a gentle curve to turn in at points. Shoulder blade is prominent. Hump is well developed; back straight; legs long and straight with small, strong and compact hooves. Dewlap is small, fine and buttoned up with the body. Navel sheath is very small, tucked up with the abdomen like a button. Tail is high set and is of moderate length (below hock) ending in a black switch. Cows have small and shallow udder. Bullocks are big and powerful. They are capable of heavy draught work in deep sands. There is a tendency to legginess and lightness of bone, though feet are strong. This characteristic has given the breed its agility and ease of movement. It runs like a horse.

Morphometric and Performance Parameters

Average body length, height and heart girth ranges from 140 to 150, 145 to 152 and 191 to 203 cm, respectively, in males, and from 130 to 148, 118 to 132 and 157 to 175 cm, respectively, in females. Average birth weight of calf is around 16.9 kg. Adult body weight is around 363 kg in males and 318 kg in females.

Average age at first calving in Nagori cows is 1,440 days (range 1,287 and 1,505 days). Cows are poor milkers. Average milk yield is 603 kg (range 479 to 905 kg). Average lactation period is 267 days (range 237 to 299 days). Dry period ranges from

Nagori bullocks

82 to 155 days. Average service period is 172 (range 121 to 203 days) and calving interval 461 days (range 423 to 549 days).

The Nagori is mainly a draught breed. Its bullocks are used for transportation and in agricultural operations such as ploughing, cultivation and drawing water from well. They are usually broken for light work at about 3 years of age when they weigh around 275 kg. A pair of bullocks cost approximately Rs 15,000.

Breeding Farm

1. Government Cattle Breeding Farm, Nagaur, Rajasthan

Contact Agencies

1. State Animal Husbandry Department, Rajasthan
2. Rajasthan Agricultural University, Bikaner, Rajasthan

NIMARI

Synonyms: Khargaon, Khargoni, Khurgoni

Origin and Distribution

THE Nimari breed is found in Nimar tract of Narmada valley in Madhya Pradesh comprising Khandwa, Khargon and Barwani districts. Some animals are also found in Jalgaon district of Maharashtra. Animals are active. Bullocks are known for their draught work but cows are poor milkers.

The Nimari breed seems to have originated from crossing of the Gir and the Khillari. Gir blood has contributed to its coat colour, massive body structure and convexity of forehead, and Khillari blood to its hardiness, agility and temper.

Khamla found in Satpura ranges of Madhya Pradesh and *Khamgoan* in Berar are very similar to Nimari and may be its strains.

Breeding tract

Location and Topography

The breeding tract known as Nimar lies between 21° and 23° north latitude, and 70° and 76° east longitude. The whole surface is hilly and undulating. Throughout the area the geological formation is the trap rock of enormous thickness. Near the Narmada river, sand-stones, limestones and other strata appear in places. The ridges and hills have forest cover.

Soil

Soil of the area is formed from disintegrated trap rock and is partly alluvial. Soil type is rich black along the banks of streams, ordinary black in the valleys and shallow brown on high lying level ground. Soil condition in Nimar demands use of heavier implements which require powerfull bullocks.

Climate

Climate is dry and healthy. Days are very hot during summer but nights are

Nimari bull

Nimari cow


Nimari calf

cool and pleasant. Winters are mild. Average maximum temperature varies from 25° to 40°C and average minimum temperature from 7° to 26° C. Rainfall is light. Average humidity varies from 25 to 80%.

Management Practices

In the monsoons, there are lot of grasses and cattle are sent for grazing. Bullocks are generally stallfed. In addition to harvested grasses, they are also fed concentrates such as cottonseed, crushed chickpeas and groundnut or sesamum-cakes. In winter all the cattle are stall-fed. Green sorghum is extensively fed. During summer when there is scarcity of feed and fodder, tree loppings are given. Special attention is paid to the rearing of male calves as they form an important source of income to the farmers. Bullocks are usually castrated and put to light work at about 3 to 3.5 years of age. Only a few cows are milked while the rest only feed calves.

Physical Characteristics

Nimari cattle are red with large splashes of white on various parts of the body. Head is moderately long with a somewhat bulging forehead. It is carried alertly and gives the animal a graceful appearance. Horns usually emerge in a backward direction from the outer angles of the poll, somewhat in the same manner as in Gir cattle, turning upward and outward and finally backward at the points. Occasionally, horns are also like those of Khillaris in size and shape, copper coloured and pointed. Ears are moderately long and wide, but are not pendulous. Muzzle in many animals is either copper- or amber-coloured.

Dewlap and sheath are moderately developed, though the sheath has the tendency to be pendulous. Hump in bulls is well developed and sometimes hangs over. Tail is long and thin with the black switch reaching to the ground. Hooves are strong and can stand rough wear on stony ground. Skin is fine and slightly loose. Cows usually have well-developed udder.

Morphometric and Performance Parameters

Body length, height and heart girth measure around 145, 155 and 175 cm, respec-

Nimari herd

tively, in males; and 120, 135 and 160 cm, respectively, in females. Adult body weight is around 390 kg in males and 318 kg in females. Age at first calving is around 1,477 days. Average milk yield is about 360 kg (range 310 to 495 kg) in a lactation of about 237 days (range 220 to 260 days). Milk fat is around 4.9%. Average calving interval is 482.5±11.6 days (range 400 to 530 days).

Breeding Farm

1. Cattle Breeding Farm, Rodhia, Khargon, Madhya Pradesh
2. Cattle Breeding Farm, Bod, Maharashtra

Contact Agencies

1. State Animal Husbandry Department, Madhya Pradesh

ONGOLE

Synonym: Nellore

Origin and Distribution

THE Ongole belongs to short-horned group of zebus which were brought by Aryans into India more than 4,000 years ago as original stock from north-west to Indus river basin and further to Indo-Gangetic plains and towards South along Godavari, Krishna and Pennar basins.

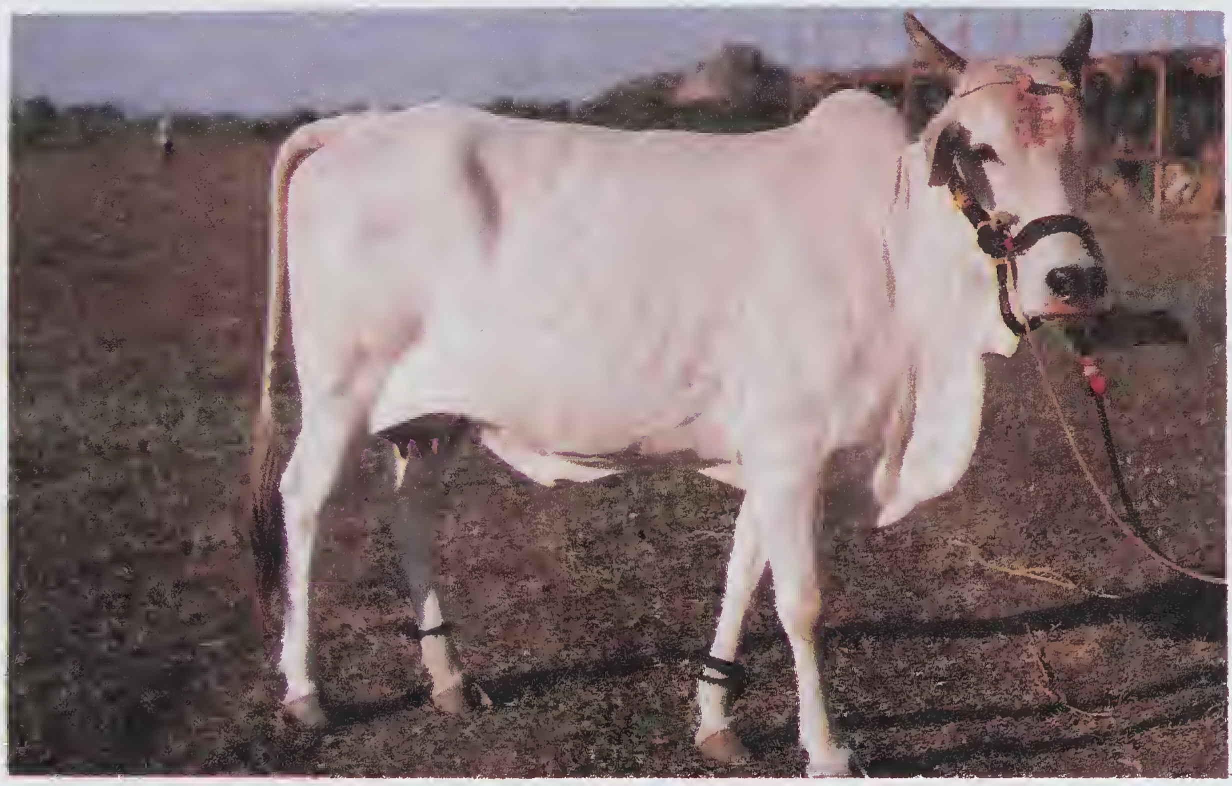
The Ongole breed takes its name from the geographical area in which it is reared. It is also called the Nellore breed since the Ongole taluk was earlier included in Nellore district but now it is included in Guntur district.

The original breed is now confined to the tract between Paleru and Gundlakamma rivers in Prakasam district though the major breeding tract extends between Pennar and Godavari rivers. The original breeding tract consists of the erstwhile Ongole, Guntur and Narasaraopet taluks, and parts of Sattena palli, Vinukonda, Darsi and Kandukur taluks. The present breeding tract extends all along the coast from Nellore to Vizianagaram, and Chittoor, Kurnool, Cuddapah, Anantapur, Nalgonda, Mahabubnagar and Khammam districts of Andhra Pradesh.

Breeding tract

Considerable efforts have been made for the development of Ongole cattle in India. The Nellore District Collector started the Ongole cattle show in 1858 to encourage the breeding of good quality Ongoles in the breeding zone. This event was conducted annually until 1871. The shows were a great encouragement for small and big breeders to produce better stock. In addition to these shows, in 1867, the Government laid down a principal that out of its uncultivated land, each village should reserve for common grazing an area equivalent to 30% of its land under cultivation, thereby providing additional pasture land for the Ongole. A key village scheme was launched by the

Ongole bull



Ongole cow

State Government at two places in the main Ongole breeding zone in 1952 and at two more places in 1956. In the area covered by the scheme all scrub bulls were castrated. To provide an additional boost to the breeding operation, bulls were stationed at several centres under various schemes such as Premium scheme, District Board scheme and free Bull Distribution scheme. The period between 1958 and 1980 saw the emergence of crossbreeding and even the Ongole breed was not spared. Development of Ongole breed suffered further with the introduction of Land Ceiling Act and removing of restriction for pasture land. After almost half a century, the Ongole cattle show was revived in March 1981. A seminar was also held to discuss the reasons for the sad state of Ongoles in their homeland. An important outcome of this seminar was the formation and registration of the Indian Ongole Cattle Breeders' Association.

The agricultural college dairy at Coimbatore maintained Ongole cows till 1924-25. Ongole cows were maintained till 1933-34 at the Hosur Farm which was established in 1919. Ongole cows were also kept at the Chintaladevi farm which was started in 1918. The objectives of this farm were to improve the milk yield, reduce the intercalving period and attain early maturity in the Ongole as well as produce large number of pedigree bulls for distribution in villages of the breeding area. The cows were shifted to the Lam farm in 1928. The Lam farm which was established in 1926 at Ongole initially for some time and again during 1964-75. The Mahanandi farm was started with Ongole cows in 1954. An Ongole cattle breeding farm was established at Ramatheertham in 1980. A composite livestock farm with Ongole cows and Nellore sheep was started at Chintaladevi in 1986 by the Animal Husbandry Department. An Ongole cattle germplasm centre was established by the Agricultural University at the Lam farm in 1986. Ongole cattle were also maintained at the Visakhapatnam and Kakinada farms earlier.

An Ongole Cattle Breeders' Association was formed on 27 August 1951. There is also a Central Herd Registration Scheme functioning at Ongole since 1978 with the objectives of survey of breeding tract, location of milk recording units, registration of animals, milk recording and formation of breeders' association. With a view to stem the decline in population of Ongole breed, the Andhra Pradesh Agricultural University has launched a Network Project on genetic improvement through associate herd testing in Ongole breed with the co-operation of State Animal Husbandry Department and the financial support of the Indian Council of Agricultural Research. An Ongole cattle germplasm unit was started at the Lam farm with a bull rearing, semen freezing and data processing centre. The Ongole cattle breeding farms of the Animal Husbandry Department at Ramatheertham in Prakasam district and Chitaladevi in Nellore district and University farm at Mahanandi in Kurnool district became associated herds. A University farm associated herd and a farmers' field associated herd were added at the Lam Farm in 1994.

Ongoles are our mute ambassadors to several countries. South American countries keep Ongoles pure. The United States of America imported Ongoles but mixed it with other Indian breeds to develop Brahman. South Americas developed Indu-Brazil by mixing the Ongole with the Gir and the Kankrej. The last shipment of Nellore bulls into Jamaica was in 1921. Until mid-1920s, most of the zebu cattle in the USA were of Nellore type. Brazil imported Ongoles first in 1895. In 1906, a large contingent of 200 Ongole cows and bulls were brought to Umeraba in Brazil. During 1961-62 Brazilians purchased 107 Ongole cows and a few bulls. The Nellore or Ongole breed's hardiness, disease resistance and its capacity to thrive on scanty and dry fodder have been quite successfully exploited for improving and upgrading the local stock of European origin. Ongoles have been imported by the USA for beef: by Brazil for beef and milk; by Sri Lanka, Fiji and Jamaica for draught; by Australia for heat tolerance and beef; and by Switzerland for disease resistance. Ongoles have been imported by many other countries like Argentina, Paraguay, Mexico, Columbia, Mauritius, Indonesia, the Philippines and Malaysia.

Location and Topography

The latitudinal position of the area is approximately between 14° and 16°50' north and the longitudinal between 79° and 80°55' east. The Ongole tract is mostly flat but the hilly ranges begin as one moves west. There are a number of perennial streams and rivers running through the tract. The banks of these rivers form excellent grazing areas.

Soil

Soils in general are very fertile and are broadly classified as black cotton, red loamy and sandy loam. Soils towards the sea coast are alluvial and of very good quality. As one goes further from the sea this soil is mostly black cotton soil containing plenty of lime. As one reaches the eastern ranges of hills, soil becomes poorer and is full of gravel. Soil on the slopes of hills is mostly red.

Climate

The climate of the tract is dry and mild, and is not subject to sudden changes. Sea breeze makes the area near the coast generally cooler than the inland areas. Average temperature varies from 18° to 40°C throughout the year. Average rainfall for the tract varies from 75 to 90 cm.

Management Practices

About 30 years ago, an average *ryot* used to maintain 4 to 8 cows but it is only 1 or 2 at present. Most of the villages had 1 or 2 breeding bulls. Ongoles constitute about 5% of total cattle population of Andhra Pradesh and were approximately 0.5 million in 1993.

The predominant crops grown in the area are paddy, sorghum, pearlmillet among cereals, blackgram, greengram among pulses, and cotton, chillies, tobacco among non-food and commercial crops. There are some permanent pastures in the dry areas of the tract. Grasses consist mainly of *Isecilema (Anthistiria) wightii* and *Andropogon monticolus* (*Chrysopogon montanus*). Paddy straw and other cultivated crops such as lentils are fed to animals. Stovers from sorghum *(Panicum miliaceum)* are also fed. Cotton-cakes and cottonseeds are extensively used for cattle feeding. Cattle are sent for grazing in groups with professional grazers known as Lambadis. Male calves are nursed better than female calves. They are allowed more milk and for longer duration as compared to female calves.

Physical Characteristics

Ongoles have a glossy white coat called *padakateeru* by the breeders. Males have dark grey markings on head, neck and hump, black points on knees and pasterns, black muzzle, black eye-lashes with a ring of black skin around eyes. Tips of ears and testes are black. Calves are generally white but sometimes are born with reddish-brown patches or reddish-brown colour. As they grow up to 6 months or 1 year, coat colour changes to white or grey as in adults. The glossy coat colour is due to the nature of the soil which is high in calcium, phosphorus and other elements. This characteristic coat colour is not observed in animals outside the breeding tract.

Ongole calves

Ongoles are large and heavy animals with loosely knit frames, great muscularity and long limbs. They have a majestic gait. Forehead is broad between eyes and slightly prominent. Face moderately long and coffin shaped. Bridge of nose is straight, slightly prominent with a shallow furrow. Muzzle is black with wide nostrils. Lower lip is also black. Eyes are elliptical with black eyelashes, a ring of black hair around eyelids 0.6 to 1.3 cm wide. Ears are alert and with moderately short black tip; inside of ear has white silky hair. Horns are short and stumpy, growing outward and backward from the outer angles of the poll, thick at the base and firm without cracks. In cows, horns are longer and thinner than in bulls. Horns in cows generally extend outward, upward and inward. Neck is short and thick in males, and moderately long in females. Black hair on neck is present in males. Hump in males is well developed and erect, filled up on both sides and not concave or leaning to either side. Dewlap is large, fan-shaped, fleshy and slightly pendulous, and hanging in folds, extending up to navel flap. Dewlap is serrated with smooth flowing folds instead of narrow constrictions. Folds are covered with soft fine hair in females. Chest is deep, wide and broad between forelimbs. Forelegs are strong, clean, medium in length, wide apart, firmly and squarely set under the body. Hooves and knees are black. In cows, navel flap is common and prominent. Tail head is sloping, well set, deeply moulded and not coarse. Switch of tail is black and extends up to the middle of the distance from the point of hock to the ground level. In males, sheath is not pendulous, but is well tucked with thin black hair on tip. Testes are well-

Ongole herd

developed, covered with silky hair and with no fleshy patches and not too pendulous. In females, there is a flap of skin in the position of sheath. Udder is well formed with well-placed and well-developed teats. Hind portion of udder is well developed. Skin is smooth and is of medium thickness, mellow and loose. Thin skin is preferred. Hair are white, silky and fine.

The points of disqualification are: red colour and red patches on body, white switch of tail, white eyelashes, white preputial hair, partly or fully flesh-coloured muzzle, light-coloured hooves, dark mottled spots and albino patches on body, black markings on hind-quarters, long neck in male, long drooping ears, raised poll, hollows in temples, presence of groove below inner canthes to bridge of nose, biconcave hump, leafy hooves, floating or uneven ribs on either side, short tail with switch ending above the hock joint, straight hock, supernumerary teats, rubbing hooves while walking, single testis (cryptorchid), winged shoulders, swinging hind limbs at hip joints and loose horns.

Farmers identify the Ongole breed with 3 lengths (legs, shoulders and back), 7 shorts (muzzle, ears, neck, dewlap, flank, sheath and tail) and 9 blacks (muzzle, eyes, tip of ears, knees, fetlocks, sheath, switch of tail, anal region and tip of testes).

Morphometric and Performance Parameters

Body length, height and heart girth average 171.1±0.95 (range 155 to 190 cm), 152.4±0.61 (range 140 to 165 cm) and 203.8±1.03 cm (range 186 to 230 cm), respectively, in males, and 133.3±1.0, 133.5±0.7 and 166.0±1.2 cm, respectively, in females. Average birth weight is around 27 kg (range 24 to 30 kg). Adult weight is from 545 to 615 kg in males and from 409 to 454 kg in females.

Age at first calving in Ongole cows ranges from 1,150 to 1,820 days (average 1,473 days). Average milk yield is 688 kg (range 475 to 1,000 kg) in a lactation period of about 230 days (range 160 to 270 days). Average dry period is 262±13.74 days (range 145 to 400 days), average service period 191 days (range 128 to 310 days), average calving interval 500 days (range 420 to 720 days) and average fat is 4.2% (range 4.1 to 4.8%).

Breeding Farms

1. Cattle Breeding Farm: Banavasi; Kakinada; Kampasagar; Mahanandi; Visakhapatnam, Andhra Pradesh
2. Livestock Research Station, Lam Farm, Guntur, Andhra Pradesh
3. Ongole Cattle Breeding Farm, Ramathiratham, Andhra Pradesh

Contact Agencies

1. State Animal Husbandry Department, Andhra Pradesh
2. Andhra Pradesh Agricultural University, Lam, Guntur, Andhra Pradesh

PONWAR

Synonym: Purnea

Origin and Distribution

THE Ponwar is a small hill type breed found in the Puranpur Tehsil of Pilibhit district of Uttar Pradesh. Animals true to breed are found in Mainakot, Mazara, Bhirkhera, Faizulaganj and Rajpur Semra villages falling under Madhotanda Veterinary Hospital area of Puranpur. A few animals are also found in Lakhimpur-Kheri district. A careful look at the physical characteristics reveals that this breed may be a mixture of hill cattle and plains cattle. As the breeding tract is near the Nepal border it seems possible that Nepalese hill cattle (Morang) and local white cattle might have contributed to the origin of this breed. The breed is largely reared by Tharu tribe in large herds. Cattle rearing is their profession. Passi and Yadavs also maintain it to some extent. Local people call it *kabri*, means mixture of colours.

Ponwar breed is maintained primarily for draught operations. Bullocks are fast movers and good for agricultural operations. Bullocks are also a good source of income to the farmers. A bullock fetches Rs 500 to Rs 600. Cows are reared only to produce bullocks and they produce very little, just sufficient to feed calves.

Location and Topography

The breeding tract lies in the foothills of Himalayas approximately between latitude 28°4' and 28°8' north, and between longitude 79° and 80°4' east. The area is only a short distance from the outer ranges of Himalayas. The entire area consists of level plains but no hills. Large parts of the area are covered by forests.

Soil

The breeding tract consists almost entirely of alluvial soil.

Climate

The climatic environment of the area is very humid and submontane.

Breeding tract

Ponwar bull

Ponwar cow

Ponwar calf

Temperature fluctuations are not much due to proximity to hills. Annual rainfall varies from 125 to 165 cm. This area is covered by dense forests and there is a lot of vegetation around. As the watertable is high because of canals and poor drainage, only those crops which can withstand water-logging conditions are grown. Paddy is grown extensively in this region.

Management Practices

Ponwar cattle are raised entirely on grazing in the forest area and no supplementary feed is provided. Animals of the whole village are taken for grazing by one or two persons in the morning at about 7 AM and brought back at about 7 PM. The animals cover as long as 10 km in the forest. Because of the predators, animals have a nervous nature and move in groups putting their heads in between each other. It is very difficult, rather impossible, to take out one animal from the group. Animals behave just like semi-wild type and are very difficult to handle. Females are not milked. Calves are allowed to suck all the milk. Bullocks are used for transportation and agricultural operations. Other stock is rarely handled. Animals are kept in the open.

Physical Characteristics

Ponwar cattle are usually brown or black with white patches. There is no particular pattern but black and white patches are intermixed. Animals possess a small, narrow face, small ears, and big, bright eyes. Forehead is slightly concave and has a white marking. Horns are medium in size emerging outward, upward and then curving inward with pointed tips. Sometimes, horns curve backward in the end. Sheath is small. Dewlap is light and thin. Hump is small in females and well developed in males. Tail is long ending in a white switch. Cows have small udders.

Morphometric and Performance Parameters

Body length, height and heart girth measure around 132 to 135, 130 to 135 and 160 to 165 cm, respectively, in males, and 127 to 130, 122 to 125 and 157 to 160 cm, respectively, in females. An adult male weighs between 315 and 360 kg and a female

Ponwar herd

between 270 and 295 kg. Heifers calve for the first time at about 1,800 days. Milk production is very low, cows are rarely milked.

Contact Agencies

1. State Animal Husbandry Department, Uttar Pradesh

PUNGANUR

Origin and Distribution

The Punganur breed is short-statured cattle found in Chittoor district of Andhra Pradesh. Its home tract is Punganur town of Chittoor district. These animals are also found in Vayalpadu, Madanapalli and Palamaner taluks of Chittoor district. This breed was developed by Rajahs of Punganur. Hence this breed is known as 'Punganur'. These are reared for milk. There are a very few animals left in the breeding tract. Only 21 cows of Punganur breed could be located during a survey conducted in the breeding tract covering about 150 villages under an ad hoc scheme entitled 'Preservation and Improvement of Punganur Breed of Cattle' by Acharya N.G.Ranga Agricultural University, Palamaner. This breed is almost on the verge of extinction. These animals were used for agricultural operations on light soils. Bullocks were used for carts like tongas and special races.

Location and Topography

The breeding tract lies between 13°10' and 13°40' north latitude, and 78°40' and 79°10' east latitude. The native tract is at an altitude of about 765 m above msl.

Breeding tract

Soil

The soil of the region is very light and deficient in calcium. Soil type ranges from red, sandy to loamy. Major source of irrigation is through tanks. Paddy and sugarcane are the major crops under wetland cultivation, and groundnut and fingermillet are the major crops under dryland agriculture. In addition pearlmillet, sorghum and maize are grown in some places.

Climate

The area receives 550 to 800 mm rainfall per year. Rainfall is spread from June to November and is low. This area is thus sometimes subject to drought.

Punganur bull

Punganur cow

Temperature ranges from 12°C during winter to 40°C during summer. Average humidity ranges from 60 to 87%.

Management Practices

Average herd size ranges from 2 to 15 animals which include cows, buffaloes and bullocks. Average family size in the breeding tract ranges from 4 to 15. Literacy rate ranges from 0 to 60%. Average land-holding ranges from 0 to 16 ha. Large number of people live as agricultural labourers. Women and children of the family look after animals. Animals are housed in a small shed made with the help of bamboos and stone pillars. Stacks of paddy straw and groundnut form the roof of cattle sheds. Animal houses are located just by the side of residential accommodation. Animals are housed only during the night. Animals are grazed in the wastelands and in nearby forests. Soon after the harvest of paddy, animals are allowed to graze over paddy stubbles. Paddy straw forms the major component of fodder. In addition, sugarcane tops, groundnut halms, fingermillet straw and mulberry leaves are fed to cattle. Milking cows are fed 1-1.5 kg concentrate (rice bran mixed with groundnut-cake) at the time of milking. About 60-70% of farmers practise AI for breeding their cattle.

Punganur calf

Physical Characteristics

Punganur cattle are white, grey or light brown to dark brown. White mixed with red or black colour animals are also available. Combination of white with brown or black patches is not uncommon. Skin, muzzle, eyelids and hooves are black. Animals of this breed are compact with comparatively tighter skin, extensive hanging dewlap, short legs, long body with well sprung ribs. Forehead is concave and broad. Horns are black, small and crescent shaped, and often loose curving backward and forward in males and lateral and forward in females. Horns are stumpy in males and slightly longer in females. Horn length ranges from 10 to 15 cm. Forehead is broad and prominent. Ears are small (17 to 18 cm) and erect. Eyes are bright. Neck is long. Hump is of small size in females and medium but inclined to be drooping in males. Legs are short, well set with hard and compact hoofs for helping them for grazing on the slopes of hillocks in the area. Tail is long (about 72 cm) with black switch almost touching the ground. Navel flap is medium in size. Cows are nervous and difficult with strangers. Their udder is small and bowl shaped with cylindrical teats having round tips. Bulls are more docile than females. Males have a prominent forehead with grey colour on neck and hump. Penis sheath flap is hanging.

Morphometric and Performance Parameters

Body length, height and heart girth average 113, 107 and 151 cm, respectively, in males, and 108, 97 and 128 cm, respectively, in females. Birth weight averages 12.8±0.29 kg (range 9 to 18 kg) in male calves, and 11.4±0.48 kg in female calves (range 6 to 18 kg) . Overall average birth weight is 12.3±0.24 kg. Adult weight averages 244.0±3.5 kg in males (200 to 270 kg) and 178.0±3.0 kg in females (130 to 200 kg). Age at first heat was around 878 days and first calving 1,125 days. Lactation milk yield is 546.0±30.6 litres (range 194 to 1,099 litres), lactation length 263.4±16.5 days (range 98 to 445 days), service period 182.8±20.5 days (range 38 to 578 days), dry period 232.3±19.64 (range 83 to 595 days) and calving interval 452.4±18.7 (range 317 to 832 days). On an average milk of Punganur cows contains 5% fat (range 3.11 to 10.0%) and 9.5±0.06% SNF (range 7.69 to 10.56%). Average number of inseminations per conception is 1.35.

Breeding Farms

1. Livestock Research Station, Acharya N.G. Ranga Agricultural University, Palamaner, Chittoor, Andhra Pradesh

Contact Agencies

1. State Animal Husbandry Department, Andhra Pradesh
2. Acharya N.G. Ranga Agricultural University, Palamaner, Chittoor, Andhra Pradesh

RATHI

Origin and Distribution

THE Rathi is an important milch breed of cattle found in the western part of Rajasthan. It takes its name from a pastoral tribe called Raths who are Muslims of Rajput extraction and lead a nomadic life. The home tract lies in the heart of Thar desert and includes Bikaner, Ganganagar and Jaisalmer districts of Rajasthan. These animals are particularly concentrated in the Loonkaransar tehsil of Bikaner district which is also known as 'Rathi Tract'. These animals are different from grey-white Hariana type animals called Rath found in the Alwar region of Rajasthan.

Rathi cattle seem to have originated from the mixture of Sahiwal, Red Sindhi, Tharparkar and Dhanni breeds, apparently with a preponderance of Sahiwal blood. Population of Rathi breed has sharply declined in the breeding tract and it may be around a few thousands only.

Location and Topography

The area lies between 27° and 30° north latitude, and between 72° and 75° east longitude. This is a typical arid region. It has large but less fertile soil resources, very low land productivity, low population pressure and fragile eco-system.

Soil

Soils are desert soil types having very little moisture retention capacity. This area is covered by sandy to loamy sand soils occurring in the form of sand dunes, parabolic dunes, etc., and are primarily infertile.

Climate

This region has harsh climate, receives very low, highly erratic and uncertain rainfall. Annual rainfall varies from 10 to 20 cm and temperature from 2° to 50°C. Groundwater is scarce and saline.

Management Practices

The home tract of Rathi breed is the

Breeding tract

Rathi bull

Rathi cow

Rathi calf

Thar desert where scarcity of fodder and water is endemic and becomes acute during summer. Vegetation is very poor. Animals graze on the sparse grass and small bushes. Most of the animals are owned and bred by nomads, who move with their herds in the tract from one place to another depending on the availability of water and grazing pastures. Animals are their mainstay and they earn their livelihood by selling milk, ghee as well as milch animals.

Feeding practices followed by most of the farmers in Bikaner include *ad lib.* feeding of roughages (generally of wheat straw), *pala* leaves (*Zizyphus nummularia*) and chaffed sewan grass (*Lasiurus sindicus*). Chaffed sorghum and pearl millet when available are substituted for grass and leaves. Dry stalks of sorghum and pearlmillet are also fed in the lean season. Lactating animals are provided concentrate mixture in proportion to their production. Mineral mixture or vitamins are usually not provided. Animals are generally not provided with shelter except during extreme weather. Animal houses are near human dwellings and are made up of *kutcha* walls with thatched roofs. Natural service is generally practised as AI services are inadequate. Calves are raised with their mothers and are not weaned.

Physical Characteristics

Rathi is a medium-sized breed with symmetrical body. The animal is usually brown with white patches all over the body, but animals having completely brown or black coats with white patches are often encountered. The lower body parts are generally lighter in colour as compared to the rest of the body. Face is broad between eyes and slightly dished. Muzzle and hooves are black. Eyelids are brown or black in colour. Horns are short to medium in size, curving outward, upward and inward. Ears are of medium length, while dewlap is voluminous. Navel flap is large. Hump is of large size in male and sheath pendulous. Tail is long, fine, tapering to a good black switch well below hock. Udder is well developed with prominent milk-vein. Females are docile and average milkers.

Rathi herd

Morphometric and Performance Parameters

Averages of body length, height and heart girth are 132.63, 121.24 and 164.23 cm, respectively, in females. Average birth weight ranges from 19 to 22 kg in female calves and from 19 to 23 kg in male calves. Adult body weight is around 295 kg for females. Age at first calving averages 1,411 days (range 1,104 to 1,581 days). Milk yield is 1,560 kg (range 1,062 to 2,810 kg). Average lactation length is 336 days (range 306 to 431 days), service period 205 days (range 168 to 208 days), dry period 181 days (range 132 to 234 days) and calving interval 519 days (range 445 to 617 days). Fat is 3.7% (range 3.3 to 4.0%).

Breeding Farms

1. College of Animal Sciences, Rajasthan Agricultural University, Bikaner, Rajasthan
2. Livestock Research Station, Rajasthan Agricultural University, Nohar, Sri Ganganagar, Rajasthan.

Contact Agencies

1. Rajasthan Agricultural University, Bikaner, Rajasthan
2. State Animal Husbandry Department, Rajasthan

RED KANDHARI

Synonym: Lakhalbunda

Origin and Distribution

THE Red Kandhari breed of cattle in purest form is found in Kandhar, Mukhed, Nanded and Biloli tehsils of Nanded district; some pockets of other districts like Ahmadpur; Parli and Hingoli tehsils of Latur district; and Bid and Parbhani districts of Marathwada region.

Red Kandhari animals in impure form and its crosses with Deoni and non-descripts are seen sporadically in all the 7 districts of Marathwada, Akola and Amravati districts of Vidarbha and border districts of Andhra Pradesh, viz. Adilabad and Nizamabad, which are close to Kinwat and Degloor tehsils of Nanded district of Maharashtra State.

In Kandhar tehsil the Red Kandhari breed of cattle is more common. It is said that this breed was taken up by the royal dynasty of King Somadevraya as far back as 4th Century A.D. Raja Somdeorai was the son of Raja Kanhar and ruled over Kandhar. The name Red Kandhari appears to be the corrupt name from Raja Kanhar. This cattle breed having red colour also naturally acquires the name Red Kandhari. The breed could have been named by Raja Somdeorai in memory of his father as Red Kanhari, now misnomered as Red Kandhari. Red Kandhari breed supplies bullock power to northern part of Marathwada. In markets like Parbhani and Purna in Parbhani district, and Loha Kundalwadi and Naigaon in Nanded district facilities are available for sale and purchase of these animals. In the last two named markets, bulls and cows of pure breed are available for breeding purpose.

The Government of Maharashtra and Marathwada Agricultural University have made various efforts for the development and improvement of this breed. In 1950, the Department of Animal Husbandry, Hyderabad, kept 10 pairs of Red Kandhari bulls and cows

Breeding tract

Red Kandhari bull

Red Kandhari cow

at Sitarampet hospital to initiate scientific breeding to study the draught and milk potential in this breed. In 1951, 8 selected Red Kandhari bulls were also introduced at the Government Cattle Breeding Farm, Hingoli, district Parbhani by the then State Government of Hyderabad, of which 2 were kept at the Cattle Breeding Farm, Hingoli and 6 were posted in nearby villages for natural service to generate bullock power for the farmers of that area. As a result of this breeding, the Red Kandhari breed was established in Hingoli tehsil of Parbhani district. In the year 1956-57, a key village centre was established at the Hingoli Cattle Breeding Farm with its 6 sub-centres in interior villages, of which 3 were establised at Isapur, Pimpri and Nandapur. At these sub-centres artificial insemination work with Red Kandhari semen was carried out up to 1962, as a result of which 3,000 Red Kandhari calves were born which are on records at the Hingoli Cattle Breeding Farm. However, the Red Kadhari herd at the Hingoli farm was discontinued and presently the farmers of this region are responsible for propagating the breed.

After the formation of the Maharashtra state in 1962 till 1980, this breed did not receive any attention. The State Government undertook crossbreeding of local cattle with Jersey and Holstein extensively with liquid semen from the year 1968 and with frozen semen from 1984. This work checked breeding with pure breed semen and indirectly it was a threat for pure breeds specially for those pure breeds which had no government farms for pure breeding like Red Kandhari. In the year 1984-85, Zila Parishad, Nanded undertook intensive breeding programme of Red Kandhari breed by keeping 10 pure Red Kandhari breeds in breeding tract of the district.

In 1974, the Government of Maharashtra started an animal unit with 18 Red Kandhari cows at the College of Veterinary and Animal Sciences, MAU, Parbhani. In 1982, the State Government of Maharashtra sanctioned a scheme on Red Kandhari cattle for research and education, and consequently 82 cows and 2 bulls were added for selective breeding. As a result of selective breeding and rigorous culling, a purebred herd of Red Kandhari breed with known and fixed characters is established at this farm.

Location and Topography

The breeding tract lies between 18°25' and 19°37' north latitude, and 76°50' and 78°30' east latitude.

Soil

The soil is typically black cotton type and possesses material of calcareous rudimentary rocks. Fertility index is low with respect to nitrogen in Parbhani and phosphorus in all districts of this region.

Climate

Climate is dry and semi-arid type. Southwest monsoon accounts for 70-95% of

Red Kandhari calf

total rainfall. Annual rainfall varies from 30 to 110 cm. Maximum temperature reaches 40°C and minimum 8° to 10° C.

Management Practices

Herd size is small. Generally, animals are maintained on grazing alone. Small quantities of concentrate is offered only to bullocks, bull calves and milking females. Cálves are not weaned. Male calves are nursed better and longer as compared to female calves. Most of the animals are given individual care.

Physical Characteristics

Red Kandhari is a medium-sized, strong and robust animal. The body is compact, squarely built, but not massive, with well-proportionate limbs. The colour is uniform deep dark-red, but variations from a dull red to almost dark brown are found. Bulls, as a rule, are a shade darker than cows. Fore-head is broad between eyes and is slightly bulging. Ears are long, drooping sideways and have rounded tips. Eyes are shining with a black colour around the eye. Muzzle is black. Horns are evenly curved and medium sized. Horns are thick at the base and taper to a blunt point. Dewlap is medium sized with a few folds. Hump is tightly formed and large in males. Hoofs are black and digits closely set. Black hair around the coronet encircles forming a ring. Navel flap is very small in cows. Sheath is well tucked-up to the body. Tail is well set on the body. It is fairly broad, tapering and is moderately long with a good black switch which extends well below hocks, and reaches coronet. Skin is tightly drawn over the body but is soft and pliable (not loose) with small short glossy hair. Udder is small and tucked up. Teats are small but squarely placed.

Morphometric and Performance Parameters

Average body length, height and heart girth measure 133 (range 120 to 148 cm), 128 (range 120 to 137 cm) and 173 cm (range 155 to 190 cm), respectively, in males; and 124 (range 106 to 140 cm), 118 (range 103 to 132 cm) and 146 cm (range 129 to 169 cm), respectively, in females. Average birth weight is 20.1±0.74 kg. Average lactation yield is 597.6±18.32 kg in a lactation period of 259.8±4.26 days. Average fat content in milk is 4.57±0.03% and SNF content 8.62±0.01%. Milk of Red Kandhari has

Red Kandhari herd

yellowish tinge which is transferable to its products. Average calving interval is 444.2±9.62 days.

Red Kandhari bullocks are used for heavy work. A pair of bullocks, yoked for different operations produce following qualities of work: (i) harrowing 1,586.7 m^2/hr; (ii) single line sowing (*mogada*) 1,651.6 m^2/hr; and (iii) ploughing 562.6 m^2/hr. Bullocks are capable of carting 3 and 20 q of load at the speed of 4.7 and 3.6 km/hr respectively.

Breeding Farm

1. College of Veterinary and Animal Sciences, Marathwada Agricultural University, Parbhani, Maharashtra.

Contact Agencies

1. Marathwada Agricultural University, Parbhani, Maharashtra
2. State Animal Husbandry Department, Maharashtra

RED SINDHI

Synonyms: Malir (Baluchistan), Red Karachi and Sindhi

Origin and Distribution

THE Red Sindhi breed is mostly found in Karachi and Hyderabad districts of Pakistan. Some organized herds of this breed are also found in India in the states of Orissa, Tamil Nadu, Bihar, Kerala and Assam.

Red Sindhi is considered to have originated from *Las Bela* cattle found in the state of Las Bela, Baluchisthan. The original herd was established at Malir outside Karachi. Red Sindhi cattle are somewhat similiar to Sahiwal and may also be related to Afghan and Gir cattle.

Red Sindhi cattle have been exported to Afghanistan, Nepal, Myanmar, Thailand, Cambodia, Vietnam, Malaysia, Brunei, Sarawak, Sri Lanka, Indonesia, the Philippines, Taiwan, Korea, Iran, Iraq and Saudia Arabia in Asia; Tunis, Kenya, Tanzania, Seychelles and Mauritius in Africa; the United States of America, Brazil and Cuba in the Americas; and Australia.

Red Sindhi is one of the important dairy cattle breeds in Indian sub-continent. Realizing its potential, the Government of India established 1 Central Cattle Breeding Farm at Chiplima, Orissa on 15.01.1968. The original mandate of the farm was to carry out progeny testing for Red Sindhi. In each set, 2 bulls were to be selected from 8 bulls which were to be used extensively through frozen semen technology. In addition, the farm was also to produce 80 high graded bulls to be distributed to different states. In 1989-90, the mandate was revised as:

(a) 50 elite and best Red Sindhi cows and followers would be kept as nucleus herd to conserve the indigenous germplasm of Red Sindhi breed. Total herd strength should not exceed 120; and

(b) 50 Red Sindhi cows next in superiority to the (a) above should be kept for production of crossbred bulls and heifers. The total herd strength should not exceed 120.

Location and Topography

Red Sindhi is native to hilly region in the north and in the west (900 to 1, 200 m above msl). In the south it is found at low altitude.

Climate

Diurnal temperature variation in most parts of the area is not large. Average temperature during most part of the year ranges from 17° to 32°C. Major crops grown in the area are paddy, sorghum, pulses, clover, wheat, linseed and cotton. Straws and stovers from these are fed to cattle.

Red Sindhi bull

Red Sindhi cow

Red Sindhi calf

Physical Characteristics

This breed has distinctly red colour. Red shades vary from dark red to dim yellow. Though patches of white are seen on dewlap and sometimes on forehead, no large white patches are present on the body. In bulls, colour is dark on the shoulders and thighs. Hair is soft and short, and skin is loose.

Head is well proportioned with an occasional bulge on the forehead. Horns are thick at the base and emerge laterally and curve upward. Ears are moderately sized and drooping. Hump 's well developed in males. Dewlap and sheath are pendulous. Udder is capacious and pendulous.

Morphometric and Performance Parameters

Averages of body length, height and heart girth are around 140, 130 and 180 cm, respectively, in males, and 140, 120 and 140 cm, respectively, in females. Birth weight in male calves is 22.5 kg (range 20 to 28 kg) and in female calves 21.4 kg (range 19 to 24 kg) with an overall average of 22 kg. Adult body weight is around 450 kg in males and 320 kg in females. The Red Sindhi cow calves for the first time at an average age of about 1,324 days (range 972 to 1,560 days). Milk production is around 1,840 kg (range 1,100 to 2,600 kg) and lactation length 296 days (range 260 to 330 days). Fat is around 4.5% (range 4.0 to 5.2%). Service period is on an average 148 days (range 90 to 175 days). Calving interval is on an average 443 days (range 380 to 550 days).

Breeding Farms

1. Cattle Breeding Farms:
   - Barpeta; Jagdaur; Silchar, Assam
   - Gauriakarma, Hazaribagh, Bihar
   - Dhat, Goa
   - Beli Charana, Jammu & Kashmir
   - Koila, Karnataka
   - Kodapanakunnu, Kerala
   - Bolangir, Orissa

Red Sindhi herd

- Pudukkottai; Chetinad; Hosur; Orthanad; Tirunelveli, Tamil Nadu
- Kalsi, Uttar Pradesh

2. Punjabrao Krishi Vidayapeeth, Warud, Maharashtra
3. Central Cattle Breeding Farm, Chiplima, Sambalpur, Orissa

Contact Agencies

1. State Animal Husbandry Department, Tamil Nadu
2. State Animal Husbandry Department, Bihar
3. State Animal Husbandry Department, Orissa
4. Department of Animal Husbandry and Dairying, Government of India, New Delhi

SAHIWAL

Synonyms: Lambi Bar, Lola, Montgomery, Multani, Teli

Origin and Distribution

THE Sahiwal is one of the best dairy breeds of zebu cattle. Though its original breeding tract lies in Montgomery (now Sahiwal) district of Pakistan, yet some herds are also found in India along the Indo-Pak border in Ferozepur and Amritsar districts of Punjab, and Sri Ganganagar district of Rajasthan. Sahiwal cattle may be related to cattle of Afghanistan and may contain some Gir blood also. It is closely related to Red Sindhi, Afghan and Gir breeds.

A few herds (around 70) of pure Sahiwal cattle are now available around Fazilka and Abohar towns in Ferozepur district of Punjab (India). About 200 years ago, the Maharaja of Bikaner invited Sahiwal breeders from Montgomery area. These breeders migrated and settled in various parts of Bikaner state because of pressure on pasture lands in the breeding tract. During the partition many breeders went back to Pakistan but some remained in India. Rearing of these cattle was the sole occupation and livelihood of these breeders. With the advent of Rajasthan canal, more land came under crops and free pasture lands were reduced. These breeders again looked for alternatives and migrated from their homes to the outskirts of various towns in Sri Ganganagar and Ferozepur districts. The closeness to urban population provided better market for milk and milk products, and they settled there temporarily.

Breeding tract

Sahiwal breed, because of its desirable traits, is being utilised widely for improvement of local stock or for initial crossbreeding of the indigenous stock before undertaking upgrading with European breeds in many warm humid countries of the world. Efforts were made to improve its production potential by establishing some herds. One such farm was established at Chak Ganjaria, Uttar Pradesh in 1950 and

Sahiwal bull

Sahiwal cow

another at Anjora, Durg, Madhya Pradesh in 1956. Sahiwal herd was also established at the National Dairy Research Institute, Karnal (earlier known as cattle-cum-dairy farm) in 1951 and at the Government Livestock Farm, Hisar, during the III Five-Year Plan. These farms have the mandate of developing herds of purebred Sahiwal, production of superior sires and distribution of these sires/semen for cattle breeding projects.

It is known to have been introduced into 17 other countries, besides Pakistan and India. These are: Mauritius, Kenya, Tanzania, Sierra Leone, Malaysia, the Philippines, Vietnam, Thailand, Myanmar, Bangladesh, Sri Lanka, Nepal, Brazil, Jamaica, Trinidad, Australia and New Zealand. In Jamaica, Sahiwal animals were crossed with Jersey and provided part of the foundation stock for the breed known as the Jamaica Hope. In Kenya they have been used in upgrading small East African zebu cattle for milk purpose. Sahiwal semen is now being produced on a large scale at one of the farms established in Queensland (Australia) for export to New Zealand. In the latter country, after contract matings by use of the Sahiwal semen on Jersey and Friesian cows, crossbred heifers are produced for commercial export to South-East Asian countries, namely Thailand, the Philippines, Malaysia and Indonesia.

Location and Topography

The breeding tract in India lies between 29°10' and 30°55' north latitude, and 73°6' and 74°4' east longitude. The area is an undulating plain. The main crops grown in the area are wheat, barley, cotton, chickpea, lentil and rapeseed. Grazing areas are limited as pasture lands have been converted into agricultural fields. These are now available only along the river banks and road sides.

Soil

Sandy loam and loam soils are predominant in this area. A very large proportion of agricultural land is now under irrigation either through canals or through tubewells.

Climate

Weather in this area is extremely hot during summer (April to August) and extremely cold during winter (December to February) with temperature varying between 0° and 48°C. The climatic environment is sub-tropical and arid. Annual rainfall is around 25 to 30 cm. Heavy dust storms occur frequently during summer.

Management Practices

The Sahiwal breeders around Fazilka and Abohar towns are landless Muslim families solely dependent on cattle rearing. They prefer to be called as 'Joiay ' or ' Gujar'. Average family size is 6.9 and literacy percentage is only 4.8. Male and female members of the families are almost equally involved (3.36 vs 2.51) in cattle rearing. Animals are not provided with any type of house. They are kept loose in an open area.

Only calves are provided with bush enclosures. It is very difficult to differentiate between breeders, huts and cattle enclosure. Practically they share their own enclosure with cattle. Animals are kept under very poor sanitary conditions; still they are resistant to most of the tropical diseases. Herd size is 30 to 70 animals with 15 to 25 milking cows.

Sahiwal calf

Animals are taken for grazing in the morning. Milking cows return early while the rest return at sunset. They are also fed green and dry fodder. Milking cows are provided supplementary feeding in the form of cotton seed, barley and cakes. Feed is given in soaked form at the time of milking. Animals are fed in groups. The source of drinking water is hand pump. Special attention is paid to calves. They are reared on whole milk up to 1 month of age after which some green fodder is also fed. Calves are allowed to suck 1-2 teats up to 6 months of age. The number of male and female calves are almost equal but the sex ratio becomes imbalanced after 1-1.5 years of age. Males are selected for breeding at very young age on the basis of dam's yield and body conformation. The selected males are fed and cared properly while the rest are disposed off.

Heifers are reared with utmost care and fed properly. Breeders are more careful after the heifers attain puberty. Natural service is practised for mating.

Physical Characteristics

Coat colour is usually reddish dun but pale red or brown occasionally mixed with white spots is also not uncommon. The Sahiwal is a heavy breed with symmetrical body and loose skin. Animals are long, deep, fleshy and comparatively lethargic. Forehead is medium sized in females but broad and massive in males. Horns are short and stumpy. Ears are medium sized with black hair on the fringes. Dewlap is large and heavy. Hump in males is massive and frequently falls on one side. Navel flap is loose and hanging. Sheath in males is also pendulous. Tail is long and fine with a black switch reaching almost to the ground. Udder is generally large, bowl shaped, pliable, firmly suspended from the body. Pendulous udder is also found in high producing females. Teats are large and cylindrical in shape.

Sahiwal herd

Morphon etric and Performance Parameters

Average body length, height and heart girth are 150, 170 and 190 cm, respectively, in males, and 131, 124 and 164, respectively, in females. Birth weight is 20 to 25 kg in male calves and 18 to 23 kg in female calves. Average birth weight is around 22 kg. Adult body weight is around 540 kg in males and 327 kg (range 301 to 360 kg) in females. Average age at first calving is 1,183 days (range 940 to 1,520 days). Average milk yield is 2,326 kg·(range 1,600 to 2,750 kg). Average lactation length is 318 days (range 285 to 375 days). Fat is 4.8 to 5.1% (average 4.93%). Service period averages 176 days (range 140 to 200 days). Calving interval averages 451 days (range 390 to 550 days).

Breeding Farms

1. Cattle Breeding Farm: Jagduar; Pachmile; Silchar, Assam
2. Sabarmati Ashram Gaushala, Bidaj, Gujarat
3. Government Livestock Farm, Hisar, Haryana
4. National Dairy Research Institute, Karnal, Haryana
5. Satguru Hari Singh Animal Breeding Farm, Sri Jiwan Nagar, Sirsa, Haryana
6. Shri Gaushala Society (Regd), Panipat, Haryana
7. Government Cattle Breeding Farm, Beli Charana, Jammu & Kashmir
8. Cattle Breeding Farm: Anjora, Durg; Imlikhera, Madhya Pradesh

Housing and feeding practices

9. Government Cattle Breeding Farm, Bod, Wadsa, Maharashtra
10. Government Cattle Breeding Farm, Nabha, Punjab
11. Pinjrapole Gaushala, Amritsar, Punjab
12. Tamil Nadu Co-operative Milk Producers' Federation Ltd, Udhagamandalam, Tamil Nadu
13. State Livestock-cum-Agricultural Farm, Chakganzaria, Uttar Pradesh
14. Military Farm, Meerut, Uttar Pradesh

Contact Agencies

1. State Animal Husbandry Department, Punjab
2. State Animal Husbandry Department, Rajasthan

SIRI

Synonym: Trahbum

SOME of the related types of Siri are:

(a) *Kachha Siri*: This is a Nepal × Siri cross, and is very similar to the Siri, but is distinguished from it by the colour pattern and position of hump and horn.

(b) *Tarai*: This type is found in Nepal and is sometimes referred to as Siri.

Origin and Distribution

The Siri is a small-sized zebu cattle of hill region. It is found in upper reaches of Darjeeling district in West Bengal and Sikkim States in India, and Bhutan and Nepal. Bhutan is said to be the real home of this breed. This is the only Indian breed with a cervico-thoracic type of hump. Similar cattle are found in the Sikong Province of China, northeast of Bhutan.

Breeding tract

Over the last few years the population of this breed has been declining due to extensive crossbreeding with Jersey germplasm. Cattle in Sikkim are either Siri or crossbreds. Despite an increase in the overall cattle population in Sikkim (6.28%) between 1982 and 1988, the population of indigenous cattle was almost constant. Siri animals are now confined only to the remote and inaccessible areas of Sikkim. Very few Siri breeding bulls are available even in the remote villages. This would affect the development of this breed. The interior areas are now becoming accessible with the ongoing development programmes and Jersey semen is reaching these areas too. This would further affect the status of the Siri population. The crossbred cows have higher milk production and lower age at first calving as compared to Siri cattle.

Siri bull

Siri cow

Location and Topography

The breeding tract lies between 27° and 28°1' north latitude, and 88° and 90° east longitude. The breeding tract is between 1,200 and 3,000 m above msl. Hills are steep and separated by deep narrow valleys. Sikkim is situated in the eastern Himalayas between 27°5' and 28°10' north latitude, and between 88°4' and 88°58' east longitude. It comprises an area of about 7,300 km^2. The state is bound in the north and northeast by the Tibetan region of China, in the southeast by Bhutan, in the south by the Darjeeling district of West Bengal and in the west by Nepal. The mountainous terrain of Sikkim possesses a series of interlacing ridges rising range above range from south toward the snow-clad northern hills. Terrace agriculture is being practised. Rice, maize, ginger, soyabean and millets are the major crops. Agriculture is rainfed and suffers from water scarcity. Livestock provide organic manure as the acidic nature of soils limits the use of inorganic fertilizers.

Soil

The soil is acidic with pH ranging from 5.0 to 6.0. The lime requirement is quite high. Soil has low availability of NPK.

Climate

Climatic variation in the breeding tract is considerable depending on the altitude. The important feature of its climate is dampness. Rainfall is heavy and well distributed during May to September, moderate during April and October and low during November to February. Rainfall varies from 3 to 55 cm during different months. While the monsoon contributes to the major part of the rains, local evaporation, condensation and precipitation greatly account for the substantial rainfall during pre-monsoon and post-monsoon periods. Winters are severe and chilly. Maximum temperature varies from 8° to 24°C and minimum from 0° to 14°C. Average relative humidity is about 80%.

Management Practices

Animals are mostly taken for grazing in forests or in fields. In East Sikkim, especially Aritar block (2,100 m above msl) large herds (herd size 10-30) of Siri animals are seen grazing in the forest area as compared to those in West Sikkim where the average herd size is around 2-3.

Animals of the entire village are taken to forest by one person in the morning at about 7 AM. They graze on steep slopes in thick forests. Cows in milk return by the milking time, i.e. around 4 PM, whereas the remaining animals return late in the evening. Animals are also fed leaves of forest trees like *khanyu* (*Ficus cunia* Ham.), *gogun* (*Saurauvia nepalensis* DC), *kairalo* (*Bauhima variegata* Linn.), *chuletro* (*Brassaiopsis mitis*), and residues of crops like ginger leaves and paddy straw. In very few cases cultivated fodder like Napier and Gotamala grasses and maize are fed to animals.

Milking cows are also offered home-made concentrates. Concentrate mixture is prepared by boiling together maize and rice grains, raddish with leaves, kuish fruit and mustard-cake. This mixture is then offered to the animals as such. Milking is done twice a day. Only the front teats are milked while the rear teats are left for the calf to suck. Animals are housed on the slope of hills in open houses which are small in size and have galvonised iron sheet roofs. Sheds are so small that an animal can hardly stand in it. These sheds are usually without drainage facilities and have *kutcha* floor with very poor sanitation. There is scarcity of drinking water and no provision is made in sheds. Bullocks are the only source of draught power for agriculture in the hilly terrains of Sikkim. They are castrated at about 4 years of age.


Siri calf

Physical Characteristics

Animals are either black with white patches or brown with white patches. In some cases they are totally black or brown. Skin is grey, and muzzle and eyelids black. Black and white pattern is similar to that of Holstein-Friesian. Tail switch is black or white and hooves are black. Forehead is convex, wedge shaped with white patches. Horns are of medium size and curved outward, forward, slightly upward and inward with prominent hairy poll. Ears are of medium size and horizontal. Abdomen and inner part of legs are generally light in colour. Hump is cervico-thoracic and covered with a tuft of long coarse hair. It is of medium size in males and small size in females. Dewlap is small to medium. Navel flap is almost absent. Udder is of small size with firm attachments. Teats are centrally placed and cylindrical in shape with rounded tips. Males have small sheath.

Morphometric and Performance Parameters

Body length, height and heart girth measure 121.8±16.82, 119.8±14.04 and 147.4±15.34 cm, respectively, in adult males, and 119.7±11.47, 118.5±8.85 and 147.9±8.18 cm, respectively, in adult females. Age at first calving ranges between 1,450 and 1,700 days.

Cattle shed

Milk yield is around 2-6 kg/day with lactation length of about 210 to 274 days. Calving interval ranges from 425 to 490 days. A large amount of variation is observed in the performance of Siri animals. Their performance can be improved further by proper selection and distribution of sires in the breeding tract.

The fat content is 2.8 to 5.5%, SNF 7.56 to 9.37%, total solids 10.36 to 14.24%, protein 3.0 to 4.10% and ash 0.701 to 0.732% at different stages of lactation.

Contact Agencies

1. State Animal Husbandry Department, Sikkim
2. State Animal Husbandry Department, West Bengal

THARPARKAR

Synonyms: White Sindhi, Gray Sindhi, Thari

Origin and Distribution

THE Tharparkar is an important dual-purpose breed raised primarily for its milking potential. The name Tharparkar has been derived from the place of its origin – the Thar desert. The home tract of this breed is in the Tharparkar district of southeast Sind in Pakistan. Tharparkar animals are also found in the vicinity of Amarkot, Nakot, Dhoro Naro and Chor in Pakistan. This tract covers an area of around 120,000 km^2, and consists largely of arid desert famous for sand dunes. In India, these animals are now found along the Indo-Pak border covering western Rajasthan and up to Rann of Kutch in Gujarat. Animals with typical characteristics of breed are found in Jodhpur, Barmer, Jaisalmer, districts of Rajasthan and Kachch region of Gujarat. Some animals are also available in Suratgarh tehsil of Sri Ganganagar district of Rajasthan.

Tharparkar is not a homogeneous breed but it has the influence of the Kankrej, Red Sindhi, Gir and Nagori breeds. On the western side of the habitat the influence of the Red Sindhi is prominent, and on the north and northeast of the Nagori. In other parts influence of the Kankrej is predominant. A sprinkling of the Gir is also evident. In spite of all the heterogeneity, a medium type breed adapted to the desert conditions has been developed.

Location and Topography

The Tharparkar district of Pakistan lies between 24°13' and 26°2' north latitude, and 68°40' and 71°11' east longitude. In India, the breeding tract lies between 23°15' and 29°19' north latitude, and between 68°4' and 74° east longitude. The whole area consists of sand-dunes 30 to 90 m in height.

Soil

The breeding tract consists largely of sand-dunes or ridges locally called

Breeding tract

Tharparkar bull

Tharparkar cow

bhits. During the hot, windy season, fine sand from the deltaic region and Rann of Kutch is blown over forming dunes or ridges. These ridges are irregular, nearly parallel and enclose valleys where animals graze.

Climate

The habitat of Tharparkar breed lies in the arid region, and has very harsh agro-ecological conditions. The temperature variation in 24 hours is very sharp. During winter season the day is fairly warm. The minimum temperature in the night occasionally dips up to sub-zero level. In summer the maximum day temperature goes up as high as 48° to 49°C but the nights are cool and comfortable. Rainy season lasts only for a very short duration and the average annual rainfall is 10 to 15 cm. Drought for 3 to 4 years at a strech is not very uncommon in this area.

Management Practices

These areas suffer from endemic scarcity of fodder and water which becomes acute during summer season, particularly between April and June. The whole area is sandy bereft of vegetation except small bushes. Only at a few places *kheri* or *khejri* (*Prosopis cinereria)* trees are available. *Sewan* (*Lasiurus sindicus*) is the only staple fodder available, either as green grass or hay. Concentrate is offered only to cows in advance pregnancy or to lactating cows. The availability of water to livestock particularly in the summer season is very scarce. In earlier days, water was provided on alternate days. But in the recent past, many villages have been provided with drinking water facility. Livestock owners provide water trough at one common point near a tap where cattle come in groups for drinking water. Animals are generally not provided with shelter or houses throughout the year, except during certain chilly nights or during extreme summer season. Animal houses are made up of *kutcha* walls and have thatched roof of senia grass. In most of the villages, there is no planned mating system but usually farmers select bulls on the basis of phenotype and sometimes dam's milk yield. Natural service is the common method for breeding animals.

Physical Characteristics

Animals are white or light grey. Face and extremities are of a darker shade than the body. In bulls neck, hump and fore- and hind-quarters are also dark. Hair are fine, short and straight, but in males they are slightly curly on the forehead. Head is of medium size. Forehead is broad and flat or slightly convex above eyes. The front of horns and face are practically in one plane. In bulls the convexity may be slightly more pronounced. A boldly convex forehead is not acceptable. Face is lean, fine and slightly dished to muzzle. Nostrils are broad and black. Lips are muscular and jaws strong. Eyes are full and placid. Ears are somewhat long, broad and slightly pendulous. Animals with rich yellow colour of the skin inside the ear are preferred. Horns are set well

Tharparkar calf

apart curving gradually upward and outward in the same line as that of the poll, with blunt points inclined inward; moderately thick at the base, i.e. 12.5-17.5 cm in circumference just above the skin. In males, the horns are thicker, shorter and straighter than in females. Horns much thicker at the base or unduly long are not preferred. Dewlap is loose and flexible but not voluminous. Skin is fine and mellow. Hump is moderately well developed in males, firm and placed in front of the withers. In females, there is a well-defined flap of skin at the navel corresponding to the sheath in males, but is not coarse or long. The sheath is of moderate length and not markedly pendulous. Tail is thin, supple and hangs loosely so that the end of the switch is 5 to 15 cm off ground. Switch is black. Udder is large and well developed in front and rear, and is carried well up at the back. Floor of udder is nearly level and not deeply cut between quarters. Skin of the udder is fine and mellow with a yellow tinge and prominent veins. Teats are 7.5 to 10 cm long, uniform in thickness and set at even distances. Skin is of fine quality, loose and mellow to touch. Colour of skin is black, except on the udder, under the belly and inside of ears where it is rich yellow.

Morphometric and Performance Parameters

Average body length, height and heart girth are 142, 133 and 184 cm, respectively, in males, and 132, 130 and 173 cm, respectively, in females. Average birth weight is 23.1 kg (range 21 to 25 kg) in male calves, and 22.4 kg (range 21 to 25 kg) in female calves. Body weight of an adult male is around 450 to 500 kg and that of an adult female about 295 kg. Tharparkar cows calve for the first time at an average age of about 1,247 days (range 1,116 to 1,596 days). Average milk yield is 1,749 kg (range 913 to 2,147 kg), lactation length 286 days (range 240 to 377 days), dry period 138 days (range 115 to 191 days), service period 128 days (range 108 to 191 days) and calving interval 431 days (range 408 to 572 days). Fat is about 4.88% (range 4.72 to 4.90%) and SNF 9.2% (range 8.9 to 9.7%).

Tharparkar herd

Breeding Farms

1. Cattle Breeding Farm: Kampasagar; Karimnagar; Mamnoor, Andhra Pradesh
2. Cattle Breeding Farm: Purnea; Sairakela; Patna, Bihar
3. Birsa Agricultural University, Ranchi, Bihar
4. Government Livestock Farm, Hisar, Haryana
5. National Dairy Research Institute, Karnal, Haryana
6. Choudhary Charan Singh Haryana Agricultural University, Hisar, Haryana
7. Cattle Breeding Farm, Ratona, Sagar, Madhya Pradesh.
8. Cattle Breeding Farm: Pohara; Yeotmal, Maharashtra
9. Central Cattle Breeding Farm, Suratgarh, Rajasthan
10. Livestock Research Centre, Rajasthan Agricultural University, Chandan, Rajasthan
11. Government Livestock Farm, Chettinad, Tamil Nadu
12. State Livstock-cum-Agricultural Farm, Barari, Jhansi, Uttar Pradesh
13. Central Cattle Breeding Farm, Andeshnagar, Lakhimpur Kheri, Uttar Pradesh

Contact Agencies

1. State Animal Husbandry Department, Rajasthan
2. Rajasthan Agricultural University, Bikaner, Rajasthan
3. Department of Animal Husbandry and Dairying, Government of India, New Delhi

UMBLACHERY

Synonyms: Jathi madu, Mottai madu, Molai madu, Southern, Tanjore, Therkathi madu

Origin and Distribution

THE Umblachery breed of cattle, one of the best draught breeds of Tamil Nadu, is found in Thanjavur, Thiruvarur and Nagappattinam districts. It derives its name from its home tract, Umblachery, a small village 10 km away from Thiruthuraipoondi town in Nagapattinam district. This breed is considered to be developed by crossing Kangayam with local animals of Thanjavur, and is very similar to Kangayam except in the appearance of head and smaller size. These are light built draught animals developed for work in the marshy paddy fields. About 60-70% of cattle in this area belong to Umblachery breed. Estimated population is around 283,000. Breedable females, breeding bulls and bullocks constituted 41.66, 0.26 and 24 % respectively.

Location and Topography

The breeding tract lies between 10°18' and 10°55' north latitude, and 79°1' and 79°5' east latitude. Total geographical area of the breeding tract is about 3,500 km². Alivation of this area ranges from 0 to 50 m above msl. The tract lies in Cauvery delta region.

Breeding tract

Soil

The soil in the breeding tract is mostly alluvial and requires suitable type of animals for working in paddy fields so that they may not sink into the knee-deep mire. The Umblachery breed being light in weight serves this purpose well. .

Climate

Climate in the breeding tract is sub-humid with medium rainfall. Mean maximum temperature is 32.9°C (range 28.2° to 37.9°C) during May. Mean minimum temperature is 23.6°C (range

Umblachery bull

Umblachery cow

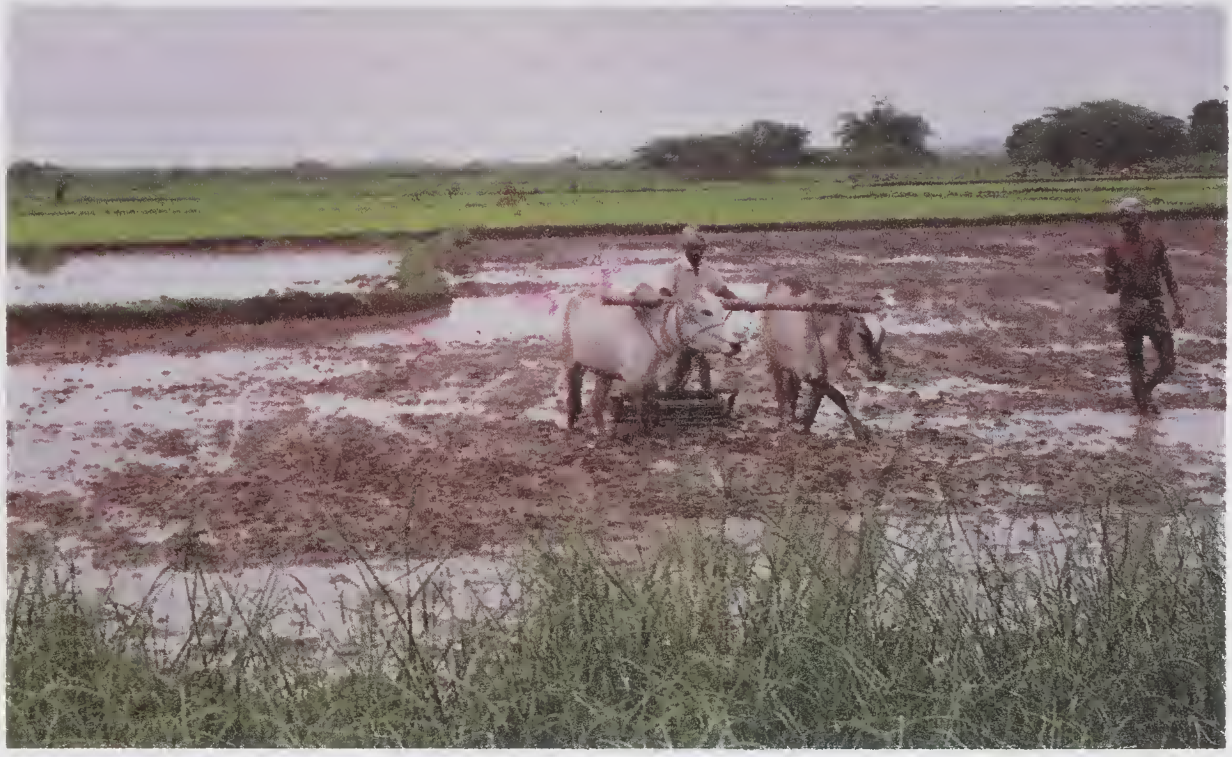
Umblachery calves

20° to 27°C). Total rainfall is around 150 cm spread over about 72 days in a year. Rainfall is maximum during November and minimum during April. Relative humidity is 83% (range 70 to 91%). Wind velocity is around 7 km/hr (range 4.2 to 13.3 km/hr).

Paddy (*Oryza sativa*) is the main cultivated crop. Sorghum (*Sorghum vulgare*) , bajra (*Pennisetum typhoides*) and ragi (*Ellucine coracana*) are the other cereals. Groundnut (*Arachis hypogea*), sugarcane (*Saccharum officinarum*) and cotton (*Gossypium hirsutum*) are also cultivated. Neem (*Azadirachta indica*), palmyra (*Borassus flabellifer*), coconut (*Cocos nilotica*), tamarind (*Tamarindus indica*), black babul (*Acacia nilotica*) and bamboo (*Bamboos bamboosa*) are the trees available in the breeding tract.

Management Practices

Average herd size is 3. Animals are housed during night and rainy season. Houses are mostly closed and of *kutcha* type. In the day time the animals are tethered in the wood packs or tree trunks. Most of the cows are not milked. Calves are allowed to suck their dams. Cows are not bred till calves are weaned. Paddy straw is the main fodder both in summer and winter. Bullocks and milking females are offered groundnut/sesame oilcakes. Rice bran and cotton seed are also fed. Animals are also sent for grazing. Herdsmen collect animals from various households in January or February and graze them for about 6 months. Usual herd strength of such groups ranges from 250 to 400 animals. Sometimes the animals are taken even for 50 to 100 km for grazing. They are



Umblachery females are used for ploughing

herded together for manuring the fields. Calves, young males and females are not taken with these herds. The practice of dehorning bullocks is peculiar in Umblachery cattle. Horn buds are removed at 6 months of age by singeing with red hot iron. Ears are pruned and hot iron branding is done. Heifer calves and bull calves considered good for breeding purpose are not dehorned. Natural service is mostly practiced.

Physical Characteristics

Umblachery calves are generally red or brown at birth with all the characteristic white markings on the face, on limbs and tail. This colour changes to grey at about 6 months of age. In adult females, the predominant coat colour is grey with white markings on face and legs. The intensity of colour varies from grey with admixture of black to full grey. Males are dark grey with black patches on head, back and pelvis. Bullocks are grey in colour. All the legs below hocks have white marks either 'socks' or 'stockings' even a portion of hooves is white. Switch of tail is white or partially white. Forehead is fairly broad, sometimes with a slight groove in the middle. It is well pronounced with white star. Face is short and straight. Muzzle is broad and black. Eyes are prominent and bright with black eyelashes. Ears are short, erect and laterally placed. Horns are very small, curving outward and inward and sometimes spreading laterally. These are thick in bulls and thin in cows. Hump is medium in size, not fleshy, generally erect. Dewlap is thin and short extending to the sternum. There are white markings on dewlap also. Navel flap is very small in cows. Sheath is not pendulous and well tucked up to the abdomen. Tail is well set, long and tapering gradually below hocks. In cows, udder is moderately developed with small and squarely placed teats. Milk-vein is not prominent. Skin is black, soft and gives a glossy appearance. Bullocks are small, swift and suited for agricultural operations.

Morphometric and Performance Parameters

Average body length, height and heart girth are 119 (range 100 to 143), 117 (range 103 to 123) and 151 cm (range 125 to 165), respectively, in males, and 109 (range 90 to 125), 105 (range 85 to 115) and 135 cm (range 120 to 145), respectively, in females. An adult male weighs around 385 kg and female 325 kg. Average age at first calving is around 1,593 days. Daily milk yield is around 2 kg. The female produces 300 to 500 litres of milk in a lactation. On an average, milk contains 4.94±0.06% fat and 7.80±0.03% SNF. Calving interval is around 446±4 days.

Umblachery bullocks are used for ploughing, carting, thrashing and paddling. The bullocks are capable of doing work for 6 to 7 hours under hot sun. A pair of bullocks can pull a total load (including cart weight) of 2 to 2.2 tonne over a distance of 20 km in about 7 hours. Price of a pair of bullocks ranges from Rs 10,000 to 15,000.

Breeding Farm

1. Cattle Breeding Farm, Korukkai, Umblachery, Tamil Nadu

Contact Agencies

1. State Animal Husbandry Department, Tamil Nadu
2. Tamil Nadu Veterinary and Animal Science University, Chennai, Tamil Nadu

VECHUR

Origin and Distribution

THE Vechur, a small cattle breed found in hills of Kerala, had its origin in Vechur, a small place by the side of Vembanad lake near Vaikam in Kottayam district of South Kerala. The dwarf cattle are also available in Kasargod district. Milk production in Vechur cattle is relatively higher than in other local cows. The movement of animals was restricted because of the barriers like rivers, canals and backwaters. The social requirement as well as the heavy rain and hot humid climate of the area coupled with low input available to the animals led to the selection of a small adaptable animal by man as well as nature. This was the basis for the evolution of Vechur animals.

Considering the importance of this breed to the local people, the Indian Council of Agricultural Research has initiated a scheme entitled “Conservation of Germplasm of Vechur Cattle of the Coastal Area and Other Dwarf Cattle of High Ranges of Kerala” at the Kerala Agricultural University, Mannuthy, Thrissur on 1 January 1996. The scheme is intended to characterize, evaluate and conserve the germplasm and to select a type of cattle weighing around 125 kg and yielding about 900 kg of milk/lactation.

Location and Topography

The breeding tract lies between 9°3' and 9°5' north latitude, and 76°34' and 77° east latitude. Kerala is a southernmost state in India, a narrow strip of land bordered by western ghats in the east and Arabian sea in the west.

Breeding tract

Soil

The soil in the breeding tract can be classified into 3 types locally known as *kari, karappadom* and *kayal* soils. *Kari* lands which are inferior swampy areas with black peaty soil with acididc nature are seen in Vaikom and Vechur areas. *Karappadom* soils are black, very loose, peaty with decomposed organic matter and are seen on the banks of the rivers. *Kayal* lands are those which are reclaimed from the backwaters with heavy clay soil.

Vechur bull

Vechur cow

Climate

The climate of the area is hot (23° to 35°C) and humid (81%) due to proximity of backwaters. The place has heavy rainfall (294 cm). The principal crops are rice, coconut, tea, coffee and spices.

Vechur calf

Management Practices

Animals in Kasargod district are mainly kept for manure. Animals from each house are let loose in the morning. These animals herd together and go for grazing in bigger groups. Breeding bulls are also present in the grazing area, some of them belonging to temples. Cows conceive out of natural mating from these bulls. Controlled breeding is not the practice. Animals return home in the evening. Sometimes animals remain in the hillside for months. But certainly they return after calving. Instances when cows come back to the owners and the house accurately after a long lapse of time and after calving even when the owners are not able to recognize the animal are common. Animals in milk return home at the exact time for milking. Generally animals are confined to sheds in the nights. Tree leaves are spread in sheds as bedding. Additional leaves are spread on alternate days on the previous layer. Daily cleaning of sheds is not done as in other parts of the state. Manure is removed 3 or 4 times a year and used as mulch (organic manure) for cultivation.

Physical Characteristics

Vechur animals are light red, black or fawn and white. They are extremely small in size and have compact body. Head is long with narrow face. Horns are small, thin curving forward and downward. In some cases they are extremely small, and are hardly visible. Hump is prominent in males. Sheath is small and tucked up with the body. Legs are short. Tail is long almost touching the ground. Udder is well developed with squarely placed small tapering teats. Milk-vein is well developed. Skin is smooth and glossy.

Morphometric and Performance Parameters

Body length, height and heart girth measure 108.8±1.79, 98.2±1.41 and 132.3±3.11

Vechur herd

cm, respectively, in bulls, and 93.4±0.98, 89.0±0.68 and 122.2±1.03 cm, respectively, in cows. Average birth weight is 11.2 kg in male calves and 10.2 kg in female calves. Average adult body weight is 178 kg (range 130 to 200 kg) in males, and 132 kg (range 95 to 150 kg) in cows. Average age at first calving is 1,073±46.4 days. Milk yield averages 514.0±37.1 kg in an average lactation of 232±16.7 days. Fat is 5 to 7.5% (average 6.2%). Calving interval is around 450 days.

Breeding Farm

1. Kerala Agricultural University, Mannuthy, Thrissur, Kerala

Contact Agencies

1. Kerala Agricultural University, Thrissur, Kerala
2. State Animal Husbandry Department, Kerala

6 BUFFALO BREEDS

BHADAWARI

Synonym: Etawah

Origin and Distribution

The Bhadawari buffaloes are known for high content of butter fat in the milk. They are found in the ravines of Yamuna, Chambal and Utangan rivers spread over in Uttar Pradesh and Madhya Pradesh. The breeding tract and natural habitat of this breed are Bah tehsil of Agra, Chakarnagar and Barhpura blocks of Etawah (Uttar Pradesh); Ambah and Porsa tehsils of Morena, and Mahangaon tehsil of Bhind district (Madhya Pradesh). These are traditionally the high density zones of Bhadawari buffaloes. This breed was the pride animal of the Bhadauria clan of the former Bhadawar state before independence of India. The term Bhadawari breed possibly was coined from the word Bhadawar, the home tract of this breed. The estimated population of this breed on the basis of 1977 Livestock Census was around 160,000 of which 70,000 were breedable females. The population declined at an alarming rate from 1977 to 1991, particularly in Uttar Pradesh. In the survey conducted in 1991 by the Animal Husbandry Department, it was speculated that around 29,000 animals existed. The survey in the breeding tract conducted by the National Bureau of Animal Genetic Resources during 1993 to 1995 presented a very gloomy picture about the population status of this breed. Most of villages had 2 to 5

Breeding tract

Bhadawari bull

Bhadawari she buffalo

Bhadawari animals. Hardly 3 to 4 villages had 20 or more buffaloes. The total population of this breed in the whole breeding tract was estimated to be 37,700. However, this figure also is on the higher side and if the trend continues then very soon this breed would come under threatened category.

The importance of Bhadwari buffaloes was well understood and some attempts were made for making improvement in their performance. In 1985, a project was initiated at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, with the assistance of ICAR, New Delhi with 58 breedable females. However, in 1990 only 16 buffaloes were left and the project was terminated. The State Government of Uttar Pradesh has also initiated some steps for its conservation. A Bhadawari buffalo farm was established at Saidpur in 1971-72 which was later shifted to Etawah in 1988-89. The mandate of this farm is genetic improvement through selective breeding and distribution of selected bulls in the field for breeding Bhadawari buffaloes. About 63 bulls were selected on the basis of dams' milk yield; 58 of these bulls were distributed in the breeding tract for natural service and 5 were used for semen collection and freezing. However, Murrah bulls, semen were also distributed in the breeding tract of Bhadawari buffaloes which has affected the progress of improvement programme on Bhadawari buffaloes. Murrah bulls, semen should not be distributed in the breeding tract of Bhadawari buffaloes which should be bred pure so as to save this breed from extinction.

Location and Topography

The breeding tract lies approximately between latitudes 26° and 27°14' north, and longitudes 78° and 79°51' east. The entire breeding tract is spread in the ravines of Yamuna, Chambal and Utangan rivers.

Crops and cropping pattern in this area have undergone drastic changes during the last two and a half decades mainly because of introduction of irrigation through canal and tubewells. Wheat, barley, rapeseed, mustard, pigeon-pea, maize and pearlmillet are the prominent crops. The area under fodder cultivation is 0.5% of the total geographial area. *Jharberi, pilua* and *deshi karaunda* shrubs; and *ruani* and *chhonkra* trees are found in ravines. Plantation of *vilayati* babool (*Prosopis juliflora*) to control in ravines by the Forest Department of Uttar Pradesh by aerial spray of seeds is a great threat to survival of the natural vegetation which is also one of the important causes of decline in Bhadawari population.

Soil

The area has mainly alluvial soil. The soil in general is deficient in nitrogen, low to medium in phosphorus and medium to high in potassium.

Climate

Rainy season is well defined from July to September. Average rainfall in Bhind is


Bhadawari calf

57 cm, and in Agra and Etawah districts 635 to 792 mm. There is wide variation in the ambient temperature of this area. In winter, temperature goes as low as 2°C and in summer as high as 49°C. This can be further classified as (i) long duration summer, and (ii) short duration winter. Relative humidity is maximum (81%) during August and minimum (around 30%) during May.

Management Practices

Integrated animal husbandry is practised in this tract, i.e. all species of livestock like cattle, buffalo, sheep and goat are reared together. Animals are housed both in *kutcha* and *pucca* types, and in most of the cases animal houses are part of farmers' residence. Animals are grazed in the field, particularly after rainy season when plenty of grasses are available. This is supplemented with green fodder in the form of berseem (*Trifolium alexandrium*), lucerne (*Medicago sativa*), pearlmillet, maize (*Zea mays*) and sorghum (*Sorghum vulgare*); and by dry fodder in the form of wheat *bhusa* (*Triticum aestivum*), *karbi* of pearlmillet (*Pennisetum typhoides*), maize and sorghum. Majority of the farmers provide concentrate in the wet form. Concentrate mixture is prepared by mixing grains of barley, maize, oat, etc. and fed after either soaking in water or boiling. Animals are generally stallfed. Some farmers provide fodder in cane baskets. Calves are allowed to suck dam's milk. Weaning is not practised. AI is not common in this region and natural mating is practised most of the times.

Physical Characteristics

Bhadawari buffaloes are medium sized with wedge-shaped body. Animals are narrow in front and wide behind giving distinctive conformation. Colour pattern of the body varies from blackish-copper to light copper. Colour of legs is usually like wheat straw which is peculiar to this breed. Hair are scanty. Calves are generally lighter in colour than adults. Skin colour is generally grey or greyish-black. Two white lines 'Chevron', locally called as *kanthi,* are present at the lower side of the neck similar to that of Surti buffaloes. Head is comparatively small, bulging between horns. In some cases forehead has white markings on it. Horns are black, curling slightly outward, downward before running backward parallel and close to neck, and finally turning

Bhadawari herd

upward. Eyelids are generally copper coloured but some animals have light brown or black eyelids. Ears are horizontal and medium in size. There are grey hair on the lower part of jaw and ears. Hooves are black. Tail is thick and long, sometimes touching the ground and ending in a brown or white switch. Udder is small and not well developed. Teats are cylindrical and centrally placed with pointed tips.

Morphometric and Performance Traits

Average body length, height and heart girth are 116.9, 122.8 and 184.5 cm, respectively, in adult males, and 115.0, 123.1 and 184.3 cm, respectively, in adult females. Average birth weight of calves is 25.3±0.23 kg (range 24 to 27 kg). Body weight of adult males is around 475 kg and that of adult females around 425 kg (range 300 to 540 kg).

Age at first calving is around 1,477 days (range 1,335 to 1,550 days). Bhadawari buffaloes are low milk producers. Average lactation milk yield is 780±25.4 kg (699 to 1,165 kg) and 300-day milk yield is 711 kg, in first lactation, and 903 kg (658 to 1,142 kg) and 812 kg, respectively, in overall lactations. On an average, these buffaloes produce milk for 272 days. Lactation period varies from 140 to 350 days. Average dry period is about 190 days (range 145 to 295 days). Fat varies from 6 to 12.5% (average 8.6%). Total solids in milk are around 17%. Average service period is 179 days (range 83 to 317 days) and interval between successive calvings is 478.7±11.55 days (range 390 to 630 days).

Bhadawari buffaloes survive and produce on low quality feed and fodder resources available in this area. This breed is an efficient converter of coarse feed into butterfat and is known for its high butterfat content. Better marketing facilities for fluid milk is tempting the farmers to cross these buffaloes with Murrah buffaloes. The Uttar Pradesh State Government is also recommending use of Murrah semen in the breeding tract of Bhadawari buffaloes, and hardly any emphasis is being laid on selective breeding of Bhadawari buffaloes or on distribution of Bhadawari bulls/semen. As a result, the population of pure Bhadawari buffaloes has declined considerably. On the other hand, Murrah-type animals being large in size require comparatively more quantity of good quality feed and fodder, a major constraint in this area. Bhadawari breed being of medium size and adapted to these conditions over the years is most suited to this area. This breed also provides good draught power in the area specially for farmers having small land holding. Even females are used for draught.

Breeding Farms

1. Bhadawari Farm, Agriculture College, Gwalior, Madhya Pradesh
2. Bhadawari Buffalo Breeding Farm, Etawah, Uttar Pradesh
3. Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh
4. State Livestock-cum-Agricultural Farm, Saidpur, Uttar Pradesh

Contact Agencies

1. Department of Animal Husbandry, Uttar Pradesh, Lucknow
2. Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh

JAFFARABADI

Synonyms: Bhavanagri, Gir or Jaffari

Origin and Distribution

THE Jaffarabadi is the heaviest of all the Indian breeds of buffaloes. It is found in Junagarh, Bhavnagar and Amreli districts of Saurashtra region of Gujarat. It is named after the town of Jaffarabad. These buffaloes are found in large numbers in this area, especially in the Gir forest area which is inhabited by the Indian lion. They constitute about 80% of the food for the lions in these forests. In spite of such difficult situations, the Maldhari herdsmen in the region continue to rear these buffaloes, which are the main source of their livelihood.

Location and Topography

The breeding tract lies between 20°5' and 22°6' north latitude, and between 70° and 72° east longitude. Most of the area is undulating. Agro-climatic conditions of the tract are mostly semi-arid. Semi-arid area ranges from 65 to 99% of total land area of these districts. Approximate area of distribution is 64,339 km². Average elevation of land is 60 m above msl.

Soil

Soils are silty clay to clay, typical medium black, giving mild cracking in dry season, high water holding capacity, highly calcareous and slightly alkaline with no salinity problem. The pH ranges from 7.9 to 9.4. Wells and canals are the sources of irrigation. Rice, millet, sorghum, maize and oat are the main cereal crops, and gram and pigeonpea are the main leguminous crops grown in this area. Other crops grown are cotton, groundnut, castor, sugarcane and sesamum.

Climate

Climate in general is monsoon tropical. Rains are common during

Breeding tract

Jaffarabadi bull

Jaffarabadi she buffalo

June to September. Rainfall ranges from 50 to 100 cm. Average temperature ranges from 20° to 36°C. Sometimes maximum temperature goes as high as 46°C and minimum as low as 11°C. Mean relative humidity is 80 % during July to September and 20 to 40 % during rest of the year.

Baniyan, pipal, raintree, neem, *babul*, etc. are the major fodder trees, and *oriya* and *vela veli* are fodder shrubs available in the native tract of Jaffarabadi animals. Major native grasses are Cynodon, Dicanthium, Aristidica, Brachiaria, Eleuropus, etc. Main cultivated crops grown in this area are pearl-millet, sorghum, wheat, gram, tur, castor, cotton, onion, sugarcane, garlic, etc.


Jaffarabadi calf

Management Practices

Average size of buffalo herd is 2-4. Most of the farmers provide some type of housing to the animals during day and night. Most of the animal houses are closed, *kutcha* and separate from the farmer's residence. Inside the forest areas, the Maldharis keep their animals in '*Nesdas*' where the animal house forms a part of the farmer's house and is heavily barricated in front to protect the animals from lions and other wild animals. As the animals are massive, they are heavy grazers. They are maintained on natural pastures throughout the year. The main green fodder fed to Jaffarabadi animals are maize, sorghum, groundnut fodder, sugarcane tops and lucerne; and dry fodder are sorghum and maize *kadbis*, groundnut fodder, groundnut husk, groundnut hulls, wheat straw, wheat *bhusa* etc. The common concentrates fed to Jaffarabadi buffaloes are groundnut-cake, cottonseed and cottonseed-cake and compounded (pelleted) feed of the Gujarat Dairy Development Corporation. In some areas of Bhavnagar district people also feed coconut-cake. Mostly natural mating is practised.

Physical Characteristics

The usual colour of the breed is black but a few animals having grey colour or white spots on forehead, feet and tail switch are also seen. The latter type of buffaloes are called 'Nav-Chandra' and are considered lucky by the Maldharis (livestock owners). Hair are medium in length, straight and glossy. Skin colour is black. Horns,

Jaffarabadi herd

muzzle, eyelashes, hooves and tail switch are black. Forehead is very prominent, broad and convex. Horns are long (about 50 cm) and exhibit wide variation, but usually emerge out by compressing the head, go downward sideways, upward, inward and finally forming a ring- like structure. It makes eyes to look small, termed as study eye, especially in males. Sometimes it leads to blindness. Ears are long and horizontal. Average length is about 26.76±1.00 cm. Head and neck are massive. Navel flap and penis sheath are medium in size. Udder is well developed. Pendulous and round udders are found in almost equal proportions. Fore-quarter is slightly larger than the hind quarter. Teats are mostly funnel shaped and have pointed tips. Quite a large number of buffaloes have cylindrical teats. Milk-vein is medium in size. Jaffarabadi buffaloes are of mild temperament.

Morphometric and Performance Traits

The averages of body length, height and heart girth are 127.7±2.20, 126.1±2.18 and 207.7±3.58 cm, respectively, in adult males, and 132.6±0.55, 129.1±0.54 and 202.9±0.84 cm, respectively, in adult females. Birth weight is around 36 to 38 kg. On an average, adult Jaffarabadi males and females weigh up to 1,000 and 700 kg respectively. In exceptional cases, Jaffarabadi bulls weigh as much as 2,000 kg.

Age at first service is around 1,000 days and at first calving is 1,361.7 days. Averages of total lactation milk yield and lactation length are 2,151.3±130.53 kg and 319.44±17.31 days, respectively, in first lactation, and 2,238.7±74.87 kg and 305.1±9.61

days, respectively, in overall lactations. Averages of dry period, service period and calving interval are 144.9±8.4, 93.4±0.69 and 440.3±14.32 days respectively. Average number of services per conception is 1.5 (range 1 to 2). Average fat is 7.68% (range 6.8 to 8.5%). Males are good draught animals for hauling heavy loads.

Breeding Farms

1. Buffalo Breeding Centre, National Dairy Development Board, Nekarikallu, Andhra Pradesh
2. Cattle Breeding Farm, Gujarat Agricultural University, Junagarh, Gujarat
3. Akshar Purushottam Mandir Gaushala, Gondal, Gujarat
4. Sabarmati Ashram Gaushala, Bidaj, Gujarat
5. BAIF Development Research Foundation, Uruli-Kanchan, Maharashtra

Contact Agencies

1. Gujarat Agricultural University, Junagarh, Gujarat
2. Department of Animal Husbandry, Gujarat

MARATHWADA

Synonym: Dudhana Thadi

Origin and Distribution

MARATHWADA buffaloes in the Marathwada region of Maharashtra state are entirely different from that of western and northern types, and clearly represent a very ancient indigenous type characterized with lighter built and long flat horns. These buffaloes are mainly found in Parbhani, Nanded, Bid and Latur districts of Maharashtra.

There are two agricultural divisions, viz. Aurangabad and Latur, in the region. The region is predominantly agrarian. Rainfed agriculture is the principal occupation of rural population. The geographical area of this region is 6.48 million ha and cultivable area is 4.8 million ha.

Location and Topography

The Marathwada region lies between 17°35' and 20° 40' north latitude, and 74° 40' and 78° 15' east longitude. It forms part of the vast Deccan plateau. The entire Marathwada region is situated at an average height of about 650 m above msl, gradually sloping from west to east, and is traversed by hill ranges originating from the Sahyadris in the west. Different ranges derive their names from local resources, the northern being Ajanta-Satmala ranges and the southern the Balaghat ranges. In addition , there are scattered hillocks of varying heights throughout the region.

Breeding tract

Godavari is the main river flowing from west to east and south-east, collecting water on its way from several large and small tributaries. It enters Andhra Pradesh and ultimately merges into the Bay of Bengal. Most of the tributaries are seasonal and dry up soon after the monsoon. The region suffers from heavy drainage due to west-east slope, ultimately affecting agriculture to a great extent.

Marathwada bull

Marathwada she buffalo


Marathwada calf

Soils

Soils of Marathwada region are typically black cotton type vertisols and possess material of calcareous rudimentary rocks, basic igneous, basalt alloevium and alluviam material commonly known as Deccan trap. It includes 32.5 million ha of medium black soils, 12.1 million ha of deep black soils and 12.4 million ha of coarse shallow soils. The fertility index with respect to nitrogen is low in Parbhani and Nanded districts, and medium in Aurangabad, Jalna, Bid, Osmanabad and Latur districts. In case of phosphorus, fertility index was low in almost all the districts. Contrary to this, it was very high for potash throughout the region in 1993. The average use of fertilizer was 50 and 39 kg/ha in Latur and Aurangabad divisions respectively.

Climate

The climate of Marathwada region is dry to semi-arid and sub-tropical rainy. The major feature of rainfall is that the south-west monsoon (June-September) accounts for 70 to 95% of annual rainfall. The monsoon as well as the annual rainfall show large fluctuations from year to year, but there is no significant evidence of any trend or periodicity in either of them. The annual rainfall varies from 300 to 1,100 mm with 35 to 65 rainy days. The coefficient of variation of monthly rainfall is as high as 40 to 50% even in the rainiest month of July. The variability of weekly or fortnightly rainfall is still high.

There are 3 distinct agro-seasons. *Kharif* (monsoon) ranges between June and September, followed by *rabi* (post-monsoon) between October and January, and summer between February and May. The maximum temperature is around 40±2°C during April-May and minimum about 8 to 10°C during December-January.

The Marathwada region is endowed with assured rainfall except in some talukas of Aurangabad, Jalna, Bid and Osmanabad districts.

Management Practices

Farmers maintain mixed herds of cattle and buffaloes. Generally, animals are housed in open close to farmers' residence. Sorghum and paddy straw, grasses, sugarcane leaves and tops are usually fed to animals. Concentrate is offered only to milking females.

Marathwada herd

Physical Characteristics

Marathwada buffaloes are of light to medium built with compact stature, and have adult weight of 300 and 370 kg. Coat colour varies from greyish-black to jet black, although white markings on forehead and on lower parts of the limbs with white switch of tail are not uncommon. Horns are medium in length, parallel to neck, reaching up to shoulder but never beyond shoulder blade like those commonly seen in Pandharpuri buffaloes and usually not flat. Forehead is moderately broad, and eyes are generally red tinged. Neck is short. Legs and feet are properly set which in males suit for draught and transportation in hilly tract. Tail is of moderate length reaching up to hock.

Morphometric and Performance Traits

Average birth weight of male and female calves is 24.5 and 23.7 kg respectively. Adult body weight ranges from 320 to 400 kg. Age at first calving is around 1,670 days. Lactation yield ranges from 845 to 960 kg in a lactation of about 302 days. Gestation period, calving interval and dry period in Marathwada buffaloes are 310, 430 and 134 days respectively.

Contact Agencies

1. Marathwada Agricultural University, Parbhani, Maharashtra
2. Department of Animal Husbandry, Maharashtra

MEHSANA

Synonyms: Mahesani, Mehsani, Banni

Origin and Distribution

THE Mehsana, a dairy breed of buffaloes, is centered around the town of Mehsana in Gujarat from where it derives its name. It is also common in Banaskantha, Sabarkantha, Gandhinagar and Ahmedabad districts. Typical animals are seen in the towns of Mehsana, Patan, Sidhpur, Vijapur, Kadi, Kalol and Radhanpura. The breed is considered to be a cross between Murrah and Surti. Approximate population of this breed is around 0.4 million. Males are moderately tractable while females are docile. Male calves are not cared properly.

Location and Topography

Mehsana district lies in the north of Gujarat between latitude 23.02° and 24.90° north, and longitude 71.26° and 72.52° east. It covers an area of 9,027 km². The Sabarmati, Rupel and Saraswati are the main rivers of the district. There are a number of small and a few large ponds in the breeding tract. About 1.78% of the area is under forest. From the north-east part to north-west part of the Mehsana district, the surface is plain and slopy. The north-east part is hilly. Average elevation of the area is around 104.37 m (range 69.5 to 154.5) above msl.

Breeding tract

Soil

The home tract forms a part of the sandy alluvial plains of north Gujarat. Soil is sandy loam and 'goradu'. In the southern parts it merges into black cotton soil area. Soil of eastern zone is highly fertile, and of western zone salty, sandy and clay where trees are less in number.

Climate

Summers are very hot and winters

Mehsana bull

Mehsana she buffalo

very cold. Mean maximum temperature ranges from 21° to 45°C and mean minimum temperature from 5° to 29°C. Average rainfall is around 57 cm (range 12 to 88 cm). Average relative humidity is around 51% (range 12 to 95%).

Management Practices

Farmers maintain animals as commercial production units. Average herd size is of 4.33 animals/unit (range 1 to 12). Breeding is performed mainly through AI using frozen semen of progeny-tested bulls. Grazing is practised in rainy season along road-side and on river beds. Lucerne is grown as major green fodder. Hay is made from pearlmillet. Concentrate is fed to buffaloes and it contains sorghum/maize, wheat bran, rice bran, groundnut-cake, sunflower, rapeseed, clusterbean *kurma* and molasses. Usually pelleted concentrate feed supplied by the National Dairy Development Board is fed to animals. Wallowing is generally restricted due to scarcity of water. Animals are tied mostly at a place over day and night. Houses in the form of temporary sheds of thatched roofs and wooden partitions are provided. Calves are weaned at about 6 to 8 months. Female calves are cared more while male calves are generally neglected.

Physical Characteristics

The Mehsana buffalo is a medium-sized animal with a low set deep body. Body is mostly black. A few animals are black-brown or brown. Muzzle and horns are black. Forehead is wide with a slight depression in the middle, sloping toward the root of horns. Face is long and straight with a wide muzzle and wide open nostrils. Eyes are very prominent, black and bright, bulging from their sockets, with folds of skins on upper lids. Ears are medium sized and pointed at the apex. There is generally a prominent hairy growth inside ears. Horns are generally sickle shaped with the curve more upward than in the Surti breed and less curved than in the Murrah breed. They are generally bent downward and then take a curve like the horns of a ram.

Neck is long and well set on shoulders. Skin over the region has folds. In males, neck is massive and dewlap is almost absent. Chest is deep with broad brisket. Shoulders are broad and blend well with body. Legs are of medium to short length with clean bones and broad, black hooves.

Barrel is long and deep, with well-sprung ribs. In females, fore-quarters are light, hind quarters wide and heavy giving a wedge-shaped appearance. In males, fore-quarters are massive, giving a heavy appearance with hind quarters set fairly wide. Back is barely straight and strong with pelvic joint higher than withers. Navel flap is very small.

Hind quarters are well developed, wide and deep, with udder well attached at the back and in front. Hips are high and prominent with points well apart. Thighs are well developed with a good curve above hock. Buttocks are muscular merging well into rump. Pin-bones are not prominent in well-fed animals. Flanks are fine. Hocks are strong with good curve. Tail is of medium thickness and is long with black switch. Switch is sometimes brown or white.

Skin is thin, pliable, soft and generally black. Hair are rough and scanty. Udder is well-developed and bowl shaped. In good specimens, it is carried well behind. Generally, rear udder is more developed than fore-udder. Teats are fairly thick, cylindrical, long and pliable. Milk-veins are prominent.

Mehsana calf

Morphometric and Performance Traits

Averages of body length, height and heart girth are 153.7 cm (range 139 to 166 cm), 133.7 cm (range 120 to 144 cm) and 200.6 cm (range168 to 218 cm), respectively, in males, and 141.7 cm (range 117 to 164 cm), 127.5 cm (range 111 to 142 cm) and 189.3 cm (range 160 to 211 cm), respectively, in females. Average birth weight of male calves is 29.5 kg (range 16 to 44 kg) and of females 28.5 kg (range 14 to 40 kg). The overall average birth weight of calves is about 29 kg. Average adult body weight is around 565 kg in males (range 400 to 602 kg) and 484 kg in females (range 315 to 580 kg). Average weight at first calving is 478 kg (range 228 to 575 kg).

Age at first service is about 830 days (range 349 to 2,178 days) and at first calving about 1,266 days (range 677 to 2,500 days). Total lactation milk yield, 305-day milk yield, lactation length and dry period average 1,940 kg (range 598 to 3,221 kg), 1,893 kg (range 598 to 3,146 kg), 308 days (range 163 to 513 days) and 179 days (range 44 to 584 days), respectively, in first lactation, and 1,988 kg (range 598 to 3,597 kg), 1,912 kg (range 598 to 3,269 kg), 317 days (range 157 to 513 days) and 167 days (range 14 to 656 days), respectively, in all lactations. Milk contains about 7% fat (range 5.2 to 9.5%). Average service period is about 161 days (range 24 to 646 days). Calving interval is about 476 days (range 313 to 945 days). Females exhibit regularity of reproduction throughout the year, but breeding and calving are more pronounced during August to January and July to December respectively. This breed is reputed for its persistency of milk production. Age at semen collection is about 1,013 days (range 680 to 1,352 days).

Mehsana herd

Breeding Farms

1. Buffalo Breeding Centre, National Dairy Development Board, Nekarikallu, Andhra Pradesh
2. Livestock Research Station, Gujarat Agricultural University, Sardar Kṛushinagar, Gujarat

Contact Agencies

1. Department of Animal Husbandry, Gujarat
2. Gujarat Agricultural University, Sardar Krushinagar, Gujarat

MURRAH

Synonyms: Delhi, Kundi, Kali (India), Kerban-banleng (Sumatra), Kerban-shungei or Karban-Sapi (Malaysia)

Origin and Distribution

BUFFALOES in the northwest region of India have long been selected for milk yield and have curled horns. They were named as Murrah meaning curled. These buffaloes were also named as 'Delhi' referring to the centre of their origin. Murrah is considered to be the best milch-cum-meat breed of buffaloes. Its home tract stretches around the southern part of Haryana comprising the districts of Rohtak, Jind, Hisar and Gurgaon, and the Union Territory of Delhi. However, this breed has spread to almost all parts of the country and is being bred either in pure form or is being used for grading up local buffaloes. In fact, this breed has even found an important place in the livestock industry of many developing countries like Bulgaria, the Philippines, Malaysia, Thailand, China, Indonesia, Bangladesh, Nepal, former USSR, Myanmar, Vietnam, Brazil and Sri Lanka, and is being bred there extensively.

With increase in the popularity of Murrah buffaloes as dairy animals, farmers in different parts of the country started maintaining either Murrah buffaloes or got their local buffaloes mated to Murrah bulls for increased milk production. This has resulted in a great demand for genetically superior Murrah bulls in different states throughout the country. To meet this demand the Government of India established the Central Buffalo Breeding Farm for Murrah breed on 1 April 1973 at Awadi, Chennai, by taking over the main Tamil Nadu State Salvage Farm for dry cows. The mandate of the farm is to produce and supply good quality Murrah buffalo bulls to different state governments and other developmental agencies for improving milk production in buffaloes in the country. The farm has supplied 656 Murrah buffalo bulls to Andhra Pradesh,

Breeding tract

Tamil Nadu, Bihar, Orissa, Maharashtra, Kerala, Gujarat, Madhya Pradesh and Karnataka during the last 10 years. Besides the males, the farm also supplied 220 heifers and many adult females to different organizations.

Location and Topography

The native tract lies between 28°15' and 30° north latitude, and 75°45' and 70°80' east longitude.

Soil

Soils of the area fall basically into two groups, viz. arid soils and enti soils. These are mostly light-textured, sandy and loamy soils. In some parts of the breeding tract, soils are sandy loam, surface soils are light in texture and heavier in lower horizons. Soils are deficient in organic carbon and available nitrogen, and medium to high in phosphorus and nitrogen.

Climate

The tract has relatively hot and dry climate. Maximum temperature goes as high as 45°C during summer. Minimum may reach near freezing point in winter with frost for a few days. Annual rainfall is around 300 mm in arid zone and 500 mm in semi-arid parts of the tract. These rains are caused mostly by southwest monsoon during July to September contributing around 80-85% of annual rainfall.

The major rainfed crops are pearlmillet, sorghum and clusterbean during *kharif*, and gram, mustard and barley during *rabi*. Major crops grown under irrigated cropping system are wheat, barley and mustard.

Management Practices

In the breeding tract, these buffaloes are kept in a mixed type of housing system. Mostly they are tied to a tree or a pole in the open, but shelter is provided during extreme weather conditions. Houses are well ventilated and mostly made up of *pucca* walls with *kutcha* floor. Animals are stallfed. Berseem, oat and mustard are the green fodder in *rabi*, and pearlmillet, sorghum and clusterbean in *kharif*. In lean season Murrahs are maintained on wheat and pulse straws in conjunction with oilcakes and other concentrates. Mostly, women are engaged in buffalo rearing (90%), and all the activities pertaining to feeding, milking, cleaning, etc. are looked after by them. Calves are not weaned. Very few farmers rear bulls exclusively for breeding purposes, otherwise males are used both for breeding as well as draught purposes. Natural service is mostly practised in the field.

Physical Characteristics

Murrah animals are jet black and massive with long and deep body. Head of females is short, fine and clear cut. Bulls are heavy and broad with prominent cushion of

Murrah bull

Murrah she buffalo

Murrah calf

short and dense hair. Horns are short and tightly curved in a spiral form. Eyes are bright, active and prominent in females but slightly shrunken in males. Ears are short, thin and alert. Neck is long and thin in females, and thick and massive in males. Hips are broad. Fore- and hind-quarters are drooping. Tail is long reaching below the hock up to fetlock and ending in a white switch. Udder is capacious extending from hind legs to just behind navel flap with prominent milk-veins. Teats are long and placed uniformly wide apart. Hind teats are generally longer than the fore ones.

Morphometric and Performance Traits

Averages of length, height and heart girth of males are 150, 142 and 220 cm, respectively, and of females 148 (range 143 to 163), 133 (range 129 to 140) and 202 (range 197 to 220) cm respectively. Average birth weight of male calves is 28 to 34 kg (average 31.7 kg), and that of female calves 26 to 33 kg (average 30 kg). Overall weight at birth is 30.3 kg (range 26 to 34 kg). Average body weight at first calving ranges from 470 to 520 kg. Adult body weight ranges from 450 to 800 kg (average 567 kg) in males and from 350 to 700 kg (average 516 kg) in females. Average age at first service is around 943.4 days (range 920 to 1,355 days), and average age at first calving is 1,319 days (range 1,214 to 1,647 days). Total lactation milk yield, 305-day milk yield, lactation length and dry period average 1,678.4 kg (range 904-2,041 kg), 1,675.1 kg (range 1,355 to 1,964 kg), 307.0 days (range 254 to 373 days) and 187.6 days (range 145 to 274 days), respectively, in first lactation; and 1,751.8 kg (range 1,003 to 2,057 kg), 1,660.1 kg (range 1,472 to 1,962 kg), 298.7 days (range 269-337 days) and 154.8 days (range 127-176 days), respectively, for overall lactations. On an average, milk contains about 7.3% fat (range 6.9 to 8.3%). Service period averages 177.1 days (range 141 to 281 days) in first parity and 136.3 days (range 125 to 187 days) in overall parities. First calving interval varies from 455 to 632 days (average 488.1 days), and overall calving interval varies from 430 to 604 days (average 452.9 days). Number of services per conception varies from 1.75 to 2.15 (average 1.93). Murrah males are used extensively for draught and meat purposes.

Murrah herd

Breeding Farms

1. Buffalo Breeding Centre, NDDB, Nekarikallu, Andhra Pradesh
2. Government Livestock Farm: Banavasi; Horesikullu; Karimnagar; Kakinada; Mamnoor; Reddipalli; Visakhapatnam, Andhra Pradesh
3. Government of Assam: Barpeta; Berhampur; Guwahati; Jagdaur; Khanikar; Pachmile; Silchar, Assam
4. Government of Bihar: Sairakela; Sepaya, Bihar
5. Government of Goa, Dhat
6. Amul Research and Development Association, Ode, Gujarat
7. Sabarmati Ashram Gaushala, Bidaj, Gujarat
8. Government Livestock Farm, Hisar, Haryana
9. Central Institute for Research on Buffaloes, Hisar, Haryana
10. Choudhary Charan Singh Haryana Agricultural University, Hisar, Haryana
11. National Dairy Research Institute, Karnal, Haryana
12. Central Cattle Breeding and Research Farm, Beli-Charna, Jammu & Kashmir
13. National Dairy Research Institute, Southern Regional Station, Bangalore, Karnataka
14. Government of Karnataka: Bankapur; Hessarghatta; Koila; Kurikuppi; Torongal
15. Government of Kerala, Kodapanakunnu, Kerala

16. Kerala Livestock Development Board Ltd.: Dhoni; Kulathupuzha; Mattupetty; Peermade
17. Government of Madhya Pradesh: Anjora, Durg; Kiratpur; Ratona
18. BAIF Development Research Foundation, Uruli-Kanchan, Maharashtra
19. Government of Punjab, Mattewara, Punjab
20. Punjab State Coop. Milk Producers' Federation Ltd., Bhattian, Punjab
21. Central Cattle Breeding Farm, Avadi, Chennai, Tamil Nadu
22. Agricultural College and Research Institute, Coimbatore, Tamil Nadu
23. Government of Tamil Nadu: Hosur; Ooty; Orthand; Pudukottai; Tirunelveli; Chettinad
24. Government of Uttar Pradesh: Hastinapur; Lakhimpur; Manjhara; Neelgaon
25. Pradeshik Co-operation Dairy Federation, Moradabad, Uttar Pradesh
26. Government of West Bengal, Haringhatta, West Bengal

Contact Agencies

1. Central Institute for Research on Buffaloes, Hisar, Haryana.
2. National Dairy Research Institute, Karnal, Haryana
3. Department of Animal Husbandry, Haryana
4. Department of Animal Husbandry and Dairying, Ministry of Agriculture, Government of India, New Delhi

NAGPURI

Synonyms: Berari, Ellichpuri, Gaulani, Gauli, Varadi

Origin and Distribution

THE Nagpuri is a dual-purpose breed of buffaloes and is native to the Vidarbha region of Maharashtra. This breed is commonly found in Nagpur and Wardha districts. This breed has 4 distinct strains, viz. Purnathadi (Akola District), Ellichpuri (Amravati district), Gaulani (Wardha district) and Nagpuri (Nagpur district). All these strains are commonly known as Nagpuri or Berari buffaloes. These buffaloes are used for heavy draught purposes. Farmers of Vidarbha region prefer to maintain this breed mainly due to its low maintenance cost, efficiency of feed conversion, moderate production and better adaptation to local climatic conditions.

Location and Topography

The home tract of Nagpuri buffaloes lies between 19° 51' and 22° 15 north latitude, and 76° and 79° 21' east longitude.

Soil

Black or brown soil is mostly found in this region. Hilly region has brown soil mixed with sand.

Climate

The home tract is predominantly a dry tract. Maximum temperature reaches more than 44°C and minimum temperature about 14°C. Winters are comparatively mild. Annual rainfall is about 95 cm.

Management Practices

Buffaloes and heifers are reared in this area as source of extra income. They are mainly reared for fat production. Regularity in breeding, high fat in milk, resistance to diseases and adaptation to hot climate are some of the characteristics of this breed. Maintenance cost is very low.

Breeding tract

Nagpuri bull

Nagpuri she buffalo

Physical Characteristics


Nagpuri calf

These are black-coloured animals with white patches on face, legs and tail tip. Puranthadi strain is slightly brownish with a predominant white patch on forehead. Horns are long (50-65 cm), flat, curved and carried back on side of the neck nearly to shoulders. Horns of this type have a distinct advantage in that they help the animals to protect themselves from wild animals while moving through forests. Horns are heavier in males than in females. Face is long, thin and cone shaped with straight nasal bone. Neck is somewhat long. Brisket is heavy. Dewlap is absent. Ears are medium in size with pointed tips. Limbs are long and light. Navel flap is mostly absent and even if present, is very short. Tail is comparatively short in some buffaloes; it reaches below the hock. Switch of the tail is white.

Morphometric and Performance Traits

Body length, height and heart girth average 180, 140 and 210 cm, respectively, in males. In females, average body length ranges from 112 to 132 cm (average 129 cm), height from 120 to 138 cm (average 123 cm), and heart girth from 160 to 200 cm (182 cm). Average birth weight of males is 29.0±0.32 and of females 28.1±0.14 kg (overall average 28.6±0.27 kg). Adult body weight of Nagpuri buffaloes ranges from 340 to 400 kg. Some females even weigh more than 400 kg. Males weigh up to 520 kg.

Heifers mature late and average age at first calving is 1,672 days. Females are fairly good milkers and produce about 780 to 1,520 kg of milk (average 1,055 kg). Lactation length averages 286 days. Fat varies from 7.0 to 8.5%. Average service period is about 116 days (range 34 to 435 days). Average dry period is 129.1±4.85 days. Intercalving period ranges from 350 to 721 days (average 430 days).

Breeding Farms

1. Nagpur Veterinary College, Nagpur, Maharashtra

Contact agencies

1. Department of Animal Husbandry, Nagpur, Maharashtra
2. Nagpur Veterinary College, Nagpur, Maharashtra

NILI-RAVI

Origin and Distribution

THIS breed is similar to Murrah in almost all respects except for some white markings on extremities and walled eyes. Home tract lies in Pakistan. In India, these buffaloes are found in Fazilka, Ferozepur, Jira and Makhu tehsils of Ferozepur district, and Patti and Khemkaran tehsils of Amritsar district of Punjab. The breeding tract is spread all along the Sutlej river on the Indo-Pak border. The name Nili is supposed to have derived from the blue waters of the River Sutlej. Ravi buffaloes are mostly bred in Pakistan around the River Ravi, after which they are named.

Before 1938, Nili and Ravi breeds of buffaloes were considered as in the milieu of Murrah breed only, while at the First All-India Cattle Show held in that year they were shown as separate. In the subsequent second and third shows, they were separately distinguished and described as independent entities in 1952. Nili and Ravi were originally two distinct breeds as they belonged to geographically isolated areas. Frequent movement of animals with improvement in communication means has resulted in their mixing. At present, it is very difficult to find typical animals of either breed. For this reason, they are generally classified as Nili-Ravi and were shown as one breed in 1960 All-India Cattle Show.

The breeding tract has mixed type of buffaloes and animals true to the breed are very rare. Only 9.4% of the total buffaloes in the breeding tract are of Nili-Ravi breed. Ferozepur district considered to be the home tract of Nili-Ravi buffaloes has 53.1% buffaloes of Murrah type and only 10.8% of Nili-Ravi type. The percentage in Amritsar district is 18.7 and 8.7 respectively.

Breeding tract

Location and Topography

The breeding tract lies between 74°04' and 75° east longitude, and 30°25' and 31°25' and 31°10' north latitude.

Soil

Sandy loam and loam soils are pre-

Nili-Ravi bull

Nili-Ravi she buffalo


Nili-Ravi calf

dominant in this area. Irrigation network through canals and tubewells is well developed.

Climate

Climate is hot and dry for most parts of the year. Summers are very hot while winters are very cold. Rainfall is restricted mainly to July and August.

Management Practices

Most of the farmers (97.6%) tie their buffaloes all the time. Animal houses though separate are located in the same premises as the residence of the farmer in most of the cases (85.6%). Animal houses are usually open (56.9%), made up of mud (48.8%) and bricks (46.5%), full walled (54.3%), and have mud floor (66.4%). These are well ventilated (91%) and clean (88%). Drainage is provided in 51% of the houses. Most of the farmers grow fodder (73%) for feeding to their animals and on an average a farmer has 0.50 ha of land under fodder production. Most of the farmers chaff the fodder and feed the animals in groups. Natural service is mostly practised (67%).

Physical Characteristics

Skin and hair are normally black-brown; fawn and grey animals are not uncommon. They are usually wall eyed and have white markings on forehead, face, muzzle, legs and tail. The most desired character of the female is the possession of white markings known as 'Panch Kalyani'. Typical animals are rarely found these days. Most of the animals have white markings on hind legs but not on forelegs. Moustache is white.

Nili-Ravi buffaloes are of medium size, and have deep and low-set frames. Head is elongated, bulging at top and is depressed between eyes.

Muzzle is fine but with wide nostrils. Double chin is conspicuous. Horns are small, tightly curled and circular in cross-section. Neck is long, thin and fine. Rump is broad, long and slightly sloping. Pin bones are prominent and set well apart. Tail is thick at the base, gradually tapers toward the end and extends below hocks with a white switch. Udder is well-shaped, capacious and extends well forward up to navel flap. Teats are long and centrally placed. Milk-veins are prominent, long and tortuous.

Morphometric and Performance Traits

Average body length, height and heart girth are 160, 140 and 230 cm, respectively, in Nili-Ravi males, and 165.4, 134.2 and 207.7 cm, respectively, in females. Birth weight ranges from 27 to 39 kg (average 35 kg). Adult weight is about 567 and 454 kg in males and females respectively.

Average age at first conception is 1,125.05±37.12 days. Average age at first calving is 1,359 days (range 1,216 and 1,617 days). First lactation milk yield, pooled lactation milk yield and 305-day milk yield average about 1,483, 1,850 and 1,820 kg respectively. Average lactation length is about 294 days (range 263 to 316 days). Fat content varies from 5.1 to 8% (average 6.8%). Dry period is about 151 days (range 115 to 202 days) and service period about 202 days (range 169 to 290 days). Average first calving interval is 520.50±2.58 days and overall calving interval about 488 days (range 313 to 945 days). Average number of services per conception is 2.38.

Breeding Farms

1. Buffalo Breeding Centre, NDDB, Nekarikallu, Andhra Pradesh
2. Central Institute for Research on Buffaloes, Nabha Campus, Nabha, Punjab
3. Government of Punjab, Mattewara
4. Military Dairy Farm, Ferozepur, Punjab
5. Punjab Agricultural University, Ludhiana, Punjab
6. Punjab State Co-operative Milk Producers' Fedaration, Bhattian, Punjab

Contact Agencies

1. Central Institute for Research on Buffaloes, Hisar, Haryana
2. Department of Animal Husbandry, Punjab

PANDHARPURI

Synonyms: Dharwari

Origin and Distribution

The Pandharpuri buffalo is a native of Kolhapur, Solapur, Sangli and Satara districts in south Maharashtra. These buffaloes are named after the name of the geographical area, i.e. Pandharpur block in Solapur district. It is hardy and well suited to dry conditions in this area. Today, there are approximately 0.19 million Pandharpuri buffaloes. These buffaloes are concentrated in Pandharpur, North Solapur, South Solapur, Barshi, Akkalkot, Sangola and Mangalvedha tehsils of Solapur district; Miraj, Walwa, Jath and Tasgaon tehsils of Sangli district; and Karveer, Shirol, Panhala, Radhanagri, Hatkanangale and Gadhinglaj tehsils of Kolhapur district. These buffaloes are also found in adjoining Belgaum district of Karnataka. Communities like Gawali and Joshi are local breeders. They maintain these buffaloes.

Breeding tract

Location and Topography

The breeding tract is a sub-montane zone. It lies between 70°25' and 76°24' east longitude, and between 16° and 22°2' north latitude. The average altitude of the area is 1,700 to 2,000 m above msl.

Soil

Soil type is deep rich loam having black to deep black hue in some parts and light shallow in other parts. Black soil is good for cotton, and light soil mixed with gravels for millets, groundnut and sorghum.

Climate

Mean maximum temperature varies between 25° and 37°C, and mean minimum temperature between 11° and 22°C. There are rains for about 74 days in a year and annual rainfall is about 150 cm. Average wind velocity is about 6.8 km/hr (range 2 km/hr in December

Pandharpuri bull

Pandharpuri she buffalo

to 17 km/hr in July). Average duration of sunshine is 7.8 hr/day. Mean relative humidity is 85% in the morning and 50% in the evening.

Management Practices

Animals are usually housed in the open close to human dwellings. In the Kolhapur area, some farmers provide conventional sheds/barns for housing buffaloes. These are either part of residence or are separately constructed. Thatched sheds with sugarcane trash roofs and temporary field shelters are sometimes found. Floor is generally uneven and *kutcha* without any drainage facilities. Natural service is practised for breeding as semen of Pandharpur bulls is not available. Weaning is practised in cities but not in rural areas. Milk let-down is not a problem. Farmers take animals to customers' doors and supply milk as per requirement. This act is repeated several times in mornings and evenings for each animal. This unique behaviour of the breed is in total variance with the physiology of let down of milk based on release of oxytoxin and completion of milking within 6 to 8 minutes. In many animals, milking is continued even for 30 to 40 animals at regular interval. Calves are weaned by a large number of farmers, particularly in urban areas, within 24 to 48 hours. Knuckling method is usually followed for milking. Complete udders are rarely washed but teats are usually washed before milking.

Paddy straw, sorghum straw (*jowar kadbi*), dry mixed grasses, green grasses, sugarcane leaves and sugarcane tops are mainly used as fodder. Maize, sorghum, napier grass, etc. are grown on a very small scale as cultivated fodder crops. Concentrate mixture is prepared from wheat bran, rice husk, crushed maize grains, pulse *chunnis*, groundnut-cake and safflower-cake. Concentrates around 2.5 to 3 kg are usually soaked and fed at the time of milking. Normally herd size in cities is around 15 to 20 buffaloes and in rural areas around 3 to 4.

Physical Characteristics

The Pandharpuri buffalo is a medium-sized animal with long narrow face. Skin colour is usually black but it varies from light black to deep black. White markings are also found on the forehead, legs and tail in a few cases. Frontal bone is comparatively long and straight. Nasal bone is very prominent, long and straight. Horns are very long extending beyond shoulder blade, sometimes up to pin bones and are of three types: (i) *bharkand* (53%) curving backward and usually twisted; (ii) *toki* (36%) curving backward, upward and usually twisted outwards; and (iii) *meti* (11%) long, flat, running downward from sides of head and usually twisted. Neck is long and thin. Switch of the tail is white in majority of animals and extends just below the hock. Hooves are usually black. Hook bones are prominent and well placed. Legs are long and straight. Udder is of medium size, compact, somewhat hidden in between hind-quarters with firm attachment. Shape of udder is mostly trough (41%) followed by bowl (31%) and round (17%) shape. Udder texture is smooth and collapsible. Teats are cylindrical and squarely

Pandharpuri herd

placed. Mostly teat tips are rounded and sometimes pointed. Milk-vein is prominent. Animals are mild in temperament and easily manageable.

Morphometric and Performance Traits

Averages of body length, height and heart girth of Pandharpuri females are 132.9, 130 and 192.8 cm respectively. Male and female calves weigh 28±0.91 and 25.6±0.74 kg respectively. Overall birth weight is around 26.8 kg. Adult body weight of Pandharpuri females is around 416 kg. Average weight at puberty is 260 kg and at first conception 304 kg.

Pandharpuri buffaloes produce, on an average, 1,502 kg of milk in a lactation period of 330 days. Total lactation and 305-day milk yield average 1,197 and 1,142 kg, respectively, in first lactation. Milk contains about 7% fat and 9.28% SNF. These buffaloes have high reproductive efficiency and low feed intake. Averages of age at puberty, age at first conception, age at first calving, dry period, service period and intercalving period are 795, 945, 1,255, 144, 165 and 465 days respectively.

Breeding Farms

1. Zonal Agricultural Research Station, Kolhapur, Maharashtra

Contact Agencies

1. Department of Animal Husbandry, Maharashtra
2. Mahatama Phule Krishi Vidyapeeth, Rahuri, Maharashtra

SURTI

Synonyms: Charotar, Deccani, Gujarati, Nadiadi, Surati and Talabda

Origin and Distribution

THE home tract of Surti buffaloes is in the southwestern part of Gujarat comprising Kheda, Vadodara, Bharuch and Surat districts. The Surti buffalo is lighter in body weight, as compared to heavy breeds, consumes less feed, thrives well both on stovers and on limited or no green fodder, and produces milk with high fat and SNF content. It is popular with landless, small and marginal farmers.

The development of Surti breed received a major boost with the establishment of a Central Breeding Farm at Dhamrod in Surat district of Gujarat state in November 1968. The main focus of this farm is on genetic improvement of Surti buffaloes for milk production; testing bulls to make available proven sires and their distribution for breeding in the field; and production, storage and distribution of semen of proven sires.

The Indian Council of Agricultural Research initiated the All-India Co-ordinated Research Project on Buffaloes in 1970-71, and Vallabhnagar and Dharwar centres were identified for medium sized breeds, viz. Surti and Mehsana. Field units were also attached to these centres during the V Five-Year Plan. The emphasis was on production of superior sires through progeny testing by including both farm and field animals. In addition to this, a Reproductive Biology Research Unit was started during 1976 at the Gujarat Agricultural University, Anand, Gujarat, to study the endocrinological aspects of Surti buffaloes.

Breeding tract

Location and Topography

The breeding tract is located between 21° 12' and 23° 15' north latitude, and between 72° and 74° east longitude.

Soil

The breeding tract has a sandy loam type soil. Rice, maize, pearlmillet, tob-

Surti bull

Surti she buffalo

Surti calf

acco, cotton and groundnut are the major crops of this area.

Climate

Maximum temperature varies from 28° to 41°C and minimum temperature from 8.8° to 26°C. Annual rainfall is about 80 cm. Relative humidity varies from 58 to 92% in the morning and from 21 to 78% in the evening. Average wind speed is about 5.5 km/hr and average sunshine is 8.5 hr/day.

Management Practices

Majority of farmers maintain mixed herds of buffaloes and cows. Animal shed is mostly a part of human residence but some farmers provide separate house for these animals. About 50% of animal houses are of open type and the remaining 50% closed ones. Almost all houses have *kutcha* walls. Wallowing is practised only in 10% cases. As the performance is not recorded in the field except in certain villages around Anand, farmers by their experience have developed some techniques for selection of buffaloes. In the Surti breeding tract, buffaloes having bigger area of *chehra* (area between two pin-bones and hook bones) and medium soft skin are preferred over others.

Physical Characteristics

Coat colour of Surti buffaloes varies from rusty brown to silver-grey. Skin is black or brown. Animals are of medium size, having a straight back. Head is elongated, fairly broad and rounded (convex) between horns. Horns are flat, of medium length, sickle shaped and are directed downward and backward, and then turn upward at the tip to form a hook. Face is clean and sharply narrowed below eyes, with big nostrils and muzzle. Eyes are round and bulging. Ears are medium sized with reddish colour inside. Neck is long in females, and thick and heavy in males with white collar. There are two white bands (Chevron) below the neck. Udder is well developed, finely shaped and squarely placed between hind legs. Teats are of medium size and squarely placed. Tail is fairly long, thin and flexible ending in a white tuft.

Morphometric and Performance Traits

Average body length, height and heart girth are 142, 130 and 190 cm, respectively, in males, and 119, 125 and 184 cm, respectively, in females. Average birth weight of calves ranges from 24 to 30 kg for males and from 23 to 29 kg in females (overall average 25.2 kg). Weight at first calving is around 380 kg (range 315 to 415 kg). Adult body weight is around 500 kg in males and 383 kg in females. Age at first service is around 750 days (range 485 to 970 days). Average age at first calving is around 1,693 days (range 1,050 to 1,770 days). Total lactation milk yield and 305-day milk yield average 1,396.5 (range 1,208 to 2,203) and 1,065.3 (range 997 to 1,363) kg, respectively, in first lactation, and 1,285.4 (range 1,256 to 2,208) and 1,289.5 (range 1,110 to 1,292) kg, respectively, in overall lactations. Lactation length, dry period, service period and calving interval are 352.2 (range 280 to 373), 242.1 (range 212 to 289), 249.6 (range 92 to 316) and 584.6 (range 482 to 630) days, respectively, in first parity, and 344.7 (range 280 to 405), 185 (range 160 to 205), 142.6 (range 93 to 164) and 534.7 (range 430 to 564) days, respectively, in overall lactations. Number of services per conception ranges from 1.5 to 3.0 (average 2.8). Fat ranges from 7.5 to 8.3% which is slightly higher than that of other breeds mainly because of high proportion of fodder in the feed.

Breeding Farms

1. Buffalo Breeding Centre, NDDB, Nekarikallu, Andhra Pradesh
2. Government of Goa, Dhat
3. Central Cattle Breeding Farm, Dhamrod, Gujarat
4. Gujarat Agricultural University, Anand, Gujarat
5. Kaira District Co-operative Milk Producers' Union, Anand, Gujarat
6. Sabarmati Ashram Gaushala, Bidaj, Gujarat
7. Amul Research & Development Association, Ode, Gujarat
8. National Dairy Research Institute, Southern Regional Station, Bangalore, Karnataka
9. University of Agricultural Sciences, Dharwad, Karnataka
10. Buffalo Breeding Station, Tegur, Karnataka
11. Buffalo Breeding Farm, Thiruvazhun, Kerala
12. Government of Kerala, Kodapanakunnu
13. BAIF Development Research Foundation, Uruli Kanchan, Maharashtra
14. Cattle Breeding Farm, Hingoli, Maharashtra

Contact Agencies

1. University of Agricultural Sciences, Dharwad, Karnataka
2. Gujarat Agricultural University, Anand, Gujarat
3. Department of Animal Husbandry, Gujarat
4. Department of Animal Husbandry & Dairying, Ministry of Agriculture, Government of India, New Delhi

TODA

Origin and Distribution

THE Toda breed is known after its herdsmen, the Toda tribe of the Nilgiris. The native tract of these is the Nilgiris district of Tamil Nadu. Probably, due to genetic isolation, they developed into a fine breed of animals which could withstand the extreme climatic variations prevailing in the region. This is one of the important breeds of buffaloes other than Kaziranga buffaloes of Assam which thrives well in the high rainfall and high humid areas. The breed has attained pre-eminence not because of its milk producing capacity, but because of its association with all the cultural (ritual) activities of the Toda tribe. The Todas are responsible for the development of this breed from its original form to its present state. Other communities of the district, especially the Badagas, Kotas and Irulas who have been herding these buffaloes for several centuries, were also responsible for the development of this breed. Earlier it was thought that Toda buffaloes were of swamp type but karyological studies have established that they are of river type.

Breeding tract

Toda buffalo herds are distributed in all the 4 taluks of the Nilgiris, viz. Udhagamandalam, Gudalur, Coonoor and Kotagiri. Their distribution is uneven with varying densities. Herds maintained by Toda tribes are located mostly in the 'Wenlock downs', an area of about 50 km² of grassland lying immediately west of Udhagamandalam. A few herds owned by Kota tribes are also located in the Toda mainland. Several herds maintained by non-Todas are clustered around the Masinagudi area of Gudalur taluk.

The total population of Toda buffaloes, surveyed as in May 1994, was 3,531÷1,955 adult females, 12 males, 74 male and 621 female young stock, and 869 calves (321 males and 548 females). Todas herded 52% of Toda buffaloes and non-Todas the remaining. Average herd size in the Toda hamlets is 34 as compared to 16 buffaloes in non-Todas. Overall herd size is 22.

Toda bull

Toda she buffalc


Toda calf (fawn)


Toda calf (grey)

Location and Topography

The Nilgiri district is the smallest district of Tamil Nadu. It is spread over an area of 2,545.5 km² and is located between latitudes 11°15' and 11°30' north, and longitudes 76°15' and 77° east. The entire district is hilly, with an average elevation of 1,831 m ranging from 668 to 2,634 m above msl.

Soil

The predominant soil type in the plateau of the hilly terrrain is laterite derived from charnockites. The surface is generally covered by a layer of clayey soil. Soil is moderately fine textured ranging from clay loam to silty clay loam and silt loam. Water-holding capacity of soils is 50 to 60%. The pH of soil is between 4.5 and 5.9.

Climate

The Nilgiris is a high rainfall, high altitude region. Mean annual rainfall is 84 to 148 cm. Mean maximum temperature is 18.8° to 19.4°C and minimum 10.2° to 10.8°C. Average relative humidity is 81.5 and 67.9 % in the morning and evening, respectively. Average wind velocity is 4.4 km/hr (range 1.3 to 6.9 km/hr).

Management Practices

Calves and adults thrive solely on grazing. No supplementary feed is given. Normally, young calves were left out for grazing 3 weeks after birth. They are grazed in the vicinity of the hamlet and are not allowed to mingle with adults for the first 3 to 4 months

Toda calf (cream)

to prevent them from sucking. Usually young calves are led to grasslands a little later in the day. Adults are let out for grazing around 8 AM after milking. When calves are young, adults return to the hamlet by themselves for the evening milking. The grasslands of the 'Wenlock downs' predominantly consist of kikiyu grass (*Pennisetum clandestinum*) interspersed with white clover (*Trifolium repens*) and *hariyali* grass (*Cynodon dactylon).* Other wild grasses and weeds include *Oxalis corniculata, Amaranthus paniculatus, Centella asiatica, Sonchus branchyotus, Embelia gardeneria, Briza minor, Cotula australis* and *Pteridium aquilinum.* Fodder trees in the region are *Acacia melanoxylon*, *Dendrocalamus strictus* and *Celtis* sp. Young ones are sheltered in calf pens constructed as temporary structures using wooden stalks for the side walls and roof. The rest are normally kept in an open pen during the night, but occassionally in a circular enclosure of uneven floor with unhygienic conditions without roof.

Toda buffaloes, maintained for years in the remote northeastern borders of the district where summer temperature exceeds 30° C, shed their body coat and take to wallowing in summer, whereas buffaloes dwelling continuously in hills grow thick hair on their body. Wallowing is not normally observed in these buffaloes; occasionally they submerge themselves in small puddles in marshy areas. These changes in Toda buffaloes (growth or loss of hair coat and wallowing) appear to be transitory and habitat related and not a permanent one.

Physical Characteristics

Coat colour of the calf is generally fawn at birth. Other coat colour variations are grey, light grey (cream) and dark grey (blackish-grey). In growing calves, at about 2 months, the fawn colour changes to ash-grey. The change in colour starts at the skin end of the hair and continues in the direction of the free end. In adult cows, the predominant coat colours are fawn and ash-grey. A few cream-coloured animals are also seen. Face, neck and anterior half of the body of adult cows are thickly covered with hair. In the posterior half hair are sparcely distributed. A narrow band of dense hair covers the topline from the crest of neck to the point of origin of tail. This band consists of black hair or an admixture of brown and black hair in most calves with fawn coat. Cream to dull white hair cover belly, groin, inside of thigh and leg regions. Occasionally a band of white or brown hair fully encircle the leg forming a ring in the pastern. In ash-grey adult females, head and face are darker in shade and in males it is still darker. In some animals two characteristic chevron markings are present, varying from dull white to brown- one just around the jowl and the other anterior to the brisket.

Toda buffaloes are medium sized. Body is fairly long with a broad and deep chest. Head is large and heavy, and carried to the level of the body. Forehead is broad, convex in calves and concave in adults. There is no hump. Ears are held horizontally. Muzzle and eyelids are black.

Horns are long (55 to 70 cm), variable in shape, and of slate colour. They are usually set wide apart, outward, slightly downward and upward with the points being recurved inward, forming characteristically a cresent shape or semicircle. Distance between horns at mid point is approximately 52 to 65 cm, and between tips 39 to 53 cm. Horns are thick at the base (20-21 cm), and tapering and sharp at the tip (3.6 to 4.0 cm). They are marked by concentric rings, running across them. In old females and males, these rings when viewed from the front appear as distinct pockets of depressions.

Legs are short, strong and sturdy. Hooves are black. Dewlap is absent. Navel sheath is small. Penis sheath flap is medium sized. Tail is long (70 to 75 cm) and slim,

Toda herd

extending beyond hock joint. Switch is black. Udder is not so prominent and is round. Teats are cylindrical and round at tip. Milk-vein is not prominent.

Morphometric and Performance Traits

Average body length, height at withers, chest girth, face length, face width and ear length of Toda buffalo cows measure 132.7±0.08, 121.8±0.56, 180.4±1.14, 40.79±0.34, 22.12±0.16 and 20.98±0.16 cm respectively. Average skin thickness is 7.53±0.18 mm. Mean birth weight of Toda buffalo calves is 27.9±0.43 kg. Birth weight of male and female calves is almost the same (27.9 vs 28.0 kg). Mean body weight at 6 months of age is 65.67±3.84 kg and at 9 months 67.00 kg.

Age at first calving varies from 1,200 to 1,400 days. Toda buffaloes produce around 500 kg of milk in a lactation of about 200 days. The mean fat is 8.22±0.08% and protein 4.45±0.12%. Calving interval is around 480 days (range 425 to 550 days). Average carcass weight was 27.17±3.94 kg in calves, 50.83±6.83 kg at 1.5 to 2 years, 69.00±7.50 kg at 2.5 to 3 years, and 142.13±10.10 kg in adults.

Contact Agencies

1. Tamil Nadu Veterinary and Animal Science University, Chennai, Tamil Nadu
2. Department of Animal Husbandry, Tamil Nadu

□

7 LESSER KNOWN STRAINS

INDIA had about 204 million cattle and 84 million buffalo population during 1992. Only 20% of these animals have been classified as recognized breeds and the rest are generally called non-descript. Thus almost 80% of the animals have either not been evaluated properly and assigned to a specific breed or their characteristics have not been fixed to qualify for a breed. Majority of these animals play an important role in the economy of the region in which they are present. These animals are known by some names in their breeding tract. They may be strains/types of the already described breeds but now are known by different names possibly because of slight variation in physical characters due to their adaptation to a particular agro-climatic region. Most of these animals are known after the name of the region in which they are reared. Some of the strains have been synthesized by crossing indigenous animals with exotic breeds. These are mostly known by the combination of names of the place of their origin and the breeds involved in their formation. Some of these find their names in literature but overall very little documentation is available on the characteristics of these strains/types. These lesser known breeds are described in the following pages.

CATTLE

Sporadic information on the various lesser known breeds have been available in the literature in different parts of the country. Some strains of cattle which are not recognized as breeds have been reported by Maule (1990), Mason (1996), and Payne and Hodges (1997).

Alambadi

Alambadi bulls are dark grey, almost black and cows grey or white (broken coloured). They have the typical backward curving horns of Mysore type cattle. They are active, useful draught animals but not fast trotters. Cows are poor milkers. This type of animals are used for draught purposes. They are found in hilly areas of Coimbatore district in Tamil Nadu and in Bangalore district in Karnataka State. Alambadi animals resemble Hallikar breed and seem to have originated from the latter.

Bengali

These are small cattle found in West Bengal, India and Bangladesh. Bengali is also known by the name Chittagong Red in Bangladesh.

Binjharpuri

Binjharpuri cattle have been evolved after 6 generations of upgradation of local cows with Hariana bulls and are distributed in Jajpur sub-division of Cuttack district of Orissa (Sahoo and Mishra, 1990). The climate in the breeding tract is hot and humid. Temperature ranges from 13.8° to 41.5°C. Average relative humidity varies from 74 to 80% and rainfall from 2 to 27 cm. These cattle constitute about 27% of the total cattle population of Cuttack district. Binjharpuri cattle are grazed along the river and canal sides. They are tied in the open at night. Thatched housing is provided only during rainy season and adverse weather conditions. Concentrate is fed only to milch cows and bullocks.

Body is more or less proportionate and compact, and it is moderately long with a graceful appearance. Adult cows are whitish to grey, while bullocks and bulls show dark colour around their eyes and in the region of face, neck, hump and quarters. Calves at heel are white with reddish colour in polar and forehead region. In some calves, the red colour extends along the top line from the poll to base of the tail. However, with increase in age the body colour changes from white to whitish grey and the red colour disappears completely. Head is medium and is carried high. Face is moderately long and narrow with flat to slightly dished forehead. Horns are broad at the base and short at early age. Adult animals have medium to large horns which are broader at the base, tapering outward, upward and slightly inward at the tip. Crest bone at pole is small and not prominent. Ears are medium, sharp and slightly pendulous. Muzzle is black with pinkish patch at the centre or at its lower region towards the upper jaw. Neck is thin and somewhat long. Dewlap is of medium size and slightly pendulous. Hump in cows is medium, being large and massive in the bull. Sheath is short, navel flap is absent. Legs are moderately long and lean. Pin bones are prominent and wide apart in female but relatively close in male. Tail is long, thin and tapering, reaching slightly above the hock with completely black switch extending well below the hock. Frequently the black switch has an admixture of white and brown hair (Sahoo and Mishra, 1990).

Average birth weight is 18.23±0.36 kg in male calves and 14.68±0.34 kg in female calves. Average adult body weight is 402.9±2.82 kg in males, and 334.0±4.07 kg in females. Average body length, height and heart girth are 146.5±0.67, 137.9±.02 and 172.5±0.58 cm, respectively, in males, and 130.3±7.90, 133.7±4.78 and 144.8±7.70 cm, respectively, in females (Sahoo and Mishra, 1990).

Binjharpuri cattle are reared for their draught capacity. A pair of Binjharpuri bullocks weighing 645.65±11.04 kg and working @ 8 hours a day ploughed 4,469.67±69.37 m^2 with a ploughing capacity of 599.43% in terms of their body weight. They pulled a total load (cart + load) of 2,279.16±19.90 and 1,395.83±17.90 kg with a carting capacity of 305.66 and 187.19 % of their body weights with a speed of 6,125.00±132.22 and

3,729.17±111.37 m/hr in plain *pucca* and undulated *kutcha* roads respectively (Sahoo and Mishra, 1990).

Frieswal

This strain has been developed at military dairy farms by crossing the exotic Friesian with indigenous Sahiwal and maintaining the exotic inheritance at 3/8 to 5/8 level. The total strength of Frieswal female cattle at various miliary farms is around 5,000 with 1,200 breedable females.

Animals of this breed are mostly black and white or brown and white. In very few cases total brown to black individuals are found. Muzzle is black. Face is slightly convex. Body is deep having clear wedges as dairy character. Hump is almost absent. Dewlap is small and thin. Navel flap is also very small. Udder is very well developed with firm attachments and is above the hock. Sheath is small and tight in males. Teats are small and cylindrical. Tail switch is white or black.

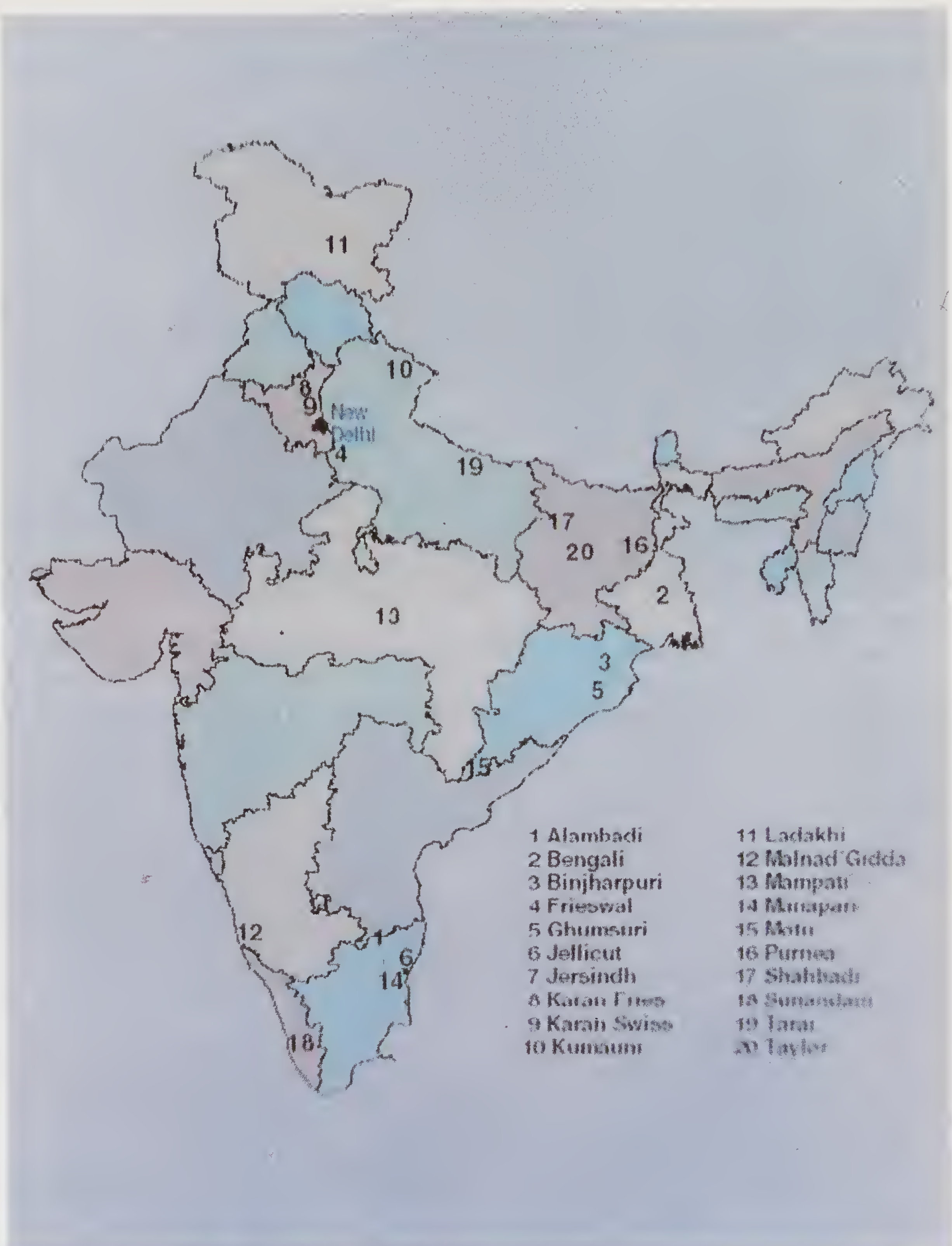
Age at first calving, service period and calving interval average 923.8, 169.2 and 443.8 days respectively. First lactation milk yield, overall lactation milk yield, lactation length and dry period average 2,926.4 kg, 3,323.3 kg, 340.9 days and 122.3 days respectively.

Ghumsuri

Ghumsuri cattle are distributed in Ghumsur sub-division of Cuttack district in Orissa. The temperature in the breeding tract varies from 15° to 35°C, humidity from 73 to 81% and rainfall from 20 to 86 cm. Almost all cattle in this tract belong to Ghumsuri type. These cattle are reared on grazing alone, and are fed paddy straw and green grass in rainy season when they cannot go out for grazing. Animals are kept in the open or under tree shade for most part of the year. These cattle are used for draught purposes.

Cows are silver-grey in colour, bullocks are white and bulls are silver-grey with dark colour from hump through neck to head region. Calves at birth are white in colour changing to silver-grey with age. Head is small, with forehead being flat, broad and depressed in between the eyes. Neck, particularly of bullock, is moderately thick and muscular and somewhat long and lean. Muzzle and hooves are deep black. Horns are medium in size, emerging from the poll, coming upward and inward on either sides. Ears are medium in size and tubular in shape. Dewlap is thin and short. Skin, sheath and navel flap are tight. Fore- and hind- quarters, particularly of bullocks, are medium in size and well proportioned with strong knee, hock, fetlock and pastern joints with rounded hooves. Udder, teats and milk-vein are ill developed (Sahoo and Mishra, 1989).

A pair of bullocks weighing 432.5 kg and working @ 8 hours a day ploughed 3,879.17±76,73 m^2 with an efficiency of 897.00% of their body weight, and pulled cart loads of 1,125.00±167 and 789.28±12.87 kg, i.e. 260.11 and 182.56% of their body



Distribution of lesser known cattle strains weights, in plain *pucca* and undulated *kutcha* roads with a speed of 5.348±0.656 km/hr respectively (Sahoo and Mishra, 1989).

Jellicut

These animals are found around Chennai, South India and are of little importance. The population is very small and no information on their production performance is reported in the literature.

Jersind

This name was given in the 1950s to a cross between the exotic Jersey and the indigenous Red Sindhi, made at the Allahabad Agricultural Institute, Naini, Uttar Pradesh. At that time these crossbred cows gave substantially more milk than the indigenous Red Sindhi and showed promise of becoming a useful dairy breed. First lactation milk yield of Jersind cows varied from 1,377 to 1,894 kg and lactation length from 338 to 491 days (Prasad and Pereira, 1985). However, the numbers involved were probably too few to consolidate the early success, and there has been little or no recent information about the Jersind. This crossbred could never get established. They have almost come under threatened category.

Karan Fries

The Karan Fries is a dairy type animal developed at the National Dairy Research Institute, Karnal, by crossing the exotic Friesian with Tharparkar breed. The strain is similar to Frieswal but Tharparkar is the zebu breed in this case instead of Sahiwal.

Animals of this breed are black and white or dark brown and white. A few animals have complete black or brown colour. Muzzle is black. Ears are short. Head is straight. Forehead is flat. Eyes are full. Body is deep with wide rib cage. Rump is wide. Dewlap is small. Udder is well developed with centrally placed teats. Teats are medium in size. Tail switch is either black or white.

Average birth weight is 29.5±0.52 kg (range 13 to 41 kg) for males and 26.3±0.64 (range 7 to 42 kg) for females. Adult body weight is 696.5±19.52 kg (range 600 to 960 kg) in males and 420.2±4.62 kg (range 300 to 600 kg) in females. Average body length, height and heart girth are 149.7±0.51 (range 126 to 181), 139.0±0.32 (range 115 to 144) and 181.1±0.70 (range 153 to 209) cm, respectively, in cows.

Average age at first calving, service period and calving interval are 1,039.9 (range 745 to 1,462), 143 (range 42 to 389) and 398.5 (range 111 to 579) days respectively. First lactation milk yield, lactation milk yield, lactation length and dry period average 3,547.4 kg, 3,873.7 kg, 310.8 days and 74 days respectively.

Karan Swiss

This is another dairy type crossbred strain developed at the National Dairy Research Institute, Karnal, using the exotic Brown Swiss semen on Sahiwal and Red Sindhi

Karan Fries cow

Karan Swiss cow

cows. The exotic inheritance has been maintained around 50%. Animals of this strain vary from light grey to deep brown. Face is flat or slightly concave. A white band is present on muzzle and upper eyelid. Eyes are full, and ears are small and hairy from inside. Barrel is long and deep. Navel flap is generally tight. Hip-bones and pin-bones are wide apart. Rump is long. Tail is below the hock and sometimes touches the ground. Skin is tight with fine hair coat. In males sheath is tight and rudimentary teats are common. Udder is deep and wide, bowl shaped; teats are medium sized, cylindrical with round or pointed tips. Milk-vein is very well developed.

Birth weight varies from 15 to 49 kg averaging 37.6±0.66 in males and 30.4±0.56 kg in females. Adult weight is 720±45.83 kg (range 630 to 740 kg) and 429.8±16.77 kg (range 250 to 570 kg) in males and females respectively. Averages of body length, height and heart girth are 148.9±0.9, 127.2±0.5 and 175.8±0.9 cm, respectively, in females, and 151.3±4.3, 136.8±2.7 and 189.8±4.1 cm, respectively, in males. Age at first calving, service period, calving interval and number of services/conception average 949.1 days, 104.6±3.3 days, 404 days and 1.8±0.1 respectively. First lactation milk yield, lactation milk yield, lactation length and dry period are 2,860 kg, 3,228 kg, 325 days and 75 days respectively.

Kumauni

These are small cattle with a compact body and powerful short limbs. Coat colour is jet black, or pale to dark red with white patches. Head is long and horns are short. These cattle have been named after their habitat, i.e. Kumaun hills of northern Uttar Pradesh. Climate in the breeding tract is sub-tropical. Hump is almost cervico-thoracic in position. As the hump is almost cervico-thoracic in position and blood group studies suggest a different origin (Singh, 1945) from other Indian breeds, these cattle might have evolved from crossbreds. Kumauni cattle are poor milkers and are used for work and production of manure.

Ladakhi

A local variety of the Indian hill cattle found in the Ladakh region of Jammu & Kashmir. No information on their production performance has been reported in the literature.

Malnad Gidda

Cattle found in coastal areas and Malnad district bordering the coastal area in Karnataka state are known as Malnad Giddas. These cattle cannot be classified into any breed. Majority of them have dark coat. They are small in size but have extraordinary power of endurance for climatic variation and are resistant to many diseases. These cows calve for the first time at about 39 months of age. Malnad Gidda cows produce about 218 kg of milk in a lactation period of about 250 days. Performance records at the District Livestock Farm, Koila, Karnataka, showed that average age at first calving for these cows was 1157.7±175.34 days, milk yield 218.3±6.15 kg, lactation length 249.6±3.85 days, dry period 141.7±8.95 days, service period 100.4±8.72 days and calving interval 403.8±7.52 days (Hegde *et al.,* 1978).

Mampati

This is a minor local type found in Madhya Pradesh with very little contribution to the economy of the farmers. No work on their performance and status has been reported in the literature.

Manapari

This is a cross between Kangayam and a local type found in Chennai, Tamil Nadu, India. Their population is very small and no information is available on their performance.

Motu

Motu cattle are distributed in Malkangiri sub-region of Koraput district of Orissa. They are also found in Khanta block of Madhya Pradesh and border areas of Andhra Pradesh. Temperature in the breeding tract varies from 7°C in December to 37°C in May. Relative humidity ranges from 61% in March to 91% in August and rainfall from 0.7 cm in January to 79 cm in August. The climate is pleasant. Almost all cattle in the breeding tract are of Motu type. These cattle are used by Koyya tribe for ploughing and carting. The animals are kept in open, together about 30 to 40 cattle tied around their neck. They strive on grazing alone.

Motu cattle are dwarf, small and compact having red coat colour intermixed with white spots in the regions of chest, abdomen and dewlap. Males show darker colour in the regions of hump and neck. Bullocks also show such darkness, which might be due to late castration at 1-12 years of age. Hair coat is thick throughout the body, being prominent in the regions of neck and thigh. Calves at birth are brown and they change to red colour with age. Head is small with forehead slightly dished. Nasal bridge is short. Muzzle is black. Eyes are bright, ears tubular, and horns very rudimentary or stumpy. Dewlap is thin and short, and skin, sheath as well as navel are tight. Legs are short with deep black rounded hooves. Tail is thin and long with black switch stretching up to the pastern. Udder is poorly developed with small teats (Panda and Mishra, 1990).

Average birth weight is 8.73±0.61 and 6.55±0.39 kg in male and female calves respectively. Body weight at 5 to 5.5 years is about 160.7±0.60 kg in males and 152±0.94 kg in females. Average body length, height and heart girth are 109.5±5.20, 104.3±5.20, 123.0±0.54 cm, respectively, in males, and 98.2±5.98, 96.1±2.03, 121.6±0.76 cm, respectively, in females. A pair of Motu bullocks weighing 369.22±7.91 kg and working @ 8 hours per day ploughed 2,564.29±0.74 m^2 with a ploughing capacity of 694.51% of their body weight and pulled cart load of 1,264.00±32.14 and 996.42±41.05 kg with a carting capacity of 342.34% and 269.87 % of their body weight in plain *pucca* and undulated *kutcha* roads with a speed of 4,750.00±86.95 and 2,321.43±44.71 m/hr respectively (Panda and Mishra, 1990).

Purnea

A small black or red hill type cattle found in north-east Bihar. These are similar to Morang cattle of Nepal. The name appears to be derived from the place of its origin, the Purnea district.

Shahabadi

The Shahabadi cattle belongs to the group of short horned white or light gray cattle. This is similar to Hariana and is also known as small Hariana and Gangotari. These cattle are found in the Gangetic plains of Shahabad and Saron districts of Bihar and some parts of eastern Uttar Pradesh. This breed also seems to be derived by the upgrading of local cows with the Hariana. Cows produce about 645 to 895 kg of milk in a lactation period of about 225 to 235 days. Age at first calving ranges from 42 to 53 months. Calving interval is about 14-15 months.

Sunandini

This breed has been developed by the Kerala Livestock Development Board (KLDB). The origin of Sunandini can be traced to the importation of 22 Brown Swiss bulls and 45 cows during the period from 1964 to 1967. The bulls were mated to a nucleus stock of 140 non-descript cows. Subsequently, semen from 11 more bulls was imported. About 40 Jersey bulls of Australian or New Zealand origin were also used in crossbreeding programme. The KLDB later imported two consignments of exotic bull semen for the production of F1 bulls. These include Jersey, American Brown Swiss and Holstein (Chacko, 1994).

Breeding policy for Sunandini was redefined taking into consideration the recommendations of the Committee to Evaluate and Formulate Breeding Programmes and policies in the state of Kerala. The present policy is aimed at creating a new synthetic breed out of a crossbred population with exotic inheritance of around 50% from Jersey, Brown Swiss and/or Holstein. Young bulls are produced by mating superior Sunandini cows maintained in the nucleus farm with proven bulls, mating superior Sunandini cows maintained by farmers in the milk recorded areas with proven Sunandini bulls, and mating local non-descript zebu cows with superior Jersey/Holstein or American Brown Swiss bulls. All the young bulls are progeny tested in the milk recorded area and only the top bulls are used for the production of next generation of bulls. There are more than 2 million Sunandini cattle in Kerala.

Phenotypic appearance of Sunandini is heterogenous. Colour varies from different shades of grey to brown. The only phenotypic characteristic that can now be considered typical to Sunandini is the straight back and comparatively short flat head.

Average birth weight of male calves is 30.4 kg and that of female calves 28.3 kg. Adult male and female weigh about 547 and 375 kg respectively. Average height and hearth girth are 128 and 189 cm, respectively, in males, and 120 and 163 cm, respectively, in females. Average age at first calving, milk yield, lactation length and fat are 32.2±0.19 months, 2,435±24.2 kg, 279.8±1.05 days and 3.89±0.01% respectively.

Tarai

This is a lyre horned, white or grey variety of the Indian hill cattle found in north-east Uttar Pradesh. These cattle have probably some blood of Hariana and Tharparkar catttle. They are used mainly for draught; milk yield is low. Cows weigh 270-370 kg.

Taylor

The Taylor is the first crossbred strain developed in the country. It is found in Patna, Bihar and is known after the name of the person responsible for its origin. In 1856 Mr Taylor, the then Commissioner of the district, imported four bulls believed to be Shorthorns or possibly of Jersey or Guernsey breeds. A crossbred strain was evolved by crossing these with the local zebu cows. This became gradually acclimatized and it proved to be a useful milker, giving 5-6 kg milk per day, and exceptionally as much as 15-20 kg per day.

Cows are red, brown, black and white or brown and white. They have no hump. Animals of this type are rarely found now.

BUFFALOES

Rao (1984) described some draught buffaloes found in various parts of India as different breeds. However, detailed studies are needed to evaluate these buffalo populations so that either they can be established as distinct breeds or merged with already known breeds. These buffalo breeds/strains are described below.

Assamese/Mongoor

This is a medium-sized animal. Face is conical with broad forehead. Horns are small and flattened at the base, round, triangular in the middle, pointed at the tip and they run upward and backward. Body is generally black and densely covered with hair. Milk yield is low.

Godavari

Godavari buffaloes are believed to have originated from crossing of native buffaloes with Murrah bulls. The main breeding tract of these buffaloes lies in East and West Godavari districts of Andhra Pradesh. These are found in Tanuku, Bhimavaram, Narasapur, Ramchandrapuram, Kothapeta and Alamuru taluks; parts of Tadepalligudem and Kovvur taluks and Krishna deltaic areas of Gudlavalluru, Gudivada, Avanigadda, Kankipadi and Vuyyura taluks (Bhat and Taneja, 1987). Soils in the Krishna-Godavari zone are mainly deltaic alluvial and black. Some parts have red sandy soils. This region has humid to sub-humid climatic conditions, characterized by heavy rains during September-October. The temperature touches 44° to 45°C during summer. Relative humidity is high (95 % or more) in the coastal districts. The animals are medium statured with compact body. Colour is predominantly black with a sparse hair coat of coarse brown hair. Head is clean cut with a lean face, convex forehead and prominent bright eyes. Horns are short, flat, curved slightly downward, backward and then forward with a loose ring at the tip. Chest is deep with well-sprung ribs. Barrel is massive and long with straight back and a broad level rump. Udder is medium in size and mostly bowl shaped. Teats are cylindrical in shape. Tail is thin and extends below the hocks with or without a white switch.

Average body length, height and heart girth is 143, 128 and 192 cm, respectively, in female buffaloes, and 151, 143 and 204 cm, respectively, in male buffaloes. An

Godavari she buffalo

adult male and female weighs around 520 kg and 452 kg respectively. Average age at first calving, peak yield, lactation length, dry period, service period and calving interval are 44.2±0.37 months, 9.3±0.19 litres, 417.9±8.80 days, 149.0±4.68 days, 266.0±10.37 days and 570.2±10.66 days respectively (Kumar, 1990). The best animals even produce about 2,000 litres in a lactation. The animals are hardy and possess good resistance against majority of the prevailing diseases.

Jerangi or Zerangi

These buffaloes are found in Jerangi hills in Ganjam district of Orissa and northern parts of Visakhapatnam district of Andhra Pradesh.

This is a small-sized buffalo and has a maximum height of just 114 cm. It has a short face, small barrel and very short tail, not exceeding 46 cm. Skin is thin, horns conical, small and run backward. Colour is black. These buffaloes are very useful for ploughing in water-logged paddy fields. A pair of males can pull one and a half cart load easily. They cannot withstand high temperature as their body colour is dark.

Kalahandi/Peddakimedi

This is known as Peddakimedi in the eastern hill regions of Andhra Pradesh and as Kalahandi in the adjoining areas of Orissa. These buffaloes were brought and bred by Peddakimedi people of Kalahandi Samsthan of Orissa, and are named after them.

The usual colour is grey or ash grey with medium long tail ending in a white switch. Forehead slightly protrudes forward, horns are broad and set apart, half curved and run backward. Eyes are prominent and large without narrow red margin around the lids. Neck is round and forequarters large and well developed. Chest is wide and distinct. Flanks are flat and broad. Kalahandi buffaloes can tolerate sun heat better than the black-coloured buffaloes because of their light colour. Its feed costs are low and water needs less. The animal is of docile temperament but quite hardy in work and good for draught purpose to carry heavy loads on to the hill tops. The male buffaloes are particularly used for ploughing paddy fields on plains and pulling carts in towns. These buffaloes are used mostly for crushing sugarcane. Milk yield is medium but the cost of production is low.

Kujang

Buffaloes present in Cuttack district of Orissa are known as Kujang buffaloes. These are distributed in eight blocks and two NACs of Jagatsinghpur sub-division of this district. This area has hot and humid climate with temperature ranging from a minimum of 13.8°C in winter to a maximum of 41.5°C in summer. Average relative humidity ranges from 72 to 80% and rainfall from 2 to 27 cm. About 16% of the total buffaloes of Cuttack district are of Kujang type. These buffaloes are grazed along the river and canal sides during day time and are tied at night in the outskirts of villages along the river or canal side. Concentrate mixture is fed to lactaing buffaloes along with paddy straw prior to milking in the morning and evening.

The body is of medium size and relatively less compact, tending to be loose. It is moderately long. The calves at heel are brown with longer hair on the body. With increase in age the brown colour changes to brownish black appearing first in head, neck and wither, subsequently spreading over the entire body. The body coat hair also become shorter with age. Adult buffalo cows are brownish black (brownish hair on light black skin). However, buffalo bulls and bullocks show relatively darker colour around the eyes and in the region of face, neck and wither. Skin is soft, smooth and loose. White markings are noticed frequently in switch followed by forehead and legs. Very rarely such markings appear on face and muzzle. Head is relatively longer and heavier. Forehead is dished with slight longitudinal central depression. Horns are long and loosely curled extending backward, upward and inward. Ears are tubular, slightly elongated, laterally disposed and alert. Muzzle is black. Neck is relatively longer and heavier. Brisket is prominent. Hump and dewlap are non-existent. Hips are broad and quarters are drooping. Limbs are long and slender. Hooves are small and moderately broad. Switch is invariably white extending nearly mid-way below the hock and fetlock. Udder is medium sized and squarely placed. Hind quarters of udder are usually larger than the forequarters. Milk vein is less prominent (Dash and Mishra, 1990).

Average adult body weight is 520.3±5.35 kg in males and 405.0±2.67 kg in females. Average body length, height and heart girth are 143.7±1.07, 130.3±0.75 and 198.0±1.34 cm, respectively, in males, and 133.8±0.61, 125.0±0.84 and 181.41±0.88 cm, respectively, in females. Average age at maturity and at first calving in Kujang buffaloes are 1,246.4±33.7 and 1,563.6±33.4 days respectively. Average daily milk yield is about 3 kg and lactation yield about 915 kg (Dash and Mishra, 1990).

Manda

Herds of Manda buffaloes are found around Kakriguma, Laxmipur, the hills of Damanjodi, the Patraput area and the Petta hills near Jeypore, Gupteswar, Jolapur, Balimela, Pedabial and the Arku Valley hills of Koraput district in Orissa. The owners move to different areas with the herd in search of pasture, water and shade. These animals are found on hills 3,000 to 1,050 m above msl, graze in deep forests of the hills and come down to the foot-hills at the onset of winter (around November). The number of these buffaloes is decreasing gradually (Patro and Kornel, 1987).

Body colour is mostly ash grey and grey with copper-coloured hairs. Mice-black and silvery animals are sometimes seen in herds, but such animals are not used for breeding by the owners. Yellowish tufts of hair on the knees and fetlock are always present. Horns are broad and emerge slightly laterally, extending backward and inward in females; in males horns remain apart permitting the gait of the yoke to be positioned.

Distribution of lesser known buffalo strains

This may be due to conscious selection of the owners. Forehead is flat; muzzle is short; and jaws, nostrils and backbone are prominent. Horn length is around 56 cm. Limbs are strong and stout. Collar bones and ribs are strong. Chest is wide and spacious, heart girth is more than the paunch girth in males.

Average body length, height at withers, heart girth and paunch girth are 115.42±2.723, 124.46±1.851, 174.50±3.330, 212.56±5.031 cm respectively.

She-buffaloes yield on an average 1.5 litres of milk/day on a single milking basis. Animals yielding up to 4 kg of milk/day are also found.

These buffaloes are reared only on grazing. They are semi-wild under forest grazing conditions but are docile when reared in villages. Only newborn calves (up to 10 days) are provided some type of housing otherwise no housing facilities are provided. Calves are allowed to suck the dams all the time except during night. Breeding bulls are inducted in the herd after the rainy season (September) and retained there until the end of winter season (February). Therefore, most of the calvings occur in the rainy season. Cows with sucking calves are not bred because milk yield stops shortly after conception.

The bulls are chosen for breeding at 2-tooth age and allowed to continue until 4-tooth age. Good and exceptional bulls are kept up to 6-tooth age. After the breeding period, bulls are removed from the herd and kept out in a village. Those which are no longer wanted for breeding are sold out as bullocks at a very high price. Selection of the bulls is done by considering the thickness of cannon bone, pastern, stifle, knee and hock joints. A large, black and strong hoof is a must. Besides this, body colour, fore- and hind-quarter conformation, horn shape, straightness of the back and pasture are also considered. Manda bullocks are famous for longevity, hard work and length of working life. These buffaloes are very good for carrying heavy loads in hilly tracts and for strenuous agricultural work.

Paralakhemundi

Paralakhemundi buffaloes are found in Paralakhemundi and Gunpur area of Orissa and around Mandasa, Bobli and Srikakulum of Andhra Pradesh, mostly in the down hill plains of eastern ghats (Patro and Kornel, 1987). The marketing centres of these buffaloes are the cattle fairs in Ganjam and Vishakapatnam districts. These animals are reared on the natural herbage in jungles and are brought down to the plains in large herds for sale through auctions. These buffaloes are hardy, heat resistant and live on roadside grazing with straw supplementation.. These animals can thrive in diversified conditions.

Littlewood (1936) and Narayana Reddi (1939) named the buffaloes in Paralakhemundi part of Ganjam district as Manda, while Kaura (1952) called these animals as Paralakhemundi. Rao (1981) observed the chromosome number of buffaloes

Paralakhemundi she buffalo

in coastal Orissa to be 2n = 48, which is different from that of riverine buffaloes. Bidhar *et al.* (1986) also found chromosome number of Paralakhemundi buffaloes to be 2n = 48 and classified these buffaloes as swamp type.

The usual colour varies from blackish grey to grey with brown hair, and sometimes grey hair on the skin. Calves are born with light red-silver-grey and mixed fawn colours. Horns are long (around 53 cm), broad and semicircular, extending backward and inward. Head is narrow, forehead is flat, muzzle is short and nostrils are wide and prominent. Neck is short and thin. Abdomen is large and spacious. Chest is wide. Legs are short, stout and comparatively thin. An arch-like curved white ring around the chest is found in some animals. It varies from locality to locality.

Average body length, height at withers, heart girth and paunch girth are 114.69±2.167, 122.89±1.470, 184.48±3.952, 205.62±4.520 cm respectively. Paralakhemundi buffaloes mature at around 2.5 years and calve almost every year. These animals start calving in September and continue until January, but most of the calvings occur during November.

These are essentially excellent draught buffaloes. Animals are slow moving but do an unmatchable job of heavy hauling, especially the pudding operations in heavy soils known for paddy cultivation. Bullocks are docile and slow, and can carry heavy loads and plough in paddy fields in hot sun. Females yield about 3-4 kg of milk per day on an average but females yielding up to 7 kg/day are known. The lactation period continues for more than 300 days if conception does not take place. Bulls are preferred to bullocks because of the supremacy of their draught value for agricultural operations.

Sambalpuri/Kimedi/Gowdoo

The breeding tract of this buffalo is referred to be the Sambalpur area of Orissa. Nevertheless, these buffaloes are also found around Bilaspur district in Madhya Pradesh, from where the calves are brought by Gowdoo herdsmen (hence the name) to Sambalpur. They are reared and then sold in cattle markets in Visakhapatnam and East and West Godavari districts of Andhra Pradesh in the name of Kimedi buffaloes.

Body is black, but brown and ash grey specimens are not uncommon. The animal is quite large, powerful, having long and narrow barrel; and prominent, broad and flat forehead. Neck is narrow and thin in females and in castrated males. Fore-quarters are shallow, and less developed than hind quarters. Horns are short, narrow, curled in a semi-circular fashion, and extend backward, upward and then forward ending in pointed tips. Tail is long and narrow with a white switch. In well-maintained stocks where normal feeding and management are taken care of, these buffaloes do calve regularly with fairly good quantity of milk than any other breed in the region with a daily average of over 7 kg in good milkers. Narayan Reddi (1939) reported an average milk yield of 2,270-2,720 kg in 340-370 days lactation period. Males are known for their fast running and heavy carting, but they cannot work for long hours in hot summer.

Sambalpuri she buffalo

Sikamese

This is a very small sized hill buffalo of the State of Sikkim. It weighs just 250-400 kg. These are hardy animals with compact, thick, black or grey coat. The buffalo is a poor milker.

South Kanara

This is a famous medium built breed around Mangalore region on the west coast owned by a sect of Hindus known as Jain Banto (Cockrill, 1974). These animals are active, fast moving, hardy and have got particular significance during the local festivities. These animals are used for race in water-bound fields as a part of annual sports race. Males are popular in wet-land agricultural operations.

These buffaloes are also known as Kanara, Kanarese and Malabar. These buffaloes are medium sized and well built with medium size, curved and flat horns projecting backward, sideward and downward at the neck region. Chromosomal complement is typical to that of river buffaloes (2n = 50).

Swamp

The buffalo population of Assam is basically swamp type. These buffaloes are hardy and quite adapted to the local warm humid conditions of the region. They live mostly on naturally available feeds and fodder which comprised aquatic, semi-aquatic, hill and highland grasses. These buffaloes are used by the farmers both for milk and work. Animals are suitable for many agricultural activities particualrly in low lying water merged areas for ploughing paddy fields. It is preferred for prepartion of curd, *ghee*, etc. because of higher fat percentage in milk, which fetches high price.

Climate of Assam is characterized by high rainfall and high relative humidity. Average maximum temparature ranges from 24.6°C (January) to 35.4°C (June) and minimum from 7.3°C (January) to 23.3°C (August).

Swamp buffaloes of Assam are reared under three systems of management, viz. semi-domesticted, nomadic and settled. In semi-domesticated system, buffaloes are let loose so that they can graze freely in the jungles to feed on the grasses, shrubs and leaves. Animals are practically wild except that they return in the evening for shelter and whatever little care is provided by the owner. In nomadic system, animals are grazed and moved year round from place to place in search of fodder growing land. In this system, animals are usually reared in large herds and during their transit, temporary camps called "*khutis*" are set up for the shelter of the animals. *Khutis* are shifted from place to place according to fodder availability and also to protect animals from natural calamities like flood or draught. In settled system, buffaloes are reared as small individual holdings in the farmers house either in intensive or in semi-intensive manner. Usually, swamp buffaloes spend most of their day time by wallowing in muddy water or beneath the trees, and graze during morning time in winter and evening time in summer.

Body colour of the swamp buffaloes is primarily black with varying shades from dark slaty gray to black. Skin colour is light black to slaty black. Albinoids are also found. Horn pattern is characteristic, essentially macrocerous being nearly straight and turning at the ends. Spirocerous type of horn - curving upwards to form a circle, is also not very uncommon. However, miscellaneous type of horns with a varying pattern between spirocerous and macrocerous are also found.

Body length, height at withers and heart girth is around 142, 125 and 169 cm, respectively, in females, and 148, 132 and 186 cm, respectively, in males. Average age at first calving, lactation milk yield, lactation length, dry period, service period and calving interval are 59.03±0.42 months, 506.0±3.14 kg, 283.4±1.44 days, 224.6±1.17 days, 181.7±2.39 days and 507.8±2.39 days, respectively. Average fat percentage is 8.48±0.067.

Swamp buffaloes have 48 chromosomes (24 pairs), out of which 4 pairs are submetacentric, 1 metacentric and 19 acrocentric. X-chromosome is the largest acrocentric while Y is the smallest (AAU, 1998).

Tarai

Buffaloes found in the tarai area of Uttar Pradesh, particularly between Tanakpur and Ramnagar, are known as Tarai buffaloes. Kaura (1950, 1952) described some characteristics of these buffaloes.

Colour varies from black to brown. Sometimes there is a white blaze on the forehead. Horns are usually long and flat with coils, bending backwards and upwards. A typical Tarai buffalo possesses a moderate body with coarse head slightly convex at the centre, drooping towards the base of the horns, and a prominent nasal bone with slight depression under the eyes. Eyes are small, ears are long. Legs are short but strong. Tail is long, reaching below the hocks. Tail switch is white.

These buffaloes produce 2-3 kg of milk per day averaging around 450 kg in a lactation period of about 250 days.

□

8 EVALUATION OF BREEDS

The Asian continent has been the heart-land of the early civilization and thus has witnessed very early domestication of various farm livestock and poultry species. In the course of time many distinct animal types/breeds were developed to meet the ever increasing demand of the human population. Organized animal husbandry practices and quest for development of need-based animal types resulted in identification of breeds. So far, almost all the indigenous breeds are described on the basis of a few subjective evaluation criteria and their parameterization is also done on limited data obtained from some organized herds. Therefore, breed description is grossly inadequate in scope and coverage, and falls short in describing the range of genetic variations. There is paucity of information on all the breeds regarding their physical description, breeding tracts, demographical and geographical distribution patterns, etc. Various qualitative, quantitative, morphological and production attributes of the native animal population still remain to be enumerated and quantified. Therefore, planned scientific surveys of all types of indigenous animal germplasm resources are warranted. These surveys will fill the lacunae in our knowledge and reveal the status of breed vis-a-vis its economic importance along with the identification of animals of the superior germplasm with the potential of higher production and reproduction. The animal types which are declining in number or are on the verge of extinction too can be identified by comprehensive surveys. These surveys will reveal the extent of genetic variability including rare variants which can be protected and conserved.

The precise characterization and evaluation of breeds in addition to morphometric traits and specific genetic markers like biochemical, mutagenic and cytogenic have already been established for temperate breeds. These provide firm basis for the characterization of animal types and breeds. There is need for such an indepth study on the animal germplasm resources of Asia.

It is known for quite some time now that chromosomes are repository of genetic information, but systematic molecular genetic studies of farm animals have remained neglected for a long time as practical utility of these in germplasm evaluation was not fully understood. Genetic evaluation of breeds assumes special significance as most of them though known by different names are almost similar, and differences only at the molecular level can reveal if these are different or not. Hence, such evaluations should also form an integral component of programmes related to characterization, evaluation and conservation of breeds, strains, types, varieties etc.

PHENOTYPIC EVALUATION

Animals maintained under field conditions and adapted to specific agro-climatic condition should be evaluated by collecting information on geographical distribution, socio-economic status of the farmers, management conditions and performance characters. Scientific surveys need to be conducted in the breeding tract by following modern sampling designs and suitable formats and questionnaires (Annexure I) for collecting all possible relevant information for a particular breed inhabiting a defined zoo-geographical zone. This information will lead to the preparation of breed descriptors (Annexure II). Such surveys of breeds/animal types must ensure mandatory recording of the following information.

(i) Demographical and geographical distribution
(ii) Native environment
(iii) Enumeration of breeds in terms of age and sex in a population
(iv) Management practices and utility
(v) Qualitative and quantitative characterization of breeds in relation to morphological traits, production potential, reproductive status etc.
(vi) Qualitative and quantitative description of unique animals, elite producers and rare or unusual characteristics in certain specimen.

Survey Plan

The breeding tract of each breed should be divided into 3 regions (conveniently the administrative districts) representing the complete variation in the breed. Each region/district would have 1 supervisor and 5 enumerators. In the first half of the first year, the supervisor and enumerators would be engaged in determining demographical and geographical distribution of the breeds. Subsequently, 3 enumerators would continue for 2 years recording information on the performance of animals and the remaining 2 enumerators would be engaged in recording management practices. The supervisor would continue for all the 2½ years.

Demographical and geographical distribution

On the assumption that the breeding tract of a breed is spread over adjoining/contiguous districts in one or more states, stratified two-stage sampling design would be adopted. Different zones within a district would be identified which would constitute different strata. Villages within the stratum would constitute the first unit and houses within the village the second unit. Totally 3 districts and within each district 4 strata would be randomly selected. From each stratum, 5 villages would be randomly selected for complete enumeration for the purpose of deriving demographic distribution of the breed.

This study would cover the following information:

(a) Age-wise and sex-wise distribution

(b) Group enumeration for calves (up to 6 months), young stock (6-24 months), adults (24-42 months), milking females, dry females, working males, stud bulls and others

(c) Geographical distribution of the breed

When the complete information is obtained by stratified survey, data regarding groupwise, sexwise and breedwise total population in the breeding tracts would be enumerated by superimposing the proportion obtained by survey on the livestock census data already available.

In total, 15 enumerators would be engaged in the study. During the first 6 months, all the enumerators and 3 supervisors would be engaged in conducting demographical study and subsequently they would take up other aspects which are given below.

During survey if individual animals with exceptionally high producing capacity or with rare genetic variation is located, they should be brought under organizational support or purchased for further studies.

Breed characterization and management practices

This study would be conducted in 3 districts. In each district, 200 animals under each of the following groups would be studied for aspects given against the group. Thus, there would be 1,400 animals in a district which would be randomly selected from 4 randomly selected zones (from each zone 350 animals from randomly selected households would be surveyed). The group classification is given below:

Group	Study coverage
(a) Calf (1-6 months)	Physical traits, feeding and management practices
(b) Young stock (6-24 months)	Physical traits, feeding, management practices and growth traits
(c) Adults (24-42 months)	Physical and reproductive traits, feeding and management practices, and growth traits
(d) Milking females	Physical traits, feeding and management practices, utility, milk production traits, and reproductive traits (e.g. oestrous cycle and service period)
(e) Dry females	Physical and reproductive traits, and feeding and management practices

(f) Working males	Physical traits, feeding and management practices, and utility
(g) Breeding bulls	Physical and reproductive traits, and feeding and management practices

Milking animals and calves

As mostly calves are expected to be along with their mothers, groups (a) and (d) would be taken together for studies. The following scheme would be followed for detailed recording:

(a) Milk recording would be done once in a month from the first month of lactation to the end
(b) Milk-fat and SNF would be estimated every month from morning milk only
(c) Physical measurements for the mothers would be recorded during the first/second and 8-10 months of lactation, and for calves measurements would be taken for every month
(d) While feeding practices for calves would be recorded every month, feeding of mothers would be done once in 3 months
(e) Disease and other management aspects would be recorded by observations and by the information provided by the farmer
(f) Reproductive aspects of these animals would be covered by observations and by the information provided by the farmer
(g) Qualitative and quantitative descriptions of individual animals other than the above which are given in the breed descriptor would be covered once

Assuming that an enumerator would be able to cover 3 pairs of cows and calves per day for the scheme of work given above, he would be able to take care of 66 such pairs in a month leaving out holidays and moving period. Thus, for a district 3 enumerators are required and for all the 3 districts 9 enumerators would be engaged for a period of 2 years.

Rest of the groups

For young stock under groups (a) and (c) body measurements would be recorded once in every 6 months and for others only once. However, for feeding and management practices, one recording would be done once in every 3 months. During the visits in each season, reproductive and disease management aspects would be recorded by observations and by the information provided by the farmer. Among the groups, breeding bulls might not be available in sufficient numbers and therefore studies would be limited to whatever is available in the area of coverage.

In addition to the above, other aspects as given in the breed descriptor would be covered once for all the animals.

For the 5 groups of animals, there would be 1,000 animals in each district. As the enumerator has to repeat recording on the same individual animal once in every 3 months for a period of 1 year, an enumerator would be able to cover 500 animals in 3 months by approximately recording 8 animals in a day. Thus, for every district 2 enumerators would be required, and for 3 districts 6 enumerators for a period of 1 year would be sufficient.

GENETIC EVALUATION

Various individuals of breeds within a species are distinguished phenotypically with more similarities within a breed. There are variations within a breed also but all the individuals of a particular breed can be grouped as representative of one breed due to similarities. These similarities are having a genetic base as they are fixed from one generation to next generation. To elucidate the genetic basis of similarity within a breed and of differences between breeds, studies need to be undertaken on cytogenetics, biochemical polymorphism, blood groups and DNA polymorphism.

A large quantum of work has been conducted on cytogenetic architecture of various breeds within a species. This included karyotyping, idiograms, NORs, SCE, various bandings such as G, C, R, GTG and GBG. All these studies could reveal a definite cytogenetic profile of a species but no difference could be highlighted between breeds of one species.

Blood group studies also had their limitations as a limited number of loci could be studied. From these loci it was not possible to clearly distinguish various populations within a species. This technique has been found to be very useful and cost effective for parentage confirmation.

Biochemical polymorphism studies on various proteins and enzymes have also been conducted on various breeds of different species. But these studies have been taken with different objectives and rarely the objective was to find genetic distance between the breeds within a species. Data from various reports are sporadic and could not be compiled to achieve any meaningful conclusion.

Cytogenetic Architecture

In the last four decades, especially after the use of tissue cultures and pre-treatment of cells in different ways, there has been rapid progress in the mammalian cytogenetics. Earlier the results were based exclusively on observations obtained through direct study of certain tissues, such as bone marrow and gonads. Knowledge of the chromosomes of different breeds of cattle and buffaloes remains very incomplete in spite of the technical improvement. Simplified methods facilitating cytogenetic investigations of a large number of animals in a short period of time have recently been found out.

It is a well-known fact that chromosome number and structure are characteristic for all higher species. However, spontaneous structural rearrangements may take place or can be induced. These structural aberrations cause phenotypic effects. Normally there is a lethal negative selection against structural aberrations in embryos both at pre- or post-implantation stages. The karyotype variation tolerated within a species is determined by several factors, and it is probable that individuals with different karyotypes may have different adaptive value in natural selection. In most of the cases polymorphic population appears to have higher fitness value than the monomorphic ones.

Chromosomal Profile of Cattle

A normal karyotype of cattle comprises 2n=60 chromosomes (Gustavsson, 1969; Gupta *et al.*, 1974). The diploid count (2n) in all the cattle breeds has been reported to be 60. Of these chromosomes, 29 pairs are acrocentric autosomes and 1 pair sex chromosomes. In females, both these chromosomes are X, whereas in male one is X and the other is Y, coming from female and male parents respectively.

The major morphological difference between cattle species is the Y-chromosome. All humped cattle (*Bos indicus*), American bison and Wisent (European bison) have an acrocentric Y (Gupta *et al.*, 1974) whereas those without hump (*Bos taurus*) have sub-metacentric Y (Table 3). Quite interestingly, the dwarf zebu of Sri Lanka had a small sub-metacentric Y chromosome (Hadziselimovic, 1971). However, this could be due to unrecorded introgression from *Bos taurus* during colonial times. In fact, it might be that the acrocentric Y of *Bos indicus* represents the evolution of an isolating mechanism which could be less important on Sri Lanka than on the mainland where *Bos indicus* overlaps with other species of cattle.

Table 3. Chromosome numbers and morphology in different species

Species	2N	Sm/n	Acrocentrics	X	Y
Bos indicus (zebu)	60	-	58	Sm	A
Bos taurus (exotic)	60	-	58	Sm	Sm
Bos banteng (Bali cattle)	60	-	58	Sm	Sm
Bos grunniens (yak)	60	-	58	Sm	Sm
Bos mutus (wild yak)	60	-	58	Sm	Sm
Bos frontalis (mithun)	58	2	54	Sm	Sm
Bos gaurus (gaur)	58	2	54	Sm	Sm
Bos gaurus hubbacki (seladeng)	56	4	52	Sm	Sm
Bison bonasus (Wisent)	60	-	58	Sm	Sm
Bison bison (American bison)	60	-	58	Sm	A

The difference between *Bos taurus* and *Bos indicus* in the Y-chromosome has made this a convenient marker. Among African cattle, the Kouri (a taurus type) cattle has sub-metacentric type Y-chromosome. The Y-chromosome of Sanga cattle is also sub-metacentric type. Sub-metacentric type Y-chromosomes have also been reported in Yellow cattle of China and Taiwan, though they have hump like typical zebu. Korean cattle which are considered to have indicine ancestry had the taurine type Y-chromosome. However, the Brahman cattle bulls have shown both types of acrocentric or sub-metacentric Y-chromosomes depending upon the bull sire used. Similar type of Y chromosome is found in *Bos taurus* and *Bos indicus* crossbred males in India.

Chromosomes are identified by both shape as well as size and are numbered accordingly. The size of chromosomes is expressed in terms of relative length of each chromosome as its percentage of total haploid genome size. The relative length of cattle chromosome is described in Table 4.

Banding Patterns

Information on banding patterns provides better understanding of the chromosomal organization. This can also be used as markers for chromosome identification with respect to normal as well as anomalous conditions, due to their universality and specificity. Various banding patterns using differential staining procedures have been evolved.

C-banding

Constitutive heterochromatin region is visualized through C-banding technique in metaphase chromosomes. The C-bands are created by Giemsa staining and these appear primarily due to the greater loss of chromatin in non-repetitive regions than in repetitive regions.

Autosomes: Irrespective of their morphological features, all the autosomes show large and distinct staining of the chromatin in the centromeric region. Some variation in the amount of centromeric heterochromatin could be observed in some of the homologues. No other heterochromatic region is present.

Sex chromosomes: No centromeric heterochromatin is present in X-chromosome, so is in Y-chromosome, though the latter stain darker than X-chromosome. Redundancy of the DNA material may be due to the presence of heterochromatin in Y-chromosome.

Although C-bands are restricted to the centromeric regions of the chromosomes, species-specific variation in the band characteristics regarding size of the band exists. Considerable reduction in the amount of centromeric heterochromatin has been observed in bi-armed chromosomes relative to acrocentric chromosomes. Loss of centromeric heterochromatin because of centric fusion of chromosomes during evolutionary process, may be the probable cause of less intense bands in sub-metacentric autosomes.

Table 4. Relative length of chromosomes in male and female cattle

Chromosome No.	Male	Female
1	5.405±0.158	5.478±0.136
2	4.795±0.167	5.044±0.187
3	4.425±0.230	4.814±0.200
4	4.285±0.138	4.616±0.151
5	4.210±0.108	4.418±0.113
6	4.120±0.094	4.272±0.112
7	3.980±0.083	4.218±0.115
8	3.875±0.085	4.080±0.066
9	3.780±0.064	3.922±0.074
10	3.650±0.076	3.778±0.021
11	3.545±0.033	3.654±0.029
12	3.455±0.069	3.476±0.064
13	3.280±0.075	3.348±0.050
14	3.240±0.049	3.262±0.067
15	3.100±0.076	3.134±0.066
16	2.975±0.063	3.034±0.074
17	2.860±0.086	2.904±0.076
18	2.765±0.074	2.800±0.082
19	2.695±0.099	2.694±0.067
20	2.625±0.072	2.632±0.077
21	2.555±0.074	2.550±0.086
22	2.475±0.088	2.460±0.096
23	2.420±0.060	2.388±0.092
24	2.335±0.062	2.302±0.079
25	2.245±0.121	2.192±0.101
26	2.165±0.082	2.066±0.088
27	2.125±0.085	1.980±0.127
28	1.995±0.098	1.874±0.061
29	1.850±0.136	1.764±0.102
X	5.240±0.218	5.306±0.178
Y	2.035±0.227	-

G-Banding

Any chemical agent, which can alter protein structure is capable of producing G-bands. There are various methods available, but mostly proteolytic enzyme treatment is used to hydrolyse the proteins of nucleo-protein complex. Subsequent staining with Giemsa reveals alternate dark and light regions, which represent A-T and G-C enriched

DNA contents respectively. The DNA in positive G-bands is relatively rich in the bases adenine and thymine (A+T rich), whereas that in the negative G-bands is relatively rich in guanine and cytosine (G+C rich). G-banding is regarded as an outcome of DNA-protein interactions on the chromosomes. The number, intensity and location of occurrence of such band patterns along the chromosome length is a characteristic of a particular chromosome pair (Table 5) and no other pair exhibit similar bands. The homologues are identical in this respect, making pairing and subsequent identification of chromosomes unambiguous (Fig. 4).

R- banding

Chromosomes are stained by using a specialized staining protocol for reverse banding (R-banding). These bands are opposite to G-bands (Table 5). The positive R-bands are early replicating, late condensing and represent G+C rich regions (Fig. 5).

Nucleolar Organiser Regions (NORs)

The nucleolar organiser regions in all bovine species is more or less fixed. The 4 large chromosomes positive for NORs in cattle are 2, 3, 4 and 11 (Fig. 6). The fifth pair with NOR site is chromosome No. 28. However, there may be some variation in the number or site of their locations on these chromosomes among individual animals.

Sister Chromatid Exchanges

The sister chromatid exchanges are the differential staining with 5 bromo-deoxy-uridine showing late replicating chromosomal arms coming from each of parental cell lines to daughter cells (Fig. 7). In normal replicating cells, this number is more or less fixed in each species. Any alteration in this frequency depicts the disturbance in the mitotic cell cycle by the agent or disease profile of the animal. Therefore, knowing the modal number of sister chromatid exchange (SCEs) frequency is a good indicator of the stability of the genome. The normal frequency of SCEs in cattle is 4.06/cell or 2.03 exchanges /cell/generation (Vijh *et al.*, 1996)

Chromosomal Profile of Buffaloes

The diploid chromosome number in water buffalo is 50. In swamp type buffalo it is 48. However some exceptions have been reported in different buffalo populations. In swamp buffaloes from Sri Lanka 2n number is 50, suggesting that this population is derived from the Indian river buffalo but has acquired swamp habits (Bongso and Hilmi, 1982). In contrast Taiwan water buffaloes and Australian feral populations have 2n=48. The chromosomal profile of different buffalo species are summarized in Table 6.

Fig. 4. G-banded karyotype of cattle

Fig. 5. R-banded karyotype of cattle

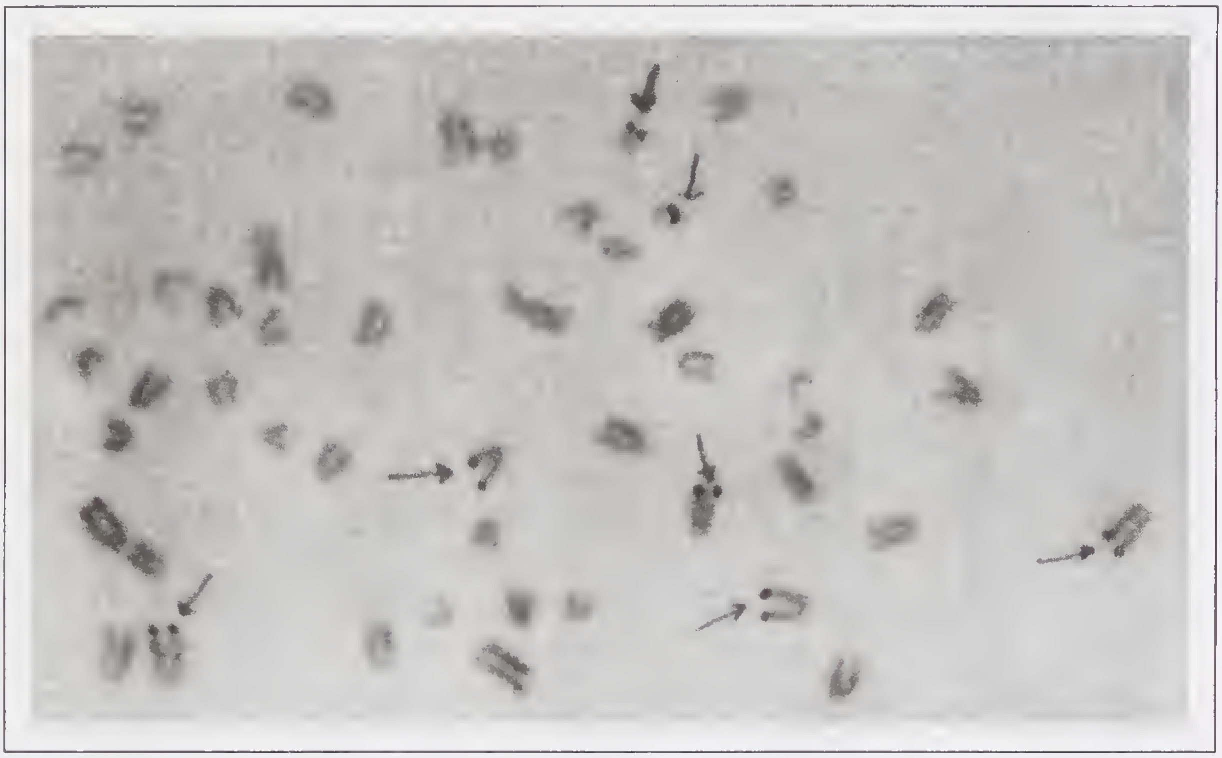


Fig. 6. NORs in cattle

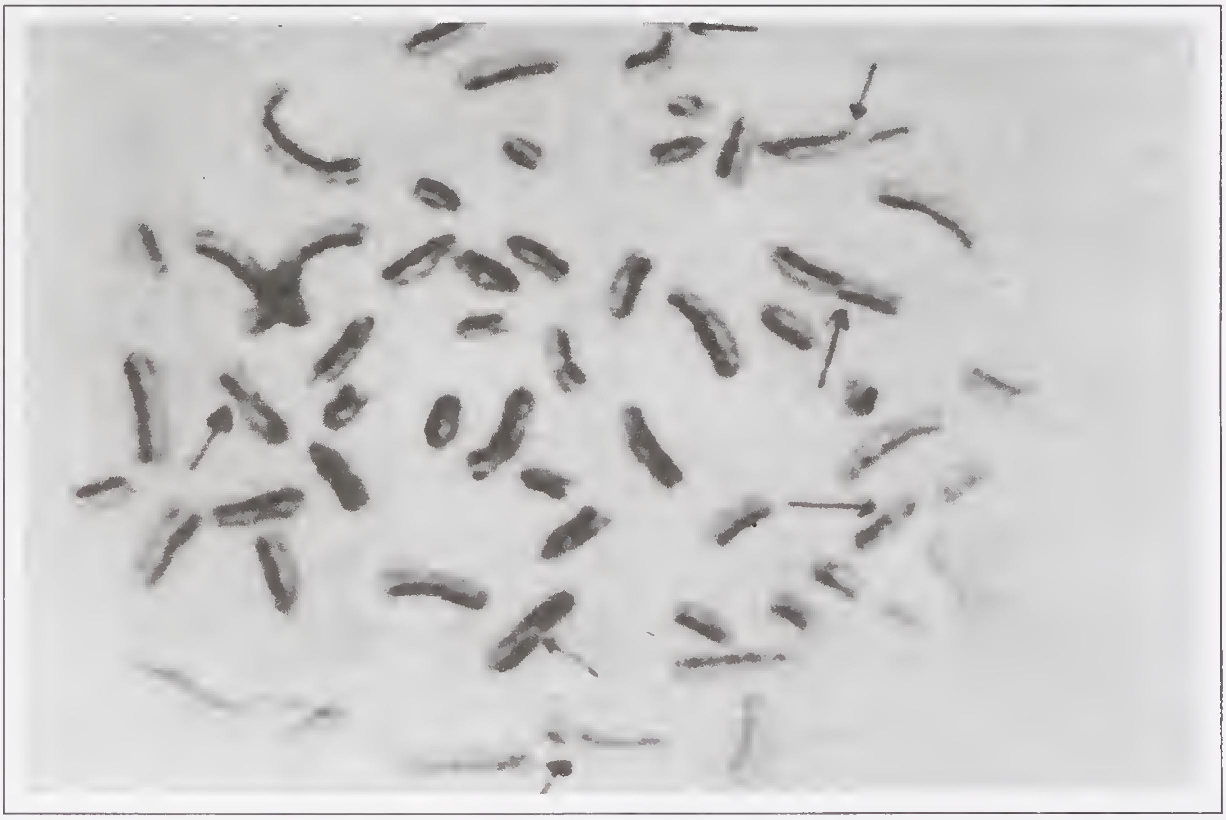


Fig. 7. Sister chromatid exchanges in cattle

Table 5. Details of euchromatic bands of cattle

Ch. No.	G-band	R-band
1	2	3
1	21 G-bands; 2 negative central bands separated by a positive band; chromosome divided into 4 regions.	21 R-bands; divided into 4 regions; 3 prominent bands; 2 central which may be joined; one terminal.
2	20 G-bands; 4 regions; 4 positive bands in the proximal half of chromosome.	20 R-bands; divided into 4 regions; 1 prominent positive band in the proximal half; 3 positive bands in the distal half.
3	15 G-bands; 3 regions; 2 prominent central positve bands separated by a large negative band.	17 R-bands divided into 3 regions.
4	19 G-bands; 3 regions.	19 R-bands; divided into 3 regions; 1 prominent positive band in the proximal half.
5	15 G-bands; divided into 3 regions separated by a group of 3 positive bands which are equally distributed.	15 R-bands; 3 regions, 3 prominent positive bands, 1 proximal; 1 central and 1 terminal.
6	15 G-bands; divided into 3 regions separated by a group of 3 positive bands which are equally distributed.	17 R-bands; 3 regions; 2 prominent negative bands.
7	13 G-bands; divided into 2 regions; prominent positive bands 1 each in proximal and distal region.	13 R-bands, 2 regions; 1 large proximal positive band.
8	16 G-bands; divided into 2 regions; 4 positive bands in 2 separated by a large negative band.	16 R-bands; 2 regions; 1 cluster of three positive bands in the distal half.
9	17 G-bands; 2 regions; 2 bands each in proximal and distal region.	17 R-bands; divided into 2 regions; 1 prominent central positive band, followed by a broad negative band.
10	17 G-bands; 3 regions.	19 R-bands; 3 regions.
11	14 G-bands; 2 regions.	16 R-bands; 2 regions.

Table 5. (continued)

1	2	3
12	11 G-bands; 2 regions; 1 prominent subcentromeric band.	11 R-bands; 2 regions, a negative subcentromeric band, followed by 2 prominent positive bands.
13	11 G-bands; 2 regions; 1 prominent subcentromeric band followed by 2 positive bands proximally.	11 R-bands; 2 regions; 1 large negative centromeric band; 1 cluster of 3 strong positive bands in the distal half.
14	15 G-bands; 2 regions; 4 small positive bands equally distributed in the proximal half of the chromosome.	15 R-bands; 2 regions, 4 positive bands equally distributed in the proximal half.
15	13 G-bands; 2 regions; 1 prominent subcentromeric positive band and a large negative band.	12 R-bands; 2 regions; 4 positive bands clustered in the distal part.
16	12 G-bands; 2 regions; 1 broad negative band; 2 small positive bands in the distal half.	12 R-bands; 2 regions; 4 positive bands clustered in the distal part.
17	11 G-bands; 2 regions; 2 prominent central positive band.	11 R-bands; 2 regions; 2 broad central negative bands followed by 2 prominent terminal positve bands.
18	11 G-bands; 2 regions.	11 R-bands; 2 regions; 1 terminal positive band with positive telomere.
19	10 G-bands; 2 regions; 1 submetacentric band followed by 3 positive bands.	10 R-bands; 2 regions; 4 broad positive bands, usually joined and giving impression of 1 broad positive region.
20	11 G-bands; 2 regions; 1 prominent positive band in the distal part is main identifying feature.	11 R-bands; 2 regions; 1 subcentromeric negative band and 3 positive bands in the proximal part.
21	11 G-bands; 2 regions; 2 subcentromeric positive bands closed to each other.	11 R-bands; 2 regions; 2 subcentromeric negative bands.
22	9 G-bands; 2 regions.	7 R-bands; 2 regions; 1 small subcentromeric negative band followed by a broad positive band.

Table 5. (concluded)

1	2	3
23.	10 G-bands; 2 regions; 1 prominent subcentromeric band followed by 2 negative bands separated by a small positive band.	10 R-bands; 2 regions; 1 prominent centromeric negative band.
24.	12 G-bands; 2 regions; 1 subcentromeric negative band and 1 negative telomere.	10 R-bands; 2 regions; 1 subcentromeric positive band followed by a wide negative band.
25.	9 G-bands; 2 regions.	9 R-bands; 2 regions; 1 centromeric negative band followed by a wide negative band.
26.	7 G-bands; 2 regions; 2 prominent positive bands; 1 subcentromeric band and 1 distilled band.	7 R-bands; 2 regions; wide subcentromeric band and 2 prominent positive bands.
27.	10 G-bands; 2 regions; centromeric negative band followed by positive bands.	8 R-bands; 2 regions; pronounced subcentromeric band.
28.	9 G-bands; 1 region; a subcentromeric positive band.	9 R-bands; 1 region; 3 positive bands; 1 proximal; 1 central and 1 terminal.
29.	9 G-bands; 1 region; 2 proximal positive bands and a negative telomere.	9 R-bands; 1 region; 2 small positive bands.
X	8 G-bands; 2 regions in the p arm; 4 regions in the q arm with 4 positive bands in proximal and distal part.	8 R-bands; 2 regions in the upper arm (p); a distal positive band, a small subtelomeric negative band and positive telomere; 4 regions in the lower arm (q), a cluster of three positive bands at the centre of the arm. A large negative band above the cluster and two negative bands separated by a small positive band.
Y	2 regions with a clearly discernible positive band in the middle.	

Table 6. Chromosomal profile of buffaloes

Species	2n	sm/m	Acrocentric	X	Y
River buffalo	50	10	38	A	A
Swamp buffalo	48	12	36	A	A
Afrikander buffalo (*Synercus caffer caffer*)	52	8	42	A	A
Congo buffalo (*Synercus caffer nanus*)	54	6	46	A	A

The karyotype of Anoa buffaloes (*Anoa depressicornis*) is 48. However considerable variation in chromosome number of different types of Anoa has been reported (Hsu and Benrischke, 1967, 1977; Amano *et al.*, 1987). The diploid count of Afrikander buffaloes (*Synercus caffer caffer*) and Congo buffaloes (*Synercus caffer nanus*) is 52 and 54 respectively. The hybrids of swamp and river buffaloes have 2n=49. Both parental types have similar type of sex chromosomes, with X the largest acrocentric and Y the smallest acrocentric. The lesser number of autosomes in swamp buffaloes is considered to be due to centric fusion of autosomes 4 and 9 of river buffalo.

In river buffaloes the first 5 pairs of autosomes are sub-metacentric types. If all the autosomes are counted for acrocentric arms, buffaloes also conform to the fundamental number of 60 chromosomes typical of most of the members of family Bovidae. The relative length is given in Table 7.

C-banding

All the acrocentrics show distinct heterochromatic bands, whereas sub-metacentric and metacentric chromosomes show very little heterochromatin.

Autosomes: First 5 pairs of sub-metacentric autosomes show a faint C-band. Acrocentric (19 pairs) chromosomes possess distinct bands in the centromeric region.

Sex chromosomes: X-chromosome exhibits large prominent triangular C-band at the centromere, extended down into the arms of the chromatids. Some workers consider that there are 3 large bands one in the centromere and 2 down in the chromatids. Y-chromosome, though an acrocentric, exhibits a characteristic C-band negative feature.

G- and R-Banding

River buffalo chromosomes have revealed a large number of banding homologies with cattle both at early metaphase (Di Berardino *et al.*, 1981) and prometaphase stages (Iannuzzi *et al.*, 1990). In particular each of the 5 river buffalo biarmed pairs originates from centric fusion translocation between 2 of 10 homologous cattle autosomes. The five translocations were accompanied by loss of constitutive heterochromatin (Iannuzzi *et al.*, 1987) and a pericentric G-positive band in chromosomes 1p, 2q, 4p and 5q (Iannuzzi *et al.*, 1990). Brief description of band characteristics of various chromosomes as per Iannuzzi (1994) is given in Table 8 and banded karyotypes are given in Figs 8 and 9.

Table 7. Relative length of chromosomes of buffaloes

Chromosome No.	Male	Female
1	7.17±0.09	7.11±0.08
2	7.07±0.03	6.96±0.05
3	6.55±0.02	6.74±0.11
4	5.74±0.01	5.93±0.03
5	4.92±0.04	4.94±0.04
6	4.66±0.07	4.59±0.06
7	4.41±0.02	4.44±0.02
8	4.10±0.02	4.40±0.02
9	4.10±0.03	4.34±0.02
10	3.89±0.04	4.10±0.06
11	3.89±0.05	3.88±0.04
12	3.76±0.04	3.65±0.03
13	3.69±0.04	3.55±0.05
14	3.58±0.04	3.52±0.03
15	3.49±0.03	3.46±0.02
16	3.43±0.04	3.26±0.03
17	3.07±0.02	2.96±0.04
18	2.87±0.01	2.76±0.03
19	2.68±0.02	2.66±0.02
20	2.46±0.01	2.37±0.04
21	2.37±0.02	2.32±0.02
22	2.25±0.01	2.18±0.03
23	2.05±0.02	2.07±0.04
24	1.84±0.01	1.77±0.02
X	6.10±0.08	6.74±0.04
Y	1.37±0.01	

Nucleolar Organiser Regions

Silver staining of metaphase chromosomes revealed the localization of nucleolar organiser regions (NORs) on the telomeric ends of short arms of chromosomes 3 and 4, and on terminals of chromsomes 6, 21, 22 and 24.

Chromosomal Aberrations and their Implications

There are several types of chromosomal aberrations giving rise to interspecific polymorphism and their role in speciation has been well documented. A specific type of chromosomal re-arrangement, viz. the translocation or centric fusion known as Robertsonian translocation, has been thoroughly studied in cattle. Initially, this was observed by Gustavsson and Rockborn (1964) in Swedish White cattle during an investigation of blood leukosis. Later studies revealed a polymorphic chromosome system

Table 8. Details of euchromatic bands of buffalo

Ch. No.	G-band	R-band
1	2	3
1	p: 2 regions; 4 positive G-bands of which 1 is proximal and large, and 1 is telomeric and small. q: 4 regions; 12 positive bands; a large negative central region with a small G-positive band divides the arm into 2 parts with 6 close positive bands in the proximal half and 5 positive bands in the distal half.	p: 4 positive bands of which 1 is larger than the other 3 and distantally located. q: 12 positive bands; 3 evident regions; 1 proximal and small, 1 large and central, 1 telomeric; telomere positive
2	p: 2 regions; 5 positive bands; 3 positive bands are almost equally spaced. q: 3 regions; 9 positive bands; 2 large negative bands divide the arm into 3 parts, 1 proximal with a prominent positive band, 1 central with 6 equally spaced positive bands and 1 distal with 2 positive bands; telomere negative.	p: 5 positive bands; 1 large proximal positive region and the other has 2 small close bands; telomere positive. q: 10 positive bands; 3 prominant positive bands; 1 proximal, 1 distal and 1 telomeric; telomere positive.
3	p: 2 regions; 5 positive bands; 5 positive bands are equally spaced; 1 is large and subcentromeric. q: 2 regions; 8 positive bands; 4 prominent proximal positive bands; equally spaced, 1 is central and large; telomere psotive.	p: 4 positive bands very large and close; telomere negative. q: 7 positive bands; proximal part with 3 small equally spaced positive bands; distal part has 3 distinct positive bands; telomere negative.
4	p: 1 region; 3 positive bands of which 2 are close and proximal and 1 is large and distal, almost telomeric. q: 3 regions; 8 positive bands; 3 regions; 1 is proximal with 2 bands; 1 is central with 3 bands and 1 is distal with 3 bands telomere negative.	p: 4 positive bands, 1 subcentromeric and another distal and prominent; small telomeric positive band. q: 8 positive bands; 3 quite evident, 1 proximal, 1 distal and 1 telomeric.
5	p: 1 region; 4 positive bands; 1 is subcentromeric, 2 are proximal and 1 is distal; telomere negative. q: 2 regions; 6 positive bands of which 2 are proximal, large and close, and 4 are distal and small; telomere negative.	p: 4 positive bands; 1 proximal, 1 small central, 2 are distal and prominent, telomere positive. q: 7 positive bands; subcentromeric positive band, large proximal negative region and a distal part with 5 close positive bands, telomere positive.

Table 8. (continued)

1	2	3
6	3 regions; 11 positive bands; 1 is subcentromeric, 3 are proximal, 2 are distal and prominent; typical central negative band; small telomeric positive band.	10 positive bands; 2 large positive regions, 1 proximal with 3 bands and 1 distal with 3 bands; central positive band.
7	3 regions; 9 positive bands; a large negative band divides 4 positive bands. 2 proximal and 2 central; prominent distal positive band; small telomeric positive band.	8 positive band; large proximal positive bands and 2 close distal positive bands.
8	3 regions; 8 positive bands; 4 large, close and proximal positive bands almost equally spaced; distal evident positive band; telomere negative.	8 positive bands; 2 small proximal positive bands and 2 rather evident central positive bands; telomere positive.
9	2 regions; 10 positive bands; subcentromeric positive band, prominent proximal positive band and 5 close positive bands distally located.	10 positive bands; 1 large negative band divides the chromosome into 2 large positive regions; 1 proximal with 2 positive bands, 1 central with 4 close positive bands; telomere positive.
10	2 regions; 7 positive bands; 3 close proximal bands and 1 large positive band centrally located; small telomeric positive band.	6 positive bands; 4 large positive, 1 proximal , 3 distal; large central negative band.
11	3 regions; 9 positive bands; small positive bands of which 1 is subcentromeric, 1 proximal and 2 rather evident close and distal; large almost telomeric positive band.	9 positive bands; 2 proximal, 3 central and 2 prominent distal; small telomeric positive band.
12	3 regions; 9 positive bands of which 5 are proximally and distally located; typical central negative band; telomere negative.	9 positive bands; 3 prominent proximal, 1 central and 2 close distal positive bands; 2 close telomeric positive bands.
13	2 regions; 5 positive bands of which 1 is subcentromeric, 2 distal and 1 almost telomeric.	5 positive bands; 2 large proximal, 1 small central and 1 large distal; very small telomeric positive band.
14	2 regions; 4 positive bands equally spaced and with decreasing size starting from centromere.	4 positive bands; 1 proximal, 1 central and 2 close distal; telomere positive.

Table 8. (concluded)

1	2	3
15	2 regions; 7 positive bands; 3 rather evident positive bands, 1 central and 2 very close and distal; telomere positive.	6 positive bands; proximal half with 4 close positive bands, 1 distal positive band; telomere negative.
16	2 regions; 8 positive bands; 2 rather evident positive bands are close and subcentromeric and 3 are distal and equally spaced; telomere positive.	7 positive bands; 3 large close positive bands centrally located; telomere negative.
17	2 regions; 6 positive bands of which 2 are proximal and close, and 3 large, close and centrally located.	6 positive bands; 2 proximal and close; 2 large and very close at the telomere.
18	2 regions; 5 positive bands, 1 subcentromeric, 3 central and 1 telomeric.	4 positive bands; 1 proximal, 1 large distal; telomere negative.
19	2 regions; 6 positive bands, 1 is large and distal.	6 positive bands; proximal half with 4 large positive bands; distal negative band; 2 small and telomeric positive bands.
20	2 regions; 5 positive bands, 2 are proximal and 2 distal and close; large central negative region.	5 positive bands; 2 central and very close and 1 telomeric.
21	2 regions; 3 positive bands, 1 subcentromeric and 2 distal, large and close; telomere negative.	3 positive bands; 1 large proximal, 1 small central and 1 telomeric.
22	2 regions; 4 positive bands; 2 proximal, large and close, and 2 distal and small.	5 positive bands; 1 subcentromeric, 3 large distal; telomere positive.
23	2 regions; 5 positive bands; 1 subcentromeric, 1 central and quite prominent; small telomeric positive band.	4 positive bands; 2 close proximal and 2 close distal.
24	2 regions; 4 positive bands; all small and almost equally spaced; telomere negative.	4 positive bands equally spaced; telomere positive.
X	4 regions; largest acrocentric; 12 positive bands; 3 evident and centrally located.	12 positive bands; 1 large proximal and 4 close distal.
Y	2 regions; 6 positive bands; 5 are very close and 4 of these are large; telomere positive.	5 positive bands; 4 very small equally spaced and 1 large telomeric; telomere negative.

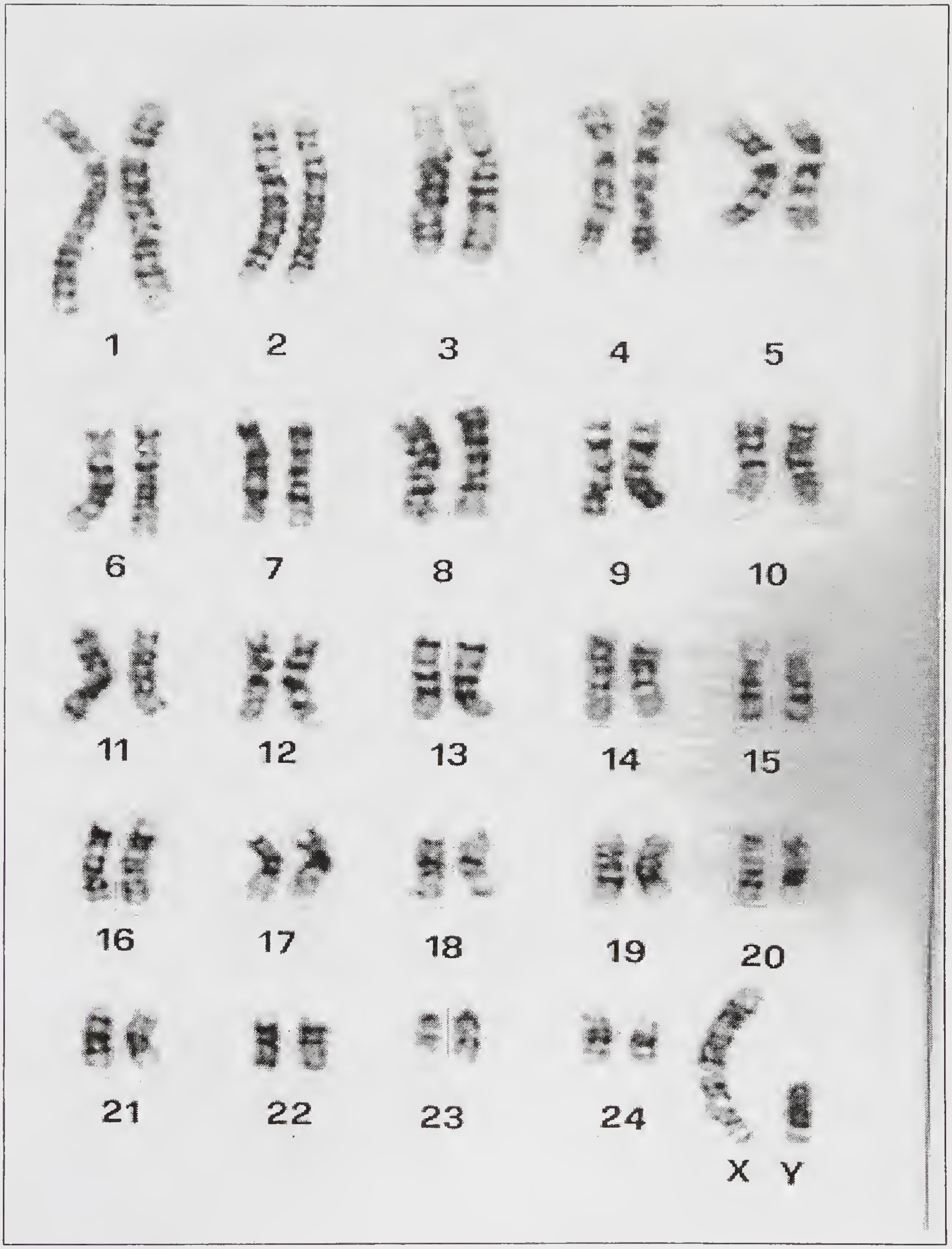


Fig. 8. GTG-banded buffalo karyotype (Source: Iannuzzi, 1994)

Fig. 9. RBG-banded buffalo

karyotype (Courtesy R. K. Vijh)

(Gustavsson, 1966). The number of chromosome polymorphisms that have been found in farm animals is very surprising in view of the relatively small number of animals that have been studied. The chromosomal profile has also helped in solving various other syndromes in cattle, buffaloes and other farm species.

Robertsonian translocation in cattle: Cytogenetic studies of individual animals and population samples from cattle breeds have revealed diploid chromosome number of 58 and 59 as well as 60. The reduction in the diploid chromosome number has been associated with the presence of one or two large metacentric or sub-metacentric autosomes, thought to be the result of translocation of the Robertsonian or centric fusion type.

The 1/29 Robertsonian translocation, found in several breeds, was associated with the impaired fertility in Swedish red and white breeds, as daughters of the sires heterozygous for 1/29 centric fusion displayed lower non-return to service, although the sires themselves were of normal fertility (Gustavsson, 1969). Consequently, several populations of bulls in artificial insemination studs in different countries were screened and several other types of Robertsonian translocation were also observed involving other autosomes.

The structural autosomal heritable translocation like reciprocal translocation was found to cause severe phenotypic effects on the animal. The reciprocal translocations are known to cause skeletal defects. Herzog and Hohn (1971) reported congenital abnormalities in the calves carrying centric fusions and tandem fusions. Mayr *et al.* (1983) studied in 50 German Simmental bulls a reciprocal translocation involving (8; 15) and (21; 24) with no apparent effect on the bulls. Robertsonian translocation which reduced the diploid number of chromosomes by one or more depending upon the number of chromosomes involved, could be a cause of specification in the course of evolution (Sahai and Mathur, 1981).

XX/XY chimerism and freemartin syndrome: A freemartin can be defined as "a sexually imperfect, usually a sterile female partner of a heterosexual twin." Hafez and Jainudeen (1966) defined freemartin as "a twin in which the development of the gonad has been controlled by the inter-circulating system of the male and female twin foetuses". In the light of the above definition and later findings, Hafez (1968) redefined the freemartin condition to include the reception of cells from a male foetus during gestation.

Not even a single case has been reported in which a bovine heifer exhibiting the evidence of choriovascular anastomosis with a male twin has been found to be fertile. The confirmation of vascular anastomosis would definitely indicate that a female member of heterosexual co-twin is certainly a freemartin which can be proved by clinical examination, homograft tolerance, blood cell chimerism or by any other method.

Blood Groups

Inherited blood characteristics are controlled through the antigenic structure of the red cells. Evidence for the existence of species differences in blood of animals was noticed as early as 1898. Individual serological differences in the red blood cells within a species led to the recognition of the ABO blood group system in human beings. These antigenic specifications have been referred to as blood groups or blood types (Stormont, 1962). Among farm animals cattle blood groups have been studied in detail, and now 12 loci which control polymorphisms are known (Khanna 1968a). These polymorphic traits have been used as important tools in animal breeding.

In Cattle

Blood group studies in Indian cattle were initiated using complement dependent haemolytic technique with the method of Ferguson (1941) by IVRI workers in 1958. These reports confirmed that the red cell antigens of Indian cattle possessed blood factors that were identified in Western cattle breeds (Ram and Khanna, 1961; Naik *et al.*, 1965). Subsequently, several monospecific reagents isolated in zebu had specificities different from standard reference reagents used in international comparison test conducted by the ESABR. Certain unknown antigenic factors were observed in these comparison tests. The identity of these factors and the blood group system to which it belonged could not be established. However, it was speculated that these mostly belonged to the complex system like B, C or S (Stormont, 1972). Some of these blood group factors might be zebu specific.

In cattle blood grouping, the red cells of animals are screened for lysis by using standard antisera in the presence of compliment. There are 12 well-recognized blood group systems in cattle (Table 9). Their complexity ranges from the simplest L (with 2 alleles and 2 blood types) to B (with over 600 alleles and over 60,000 blood types). The large number of specificities in the B and C systems make them very useful for parentage pedigree exclusion and breed differentiation. Since most of the blood groups like other biochemical traits are inherited according to simple Mendelian laws, the inheritance can thus be controlled independent of herd book records.

The A system phenogroup A1D2Z1 has its origin in *Bos indicus*. This allele has the frequency of 0.02 and 0.04 in American Guernsey and Jersey breeds. The occurrence of A1D2Z1 in Channel Island cattle provided strong evidence that one of the ancestral lines of these breeds could be traced to *Bos indicus* (Stormont, 1962).

The extreme discriminatory power of cattle blood typing using 2-3 scores of reagents is tantamount to fingerprinting of the surface of red cell membrane. The complexity of blood group genetically determined factor was first reflected in the discovery that a number of blood group factors (B and C systems) segregated in a variety of unique combinations referred to as phenogroup (Stormont 1950, 1951). It is debatable whether the phenogroups of complex B and C systems of cattle are coded by a single series of allelic genes or by a cluster of closely linked genes. At least 11 phenogroups are distinguishable in the A system, 1,000 in the B system and 100 in the C system. Knowing the fact that the phenogroups or blood groups in any one system are inherited independently of those in all other systems, the amount of phenotypic variations in cattle blood type is almost beyond comprehension (Stormont, 1982). Earlier it was conservatively estimated that the number of possible blood types was approximately two trillions (Stormont, 1967).

Table 9. Blood group systems in cattle

System	No. of phenogroups	No. of genotypes	No. of phenotypes
A-H	6	21	6
B	164	12,530	10,000
C	35	630	200
D	2	3	2
F-V	2	3	3
J-OC	4	6	4
L	2	3	2
M	3	6	3
S-V	6	21	15
Z	2	3	3
Z1	1	3	3

Source: Stormont (1978).

The most important direct application of the genes controlling blood group factors lies in the identification of population and maintenance of purity of the breeds. For any breeding programme, it is imperative that correct records of parentage and pedigree are available. The reliable and effective check of the pedigree information is particularly important in this country in view of extensive use of artificial insemination being carried out in cattle and buffaloes.

The great deal of genetic variations controlled by blood group genes provide a reliable tool for studying the phylogenetic relationship. Singh and Bhat (1981) observed a closeness of grey cattle breeds, viz. Hariana, Tharparkar and Ongole, using biochemical polymorphic alleles. The coloured breeds, viz. Gir, Red Sidhi and Sahiwal, formed another group. More defined and clear-cut relationship between these breeds is likely to come out from the information on blood group alleles.

In Buffaloes

Buffalo blood groups studies were initiated 6 decades ago (Singh, 1942). However, till date blood typing reagents used are from cattle. In isolated efforts buffalo blood group reagents have been prepared for blood factor B in water buffalo by isoimmunization. Repeated intramuscular injection of small amount of blood (10 cc) over a period of 3-4 weeks is done to evoke the products of anti-B and anti-C in the recipient.

Khanna (1968b) carried out immunization experiments on buffaloes and developed 33 different blood typing reagents by iso- and heteroimmunizations. The antigens were designated as A, B, C, etc. in order of their detection. According to Ram *et al.* (1964), Murrah water buffaloes reacted with 16 of the 35 cattle reagents.

Reagents have also been produced from hetero-allo-immunization of swamp buffaloes. Cells from river buffalo did not react with the anti-swamp reagents, but cells from hybrids between swamp and river buffaloes did react (Amano, 1982).

Later, investigations on the blood groups of buffaloes were made using cattle blood typing reagents. Loypetjra (1962) typed 120 Siamese buffaloes using blood typing reagents belonging to 9 cattle blood group systems A, B, FV, J, L, M, SU, Z and R S. He reported that the red cells of buffaloes reacted with the blood typing reagents indicating cross-reacting antigenic specificities between the two species. Datta and Stone (1963) typed 40 Indian buffaloes using anti-F, anti-V, anti-J and anti-Z blood typing reagents of cattle. Only anti-J showed reaction. Ram *et al.* (1964) typed 150 Indian buffaloes using 35 cattle blood typing reagents, viz. anti-A, E, G, J, K, L, M, Q, R, U1, V, W, X1, Z and 21 unidentified reagents. The buffalo red cells showed crossreactions with 16 reagents including anti-J. These reagents were anti-A, E, G, J, K, L, Q, U, Z and 7 unidentified reagents. Egyptian buffaloes showed cross-reactivity between the A, H, O, P, S and J antigenic factors in cattle and buffaloes. Cattle antigenic factors A, B, K, Y, O, W L, SH, R, U, J , F, V, Z and J had corresponding factors on the red blood cells of buffaloes from Italy (Bettini and Iannelli, 1967). Bulgarian and Indian buffaloes and their crossbreds were typed against 36 bovine blood typing sera (Mokaveev, 1968, 1970). He observed that Bulgarian buffaloes reacted positively with 28, Indian buffaloes with 17 and their crosses with 19 blood typing reagents respectively. A close genetic relationship between Bulgarian and Indian buffaloes was suggested. Out of 36 cattle blood typing reagents used in the typing of red blood cells of Romanian water buffaloes 13 reagents, A1, B, C2, J, L, P, S, U, V, Y2, E1, I and O, showed cross-reactivity.

Khanna (1973) blood typed 1,734 buffaloes belonging to 6 breeds, viz. Marathwada, Murrah, Nagpuri, Nili, Pandharpuri and Surti, against 22 reagents. Distribution of the factors showed that no factor was exclusively present in a particular population, though the frequency varied from population to population (Table 10).

Table 10. Estimation of gene frequencies at the B blood group system

Breeds/herds	No. tested	BB	BY	BBY	Bb
Murrah					
Bareilly	94	0.191+0.034	0.150+0.032	0.058+0.024	0.601+0.0412
Haringhatta	142	0.194±0.027	0.032+0.013	0.129+0.022	0.645+0.0321
Hisar	132	0.043+0.016	0.142+0.026	0.219+0.028	0.596+0.0349
Izatnagar	140	0.107+0.021	0.034+0.013	0.147+0.122	0.712+0.0296
Ludhiana	87	0.124+0.031	0.091+0.027	0.198+0.034	0.587+0.0433
Mathura	91	0.107+0.025	0.028+0.014	0.095+0.023	0.770+0.0334
Meerut	129	0.110+0.023	0.044+0.015	0.164+0.026	0.682+0.0322
Pantnagar	122	0.051+0.016	0.005+0.005	0.165+0.025	0.779+0.0284
Visakapatnam	113	0.056+0.017	0.017+0.010	0.163+0.026	0.764+0.0303
Pandharpuri	37	0.271+0.0889	0.238+0.087	0.327+0.093	0.164+0.0811

Source: Khanna (1973).

Biochemical Polymorphism

Biochemically variable traits have been found to be inherited according to simple Mendelian laws. These can be useful in identification of pedigrees. The advancement in immunogenetics and biochemical genetics was stimulated by the hope of finding direct relationships between biochemically polymorphic and performance traits. During recent years, a variety of biochemical variants were studied in cattle and buffaloes.

Protein Polymorphism

Protein polymorphisms are usually detected by electrophoresis. This process separates the charged molecules in solutions exposed to a voltage gradient and electric impulse. The migration of each molecular species is influenced by a variety of factors, viz. electrostatic charge of the molecule, strength of the voltage gradient and the nature of medium used for electrophoresis. A variety of staining procedures have been developed to identify each polymorphic band. A number of proteins have been studied for their differential movement under electrophoresis and their polymorphism in cattle and buffaloes studied in different laboratories. Some of these are given below.

Haemoglobins

Haemoglobins are one of the most thoroughly investigated protein molecules. Haemoglobins are large spheroid molecules having a haemprosthetic group combined with a protein moiety, globin. Each molecule consists of 4 polypeptide chains normally occurring in 2 pairs of identical chains. It is now well established that differences in the globin portion of the haemoglobin are responsible for interspecies and intraspecies haemoglobin differences. Haemoglobin polymorphism has been found in many species. The incidence of different variants in a species, however, varies from strain to strain and breed to breed.

In Cattle

Polymorphism in haemoglobin types has been reported in different breeds of cattle. Naik *et al.* (1965) reported haemoglobin polymorphism in 5 indigenous breeds of cattle. Among a Khillari bull, a unique haemoglobin variant named Khilari was idenitified. Lehman (1959) reported that the gene frequencies of haemoglobin types Hb^A and Hb^B were more or less equal in randomly selected animals of Gir breed, but the genotypic frequency of HbAB was higher than either of HbAA and HbBB types. However, Naik *et al.* (1965) showed higher gene frequency of Hb^B in 5 Indian breeds. Balakrishnan and Nair (1966) reported the gene frequency of Hb^A in Red Sindhi, Sahiwal and Tharparkar cattle to be 0.632, 0.619 and 0.894 respectively. Sen *et al.* (1966) reported the gene frequency of Hb^B to be 0.422, 0.375, 0.300, 0.0176 and 0.295 in Hariana, Sahiwal, Tharparkar, Red Sindhi and non-descript type cattle respectively. Mangalraj *et al.* (1968) reported the frequency of Hb^B allele to be 0.36, 0.32 and 0.34 in Ongole, Kangayam and non-descript cattle respectively.

In Buffaloes

The distribution of haemoglobin types in buffaloes has been reported to be quite uniform. About 99.1% of samples showed an electrophoretic separation into 2 bands where the average concentration of haemoglobin was 71 and 29% for the faster and the slower bands respectively (Khanna,1973). Similar observations were reported by other workers in the water buffaloes. Naik and Sukumaran (1967), however, reported absence of slower bands in a few samples.

The occurrence of the 2-band pattern indicates the existence of polypeptide chains, one of which may be common for the two bands. The structural studies on haemoglobin of water buffalo by Balani and Barnabas (1965) showed that the two components differed from one another in ∝-chains while ß-chains were common. The ∝-chains were thought to differ in 2 or probably more amino acid residues. More than one type of ∝-chains have been observed in other species also. Ranjekar and Barnabas (1969) considered that a duplication of the ∝-chain genes followed by mutation was responsible for the presence of two variants ∝-chain genes in buffaloes.

The quantitative differences in haemoglobin ratios in the two components were observed in one of the haemoglobin variant. The haemoglobin ratio was approximately 85/15 in the A1 and A2 bands. Abe *et al.* (1969) found 3 animals which possessed a faster haemoglobin component and a faint slower component with much less haemoglobin quantity as compared to the normal slower band. Barnabas (1973) also observed a few buffaloes which had shown comparable quantitative differences.

Another possible explanation is the existence of more than one α-chain genes giving rise to quantitative differences in haemoglobin ratio in buffaloes. This could have resulted by point mutation in one of the several duplicated genes present. It has been recognized by amino acid sequence studies that the gene duplication and point mutation generate most genetic variations in the protein structure (Feeney and Allison, 1969; Manwell and Baker, 1970). It has also been reported that DNA present in the mammalian cells is in excess of what is required to contain all the genetic information. It has been further deduced that many amino acid substitutions in proteins which became fixed in different species were caused by selectively neutral mutations.

A total of 1,746 buffaloes belonging to 7 buffalo breeds were examined for haemoglobin variation using starch-gel electrophoresis. Of these 1,730 animals showed 2 bands designated as A1 and A2 in order of decreasing mobility towards anode, in alkaline pH (Khanna, 1973). The concentration of haemoglobin in A1 and A2 bands was 71 and 29%, respectively, when quantification was done by excising haemoglobin fractions after performing starch-gel electrophoresis and then measuring the haemoglobin quantities spectrophotometrically.

No difference in electrophoretic mobility was observed between foetal and adult haemoglobins in buffaloes. In all, 90 calves below 1 month of age and 14 foetuses ranging from 6 to 15 weeks of age were examined. One foetus aged 6-7 weeks, however, showed a third faint band having slowest mobility.

Transferrins

The transferrin or siderophilin is a specific iron-binding protein. Its major function is transportation of iron to the bone marrow and tissue storage organs. Transferrin plays a significant role in the cyclic process whereby iron derived from the catabolism of haemoglobin and other proteins is conserved by its return to the haemopoietic tissues. The transferrin also participates directly in the regulaion and control of iron absorption, and protects against iron intoxication.

In Cattle

The variation in the gene frequency of different transferrin alleles has been reported by various workers for different breeds of zebu cattle. A high frequency of TF^E among Indian breeds has been observed by many workers. Singh (1974) and Prasad *et al.* (1978) reported a high TF^E allele in Red Sindhi, Sahiwal and Tharparkar breeds; however, a low frequency of TF^B was also delineated in these breeds. Similar observations were also recorded by Singh *et al.* (1972) in other Indian breeds, viz. Hariana, Kankrej, Ongole and Gir breeds. According to Singh *et al.* (1972) occurrence of Tf^F

allele in Hariana, Ongole and Kankrej breeds was quite frequent. The occurrence of different types of transferrin types in Indian cattle breeds are summarized in Table 11.

Table 11. Transferrin phenotypes in Indian milch breeds

Breed	Transferrin types								
	AA	DD	AD	AE	DE	EE	BE	AF	Total
Tharparkar	42	38	96	71	64	11	3	1	326
Sahiwal	1	7	13	33	111	121	4	-	290
Red Sindhi	3	13	12	24	45	16	6	1	12
Overall	46	58	121	128	220	148	132	2	736

Source: Shanker (1979).

In Buffaloes

Loypetjra (1962) described polymorphism of transferrin in Siamese water buffaloes. He reported 3 phenotypes having mobilities equivalent of TfAA, TfAD and TfDD of cattle. Mokaveev (1968, 1970) reported polymorphism in water buffaloes from Bulgaria, imported Indian water buffaloes and in crosses between the two types of buffaloes.

He found 3 phenotypes controlled by 2 co-dominant alleles called TfB and TfC. Khanna (1969) described 3 phenotypes designated as DD, DK and KK in decreasing order of mobilities towards the anode governed by the alleles having no dominance. Three transferring phenotypes controlled by 2 co-dominant alleles mirrored in different nomenclatures have been reported in buffaloes from various countries.

Out of the 3 variants, viz. TfD, TfK and TfN, observed in Indian water buffaloes, the TfN variant was not reported earlier. This variant was observed in a low frequency in Nili and Surti breeds (Table 12). These two breeds belong to different regions of India and have little similarity in their biometrical and morphological characteristics.

In other species of buffaloes from other parts over the world, viz. American bison (*Bison bison*), European bison (*Bison bonasus*) and African buffalo (*Syncerus caffer*), the transferrin are monomorphic. On the basis of segregation of the transferrin phenotypes it can be concluded that co-dominant alleles were involved in control of transferrin polymorphism.

Transferrin polymorphism was studied in 1,729 buffaloes, using horizontal starch-gel electrophoresis (Khanna, 1973). Five transferrin phenotypes, viz. TfDD, TfDK, TfKK, TfDN and TfKN, were observed. The family data showed that these patterns were controlled by 3 co-dominant alleles called as TfD, TfK and TfN in order of decreasing anodic mobilities. The autoradiography confirmed the iron-binding characteristic of the electrophoretically separated proteins. The neuraminidase treatment

Table 12. Transferrin gene frequencies in different buffalo breeds/herds

Buffalo breeds/ herds	No. of animals typed	TfD'	TfK	TfN
Bhadawari	91	0.06±.017	0.94±.017	-
Marathwada	37	0.05±.025	0.05±.025	-
Murrah:				
Ambala	171	0.06±0.013	0.94±0.013	-
Haringhatta	149	0.18±0.022	0.82±0.022	·
Hisar	129	0.10±0.018	0.90±0.018	-
Izatnagar	210	0.16±0.017	0.84±0.017	
Jhansi	108	0.22±0.028	0.78±0.028	
Ludhiana	85	0.15±0.027	0.85±0.027	-
Mathura	51	0.08±0.026	0.92±0.026	-
Meerut	108	0.12±0.022	0.88±0.022	-
Pantnagar	118	0.26±0.028	0.74±0.028	-
Vishakapatnam	109	0.12±0.022	0.88±0.022	-
Nagpuri	75	0.05±0.018	0.95±0.018	-
Nili	115	0.11±0.020	0.87±0.022	0.02±0.009
Pandharpuri	34	0.09±0.036	0.91±0.036	-
Surti	139	0.11±0.018	0.88±0.019	0.01±0.006

Source: Khanna (1973).

reduced the mobilities of the transferrin phenotypes but did not change band pattern. Each allele produced 3 electrophoretically separated zones. The TfK allele was most frequent while TfD and TfN were found in low frequencies. Out of 7 breeds studied, TfN was confined to 2 breeds, viz. Nili and Surti. Age and sex had no detectable effect on distribution of the transferrin phenotypes. All the populations studied were in Hardy-Weinberg equilibrium. Significant differences were observed in the gene frequencies between breeds and herds.

Albumin

Albumin is one of the major serum proteins which has been studied very widely. It is of paramount importance because of its relative abundance, homogeneity, osmotic and transport functions. The physiological consequences of the iron binding behaviour of the serum albumin and affinity for dyes, drugs and other molecules have been emphasized. Albumin has a molecular weight ranging from 65,000 to 70,000 in different mammalian species.

In Cattle

Albumin polymorphism in exotic cattle imported in India have been studied by several workers (Juneja and Chaudhary, 1971; Singh, 1974; Singh and Bhat, 1980a).

Three albumin phenotypes were controlled by 2 alleles Alb ^{A} and Alb ^{B} . However, Alb^{A} allele was universally common in all the breeds of exotic cattle. In Hariana cattle, only AlbBB phenotype was prevalent. However, the polymorphism of Alb ^{A} and Alb^{B} alleles was reported in Hariana cattle by Khanna and Singh (1974) and Singh and Bhat (1980a). The albumin polymorphism was also reported to be present in Kankrej, Ongole and Gir cattle breeds by Singh (1981). Singh and Bhat (1980a) revealed the presence of 4 albumin variants, viz. Alb^{A}, Alb ^{B}, Alb ^{C} and Alb ^{D}, but Alb ^{B} was more frequent among zebu breeds.

In Buffaloes

Albumin polymorphism in Indian water buffaloes was reported by Khanna and Braend (1968). Three phenotypes controlled by 2 co-dominant alleles called as AlbF and AlbS were demonstrated. Similar findings were reported by Mokaveev (1968, 1970) in water buffaloes of Bulgarian and Indian origin, by Masina *et al.* (1971) in Italian water buffaloes and by Juneja and Choudhary (1971) in Indian buffaloes. Abe *et al.* (1969) in Formosan water buffaloes and Osterhoff *et al.* (1970) in African buffaloes found only 1 type of albumin when subjected to starch-gel electrophoresis. It was found appropriate to study more buffalo populations of India for this polymorphism, to look for eventual new variants and for differences between breeds/herds of buffaloes.

Khanna (1973) studied albumin polymorphism in 1,715 buffaloes belonging to 7 breeds. Two electrophoretically separated components called AlbF and AlbS were observed. Each component consisted of 1 zone. The family material indicated that co-dominant alleles were involved in the control of albumin polymorphism in buffaloes. All 16 populations studied were in genetic equilibrium with respect to the genes controlling albumin types. Age and sex had no effect on distribution of the albumin phenotypes. The frequency of AlbF varied from 0.04 to 0.29. Significant differences were observed in the gene frequencies between breeds and between herds within a breed. It was further observed that there was no phenotypic association between the transferrin and albumin types.

Amylase

Of the various enzymes which catalyse the hydrolysis of the homopolysaccharides, amylases are the most important enzymes. Their substrate include starch and glycogen. Amylase has molecular weight of around 45,000. The optimum pH for the enzymatic activity is 6.9. The enzyme is very stable at room temperature. There are 2 types of amylases differing considerably in their mode of action. The mammalian amylase or alpha-amylase degrades starch and glycogen to disaccharide maltose by hydrolysing 1,4 -glycosidic bonds. Plants and micro-organisms contain ß-amylase which produces maltose units from the non-reducing end of the carbohydrate chains.

In Buffaloes

In a material consisting of 1,539 serum samples from 7 breeds of buffaloes (Table 13), the amylase was observed to occur in 3 forms by Khanna (1973). The amylase isozymes were designated as AmC, AmA and AmB in order of decreasing anode mobilities in the starch-gel. Each amylase isozyme was characterized with 1 electrophoretically separated zone. A distinct extra shower zone of amylase activity was observed on addition of calcium chloride ions. This zone remained very near the insertion line of the samples.

The AmA isozyme was most frequent while the other two variants existed in very low frequencies. It was assumed that co-dominant alleles were involved in the control of amylase polymorphism in buffaloes. The limited family data supported this hypothesis. Further, a very good agreement was found between the observed and expected amylase phenotypes. The populations studied were in Hardy-Winberg equilibrium. The gene frequency for AmA ranged from 0.85 to 1.00, while the frequencies for AmC and AmB were 0 to 0.03 and 0 to 0.12 respectively. The differences in the gene frequencies amongst different populations were not very much marked.

Table 13. Amylase gene frequencies in different buffalo breeds/herds

Breeds/herds	No. of animals typed	AmC	AmA	AmB
Bhadawari	91	-	0.93±,019	0.07±0.019
'Marathwada	37	-	10.00	-
Murrah:				
Ambala	171	-	10.00	-
Haringhatta	126	0.03±0.010	0.85±0.022	0.12±0.020
Hisar	129	0.01±0.006	0.98±0.009	0.01±0.006
Izatnagar	134	-	0.93±0.016	0.07±0.016
Jhansi	108	-	0.96±0.012	0.04±0.012
Ludhiana	85	-	0.97±0.013	0.03±0.013
Meerut	108	-	0.95±0.015	0.05±,0.015
Pantnagar	78	-	0.96±0.016	0.04±0.016
Vishakapatnam	109	-	0.97±0.011	0.03±0.011
Nagpuri	75	-	0.98±0.011	0.02±0.011
Nili	115	0.02±0.009	0.95±0.014	0.03_0.012
Pandharpuri	34	-	0.96±0.024	0.04±0.024
Surti	139	0.01±0.006	0.94±0.014	0.05±0.013

Ceruloplasmin

Ceruloplasmin is a blue alpha globulin with a molecular weight of 151,000 (Holmberg and Laurell, 1948). Its purification, function and biological variation have been reviewed by Laurell (1960). Ceruloplasmin is a glycoprotein and has oxidase activity. Each molecule binds 8 atoms of copper and virtually all of the copper in plasma is so bound. This protein is of great biochemical and clinical interest, as there is a regular variation in the ceruloplasmin level in various diseases and during pregnancy. However, the biological function of this protein is still obscure.

In Cattle

Ceruloplasmin polymorphism was reported in indigenous cattle breeds and their crosses with exotic breeds by a number of workers. Singh and Bhat (1980b) reported a pattern of 3 ceruloplasmin variants (Cp^A, Cp^B and Cp^C) in 6 different combinations, viz. CpAA, CpAC, CpAB, Cp BB, CpBC and CpCC.

In Buffaloes

Five hundred serum samples of the buffaloes were subjected to starch-gel electrophoresis for the ceruloplasmin typing by Khanna (1973). All the animals were observed with one band only, showing no polymorphism in this protein.

A number of studies have been conducted to establish the relationship of the blood groups and biochemical variants with production, reproduction and fitness traits. Some positive correlations were found among a particular gene frequency with quantitative traits but, definite relationships could not be established due to lack of data on large samples from random-bred populations to carry out marker-aided selection for faster improvement at farm level production.

Molecular Approach

Recently, a more powerful tool in terms of molecular genetics has acquired prominence in the study of genetic basis for any phenotypic trait/character. This technique needs to be used in a comprehensive manner to achieve the desired results of genetic distancing between breeds within a species. It is more powerful because a large number of loci are studied and meaningful results are expected. Various methods and markers have been used for identifying the genetic variability or studying the polymorphism such as RFLPs, RAPDs, AFLPs, micro-satellites and mini-satellites. Micro-satellites which represent the short simple repeat of DNA sequences are more or less spread in most eukaryotic genome and can be used for such work. The amount of polymorphism for micro-satellite loci and the comparative ease of their typing make them ideal markers to study genetic variation in population. The information is also vital to determine the unique genes/genetic groups for taking rational decision for conservation of the breeds and their genetic variability. After considerable experience the technique of micro-satellite polymorphism using a set of primers recommended by the FAO (Annexure III) for the global genetic distancing project has been finalized under the Network Project on Animal Genetic Resources for genetic characterization of the cattle breeds.

The micro-satellites are the repeats of nucleotides (up to 10 bases) in the genome. In case of cattle and buffaloes the dinucleotide repeats are maximum followed by tetranucleotides. Among dinucleotide repeats also CA repeats are reported to be highest. The micro-satellites are less spontaneous to mutations and thus can be used to characterize a close population breed within a species. The primers have been selected for dinucleotide CA repeats. All these selected primers are amplifiable with GC content less than 50% and little changes of mutual dimerization.

The selected primers for micro-satellites are to be screened on 50 unrelated individuals of a breed. The detailed technical programme includes isolation of DNA, polymerase chain reaction and polyacrylamide-gel electrophoresis. The allelic frequencies are to be calculated by using gel documentation system.

Based on these allelic frequencies of various alleles with all the selected primers it is expected that various breeds within a species can be characterized.

Quantitative Trait Loci (QTL)

Most of the economically important traits of livestock are quantitative in nature and are controlled by a number of genes and influenced by environment. The genes influencing quantitative traits have pleiotropic effects and some are linked to each others. Selection of animals is being carried out by man since time immemorial for these quantitative traits. In the past selection was mostly based on stature/size of the animals and characters like body colour and horn type. The animal breeders/farmers were always interested in enhancement of economic returns from livestock rearing. The method of selection of animals has changed with the advance in knowledge of genetics. The selection method used was mostly based on biometrics technique based on the animals' own phenotypic performance or its relatives performance. However, these techniques need recording of performance of economic traits in large number of animals to have substantial genetic gain over the generations. Other limiting factors are that important economic traits in livestock are sex limited, i.e. expressed in one sex only, e.g. milk yield and egg production, or are measurable after the slaughter of the animal, e.g. meat quality. The measurement of quantitative traits in individuals also increases the generation interval thereby reducing the gain per year. Moreover, the large genetic variation and recording of information under different environmental conditions are also problems in following the traditional breeding practices. Besides, conventional breeding techniques do not facilitate exploitation of the individual gene influencing the quantitative traits.

If genetic and other effects on the traits are known at the DNA level, it would be possible to estimate breeding value of a quantitative trait without phenotypic observation of that animal. This would not only result in reduction of generation interval but also would have more reliability as the observations are not influenced by the environment.

Also many breeds in the world have reached the plateau and further improvement in the performance of these breeds has slowed down. Breeders have started looking for other tools such as genetic engineering wherein use of genetic markers can be of some use to them for improving the performance of their livestock. The information generated on polymorphic micro-satellite markers will also be useful for construction of genome map which would be important in mapping and cloning of major genes of economic importance. This genome map or genetic map in farm animals will help in identifying the cloned genes which are controlling number of traits of economic importance. Availability of such methods would remove the constraints which are being faced in the genetic map of the animals using conventional methods. It will also be possible to identify gene markers linked with major genes controlling qualitative traits and to use them for commercial selection programme. In the long term, such maps would also facilitate identification and isolation of genes, and creation of animals with pre-determined phenotype by direct manipulation of candidate genes. The confirmation of parentage record in progeny testing and genetic improvement can also be achieved using these markers. If a complete map of animals is available, it will be useful to identify QTL with desirable effect for various traits and selection can be much more effective, particularly for traits having low heritability, and also economical because animals can be selected at an early age for those traits expressed in the later part of the life on the base of QTL marker association.

Geldermann (1975) introduced the term quantitative trait locus (QTL) as a convenient acronym for a locus which affects performance of a quantitative trait. The same was described as economic trait locus (ETL) by George and Massey (1991) to emphasize the fact that marker-assisted selection (MAS) is concerned with economic traits in livestock improvement. MAS depends on identifying association between polymorphic genetic markers and linked QTL with useful effects. Its use may be family-specific, depending on the linkage phase and heterozygosity at the QTL, or apply across the population if there is linkage disequilibrium. The use of MAS in the genetic improvement of economic merit is limited by several factors. Some of these are: family-specific nature of information, erosion by recombination, incomplete tracking rates, site and complexity of the genetic formulation needed and statistical methods required. These limitations would be substantially reduced if close linkages of markers with QTL could be found.

The number of QTL with effect on a trait which are enough to be useful in MAS is likely to be small. The additive genetic effect (a) of QTL is measured (in standard deviation (SD) units) as half the difference in the economic trait between the homozygotes at that locus (Falconer, 1989). QTL with small effect are difficult to identify, estimation will be less precise and individually they will contribute little to the selection response. The loci with large desirable effect will be of high frequency due to selection. Both theoretical (Falconer, 1989) and deterministic simulation (Smith, 1982) results show that after 2-5 generations of selection for the economic traits, any gene of moderate or large effect would have been largely exploited. If the initial frequency of the favourable allele is low, then exploitation may take 5-10 generations. The number of QTL with moderate ($a = 0.5$ SD) effect is limited by the total genetic variation for the economic trait. The maximum possible number of QTL of moderate effect and intermediate gene frequency P ($0.1 < P < 0.9$) ranges from 1 to 20, with 2-10 covering most of the cases (Smith and Simpson, 1986).

Marker Assisted Selection (MAS)

Most of the authors agree that MAS is likely to complement rather than replace conventional selection systems leading to increase in rates of genetic change. MAS allows selection in early life or selection for sex limited traits. So far, the number of markers available for selection of QTL is limited and also there is little linkage disequilibrium to allow selection across the population. The QTL effects and recombination rates with markers can be estimated from data on many families using mixed model method (Kennedy *et al.,* 1992). To determine whether the QTL is segregating within a family and establishing the linkage phase will require a large number of progeny per family to be typed for the marker and tested for the economic trait (Weller *et al.,* 1990). With close linkage there will be more and more disequilibrium, and selection on the markers will become more effective. Close markers are of value both in the identification phase and in the utilization phase. They will allow to check the QTL and also give better estimate of its effect. This will also help to separate the recombination rate and the QTL effect, which tends to be confounded in the estimate of the QTL-marker association. The use of close markers in within-family selection will allow increase in accuracy of selection and lead to fewer recombination errors and less erosion of information across generations.

The micro-satellites are simple dinucleotide, trinucleotide and tetranucleotide repeats present in most eukaryotic genome. The polymorphism in these sequences stems from very large number of simple repeats present at given loci in individual genetic population. The high level of polymorphism and more or less even distribution of the simple repeats all over the genome combined with the use of polymorphic chain reaction for micro-satellite analysis have made them ideal markers for studying genetic structure of population and evolution for building up linkage maps. These markers will help in studying genetic diversity, identification of unique genetic resources for parentage confirmation and development of linkage map.

About 200-250 markers would be needed to provide (with 90% probability) a marker within an average of 10 cM of an individual QTL (Beckmann and Soller, 1983). The marker density should be sufficient for the initial detection of marker-QTL associations. The micro-satellite markers are highly polymorphic repeats that are present at a density of about 2-3 per 10^6 bp (Weber, 1990), and individual loci can be typed by PCR using specifically designed oligonucleotide primers. Screening for QTL associations is more efficient if there are many markers with known map positions, so that a subset can be chosen to give uniform spacing and high levels of heterozygosity.

Mapping QTL in Crosses between Segregating Populations

The QTL may be traced by crossing extreme lines, or of selected and exotic stocks. The QTL or markers linked to them may be detected in the segregating F_2 or back-crosses. The other route may be to use band sharing of multilocus probes of DNA fingerprints on the pooled DNA of high- and low-performing progeny of individual sires (Plotsky *et al.,* 1990). This information is sire family-specific. Unless there is linkage disequilibrium with the QTL and it has moderate to large effect on the trait these cannot be detected.

A number of theoretical advances have been taken place with particular relevance to marker-QTL mapping in cattle. Marker-QTL methods of application to the bovine genome have been considered in terms of mapping QTL within a particular population. This is appropriate for most traits of interest in cattle or other animals species, because such populations are generally polymorphic at both marker alleles and QTL. In some cases, however, breeds may differ radically in QTL affecting a particular trait, e.g. resistance to trypanosomiasis of the west African N'Dama breed of cattle or tick resistance of zebu cattle. In this case it is not possible to map the loci involved by within breed analyses, because genetic variation at the QTL is not present within either resistant or sensitive populations. In this case it is possible to cross the two breeds/populations and carry out marker-QTL linkage studies by following co-segregation of markers and traits within families, pooling results over many families.

Methods of Detecting QTL

Selective genotyping

This method helps in reducing the number of offsprings that need to be scored for markers by scoring increased number of offsprings for the quantitative traits. This is particularly important for dairy cattle, because quantitative data on large number of dairy cows are routinely collected for purpose of herd management and progeny testing. This method was based on the observation of Stuber *et al.* (1969), that selection of quantitative traits changed marker allele frequencies in segregating populations.

The QTL may be traced by crossing extreme lines, or selected and exotic stocks. The QTL or markers linked to them may be detected in the segregating F_2 or back-crosses. The other range may be to use band sharing of multilocus probes of DNA fingerprints on the pooled DNA of high and low performing progeny of individual sires (Plotsky *et al.*, 1990). This information is sire family-specific; unless there is linkage disequilibrium with the QTL and it has moderate to large effect on the trait these cannot be detected.

Grand daughter designs

The second method for reducing number of offsprings scored for markers, at the expense of increased numbers scored for the quantitative traits, is to progeny test the offspring to decrease the error variance of quantitative trait evaluation. Application to dairy cattle is based on the fact that a small number of elite sires father most of the young progeny-tested sires of any given generation. In this method, sons rather than daughters of a heterozygous elite sire are scored for markers and divided into two groups on the basis of the marker allele transmitted from their sire. Each son would then be progeny tested to estimate his quantitative trait value.

Present Status of QTL in Cattle

Several workers have analyzed QTL-marker linkage for various economic traits in cattle. Some of the significant observations are given below.

Bovenhuis (1992) estimated direct and linked effects of milk protein genes on milk production traits. Significant effects of beta-lactoglobulin genotypes on fat percentage were observed. The beta-lactoglobulin B allele was associated with a higher fat content. Animals carrying beta-lactoglobulin AIB genotype had a higher fat content. Kappa-casein and beta-casein genotypes had significant effects on protein percentage.

Rocha *et al.* (1992) observed that 3 growth hormones-Taq1 alleles, viz. B, C and D, are associated with decrease in birth weight and shoulder width of calves at birth. Cows homozygous for the B, C or D alleles gave birth to calves that were 4.0 kg lighter than calves of cows homozygous for A allele.

Georges *et al.* (1993) reported that a genetic disorder, progressive degenerative myoencephalopathy (weaver disease) in cattle was associated with increased milk production. This association resulted from a pleiotropic effect of a single gene, or from linkage disequilibrium between the gene causing weaver disease and a QTL for milk yield. A micro-satellite locus (TGLA116) closely linked to weaver gene was identified.

Georges *et al.* (1994) studied genotypes of 1,518 progeny tested sires from 14 paternal halfsib families using 159 autosomal micro-satellites markers. The result showed strong evidence of linkage between these micro-satellites and loci controlling yields of milk, fat and protein. Each of the mapped QTL affected the traits differently: the QTL on chromosome 9 increased milk yield without affecting fat or protein content; the QTL on chromosomes 6 and 20 increased milk yield and reduced fat and protein percentages; the QTL on chromosomes 1 and 10 increased milk yield but seemed to have opposite effects on milk composition. Ron *et al.* (1993) typed 7 sires and 101 sons from a dairy cattle population, suitable for determining linkage of a QTL by grand daughter design for 5 micro-satellites. The mean number of alleles per locus was 8.2. They concluded that compared with diallelic markers, the use of multiallelic micro-satellites for the detection of QTL would enable at least 60% grandsire families to be included in the analysis and the number of sons typed to be reduced by 40%. Kuhn *et al.* (1996) analyzed 5 German Holstein halfsib families, using grand daughter design to detect QTL for milk production traits. They observed significant differences in mean breeding values between sons receiving alternative alleles in 3 families. The results also suggested the existence of a quantitative trait locus with positive effects on milk yield and fat and protein yields in close proximity to 2 markers.

Freyer *et al.* (1996) used loci controlling alpha1-, beta- and Kappa-casein as markers. The QTL effect on milk, fat and protein yields estimated by maximum likelihood method was significant. Liu *et al.* (1994) also detected significant QTL effects for milk and protein yields.

Hetzel *et al.* (1997) typed 16 micro-satellite markers in 7 large halfsib US Holstein cattle families using grand daughter design. Potential QTL for somatic cell score, fat yield, fat percentage, protein yield and protein percentage were identified. The result supported the presence of QTL for milk yield and protein yield on chromosome 21.

Moody *et al.* (1997) reported that reasonable power (P>0.75) could be achieved using a grand progeny design for QTL having moderate effects (0.3 SD) on weaning weight and large effects (0.4-0.5 SD) on birth, yearling and maternal weaning weights by genotyping 500 animals.

Taylor *et al.* (1998) used PCR primers that amplify a 441 bp fragment of GHI to screen a cattle bacterial artificial chromosome (BAC) library comprising 60,000 clones and with a 95% probability of containing a single copy sequence. Micro-satellite KHGH1 was isolated from BAC-110R2C3 and scored in 529 reciprocal backcross and F_2 fullsib progeny from 41 resource families derived from American Angus and Brahman cattle. Interval analysis localized effects of Angus vs Brahman alleles on subcutaneous fat and the percentage of ether-extractable fat from the longissimus to the region of BTA19 containing GH1.

Grupe and Schwerin (1998) studied the genotype of 527 bulls of 10 paternal halfsib families for 7 micro-satellite loci covering 81cM of chromosome 23. They reported that locus BoLa ADRB3 accounted for approximately 5 and 3% of the additive genetic variance for dystocia and stillbirths respectively. They also observed QTL on telomeric region of chromosome 23 affecting milk yield and milk-fat, and the magnitude of the effects were 1.2 and 4.5% respectively.

Davis *et al.* (1998) collected data from 599 progeny of F_1 Charolais × Brahman sires mated to dams from a composite population for birth weight and genotyped these animals for 167 DNA markers. They detected QTL for birth weight on 5 chromosomes: 5, 6, 14, 18 and 21. The estimates of allele substitution effects ranged from 1.8 to 3.8 kg. The QTL detected accounted for 31-40% of phenotypic variance within sire families.

Mosig *et al.* (1998) used pooled DNA from daughters of 7 sires for marker analysis. The DNA pools were genotyped for 38 markers on chromosomes 1-17 and the marker spacing was 30 cM. They observed highly significant associations with milk protein percentage for 9 markers. Statistical analysis showed that selective pooling of DNA was able to access 81% of the information that would have been available through individual selective genotyping or total population genotyping. Lipkin *et al.* (1998) also reported that selective DNA pooling accessed 80.6 and 48.3%, respectively, of this information that would have been available through individual selective genotyping or total population genotyping. Lindersson *et al.*(1998) used grand-daughter design to estimate marker-QTL linkage for 5 milk production traits and observed significant effects of QTL on fat and protein percentage.

Several genes with major effects on economic traits in domestic animals have been identified. Methods have been developed for screening of dairy cattle population systematically for each gene. The large network for progeny testing in cattle for sire evaluation provide quantitative traits data and also provide pedigree information. The QTL-marker linkage has given an opportunity to select animals at very early age. It is a matter of time when QTL analysis data will be routinely utilized along with conventional selection methods to bring faster genetic improvement in economic traits of livestock.

□

ANNEXURE I

EVALUATION OF BREEDS UNDER FIELD CONDITIONS

Questionnaire 1. General information about the householder and animals

---

Date of visit: .... District/Stratum: .... Code: ....
Tehsil/Taluka/Zone: .... Village: ....
Code: .... Household Number: ....
Name & Address...
Name of Enumerator: ....

I. General Information

Ag. holding (ha): ....
Irrigated (ha): ....
Unirrigated (ha): ....
Fodder grown: Yes (1) / no (2): Winter: .... Summer: ....
Profession: ....
Annual income (Rs.): ....
No. of family members:
No. of literate members: .....
No. of members engaged in dairying: Male: .... Female: .....
Sale / purchase of animals: 1) Animal fair: .....
2) Middle man: .....
3) Any other: ....

II. Utility

	Cattle	Buffalo
1. Milk production	....	....
2. Agricultural operation:	....	....
3. Breeding:	....	....
4. Religion:	....	....
5. Any other:	....	....

III. Management Practices

Housing

during day (1) / night (2)/ both day and night (3) / none (4): ......
a) Open (1) / closed (2): ..... b) *Kutcha* (1) / *Pucca* (2): ....
c) Separate (1) / part of residence (2): ....d) Flooring: *Kutcha* (1) / *Pucca* (2):
e) Full walled (1) / half walled (2): ...... f) Well ventilated: yes (1)/no (2): .....

g) Sanitary condition of the stall: very clean: Yes (1) / no (2): ....
h) *Pucca* drain for urine to drain out: Yes (1) / no (2): ....

Wallowing

Morning:	Noon:	Evening: ......
Yes (1) / no (2)	Yes (1) / no (2)	Yes (1) / no (2)

Fodder Grown (Yes / no)

<u>Green Fodder</u>	<u>Dry Fodder</u>
Winter:	Winter: ......
Summer:	Summer: ......
Chaffed (1) / unchaffed (2): ...	Chaffed (1) / unchaffed (2): ...

Feed

Seeds/grains: .... Cakes/concentrate: ......
Others: .... Feeding: Soaked/cooked/raw: ....
Feeding: Mixing with fodder / alone: .... At milking time/other times: ......
Cleaning of milking utensils: Yes (1) / no (2): ....
Udders washed before milking: Yes (1) / no (2): .....

Health

Disease	Treatment	Herbal (1) / Allopathic (2) / Local (3)
....	....	....
....	....	....
....	....	....
......	....	....
......	....	....

Vaccination

....
....
....
....
....
....

Breeding method: Natural (1)/ artificial Insemination (2)

HERD STRENGTH

Species/	Up to 1 year		1-3 years		3 years and above					
Breed	Male	Female	Male	Female	Male			Female		
					Breeding	Breeding and work	Work only	In milk	Dry	Not calved even once
Cattle										
Buffalo										
Others										

Questionnaire 2. Feeds and feeding practices (individual animals)

Date of visit: .... District/Stratum: .... Code: ....
Tehsil/Taluka/Zone: .... Village: ....
Code: .... Household Number: ....
Name & Address..
Name of Enumerator: ....
Allotted No. .... Breed: .... Classification: ....
Date of birth: .... Age...............
Dam No.: .... Sire No.: ....

Feeding

a) Grazing

	Distance (km)	Time (hr)
Morning (1)	....	....
Evening (2)	....	....

b) Individual (1) / Group feeding (2)...........

c) Feed

	Morning		Noon		Evening	
	Name	Qty (kg)	Name	Qty (kg)	Name	Qty (kg)
Green fodder	.....	.....	.....	.....	.....	.....
Dry fodder	.....	.....	.....	.....	.....	.....
Concentrate	.....	.....	.....	.....	.....	.....
Minerals	.....	.....	.....	.....	.....	.....

d) Water: Adequate (1) / inadequate (2): .... Qty: ....
Water source (name): ....

e) Feeding (green fodder/dry fodder)
  a) Green fodder mixed in dry fodder: ....
  b) Drying method of fodder: ....
  c) Silage making: ....

Questionnaire 3. Physical and qualitative traits (individual animals)

Date of visit: .... District/Stratum: .... Code: ....
Tehsil/Taluka/Zone: .... Village: ....
Code: .... Household Number: ....
Name & Address..
Name of Enumerator: ....
Allotted No: .... Breed: .... Classification: ....
Date of birth: .... Age...............
Dam No.: .... Sire No.: ....
Purpose of breeds: milk (1) / meat(2) / draught(3) / others (specify): ....

Hair characters

a. Length Short(1) / medium(2) / long(3): ......
b. Sheen Glossy (1) / dull(2): ....
c. Curl Curly (1) / straight(2): ....

Colour

a. Coat (hair): ....
b. Skin: ....
c. Muzzle: ....
d. Eyelids: ....
e. Hoofs: ....
f. Tail switch: ....

Horns

Present (1)/absent (2)

a. Colour: Black (1)/ brown (2)/ white (3)/ others (specify): ....
b. Size (cm): ....
c. Shape: Straight (1)/ curved (2): ....
d. Orientation: ....
e. Lateral pointing tips (1)/ inward pointing tips (2)/upward pointing tips (3)/ downward pointing tips (4)/ forward pointing tips (5)/backward pointing tips (6): ....

Ears

a. Length(cm): .....
b. Orientation: horizontal(1)/dropping(2): ....

Head

a. Length(cm): ....
b. Poll prominent (1)/not prominent (2): ......
c. Any other peculiar character (specify): ....

Body

a. Hump: large (1)/medium (2)/small (3): ....
b. Dewlap: large (1)/medium (2)/small (3): .....
c. Navel flap: large (1)/medium (2)/small (3): .....
d. Penis sheath flap: large (1)/medium (2)/small (3)/absent (4): .....
e. Basic temperament: docile (1)/moderate (2)/tractable (3)/wild (4): ....

Udder

a. Shape: bowl (1)/round (2)/trough (3)/pendulous (4): ....
b. Fore udder size: large (1)/medium (2)/small (3): .....
c. Rear udder size: large (1)/medium (2)/small (3): .....
d. Teat shape: cylindrical (1)/funnel (2)/pear (3): .....
e. Teat tip: pointed (1)/round (2)/flat (3): .....
f. Milk vein: large (1)/medium (2)/small (3): .....

Body size

Massive/large/medium/small

Weight (kg)	Measurements
a. Birth weight:	a. Chest girth (cm): ......
b. 6-month weight:	b. Body length (cm): ......
c. 12-month weight:	c. Height at withers: .....
d. 24-month weight:	d.Tail length (above hock/at hock/ below hock/ touching the ground)
e. Weight at Ist mating:	
f. Weight at Ist calving:	

Reproduction (females)

a. Age at 1st oestrus (months): ......
b. Oestrous cycle duration (days): ......
c. Oestrus duration (hr): ......
d. Age at first mating (months): .....
e. Age at first calving (months): .....
f. Interval from calving to first conception (days): .....
g. No. of services/conception: ......
h. Calving interval (days): .....
i. Gestation length (days): ......
j. No. of calvings: ......

Reproduction (males)

a. Age at training of bull: .....
b. Age at first ejaculation/mounting (days): ....
c. Age at first mating (N. S.): .....
d. Age at first collection of quality semen (AI): ....

Abnormalities

a. Twinning: ....
b. Dystocia: ....
c. Placental retention: .....
d. Abortions: ....
e. Stillbirths: .....
f. Post-gestational mortality: .....
g. Others (specify): ......

Type of work

a) Drought tolerance
(allocate grades 1 to 5, 1=high)
b) Heat tolerance
(allocate grades 1 to 5, 1=high)
c) Purpose: ploughing (1)/threshing (2)/power (3)/etc.
d) Capacity for work: hard (1)/medium (2)/light (3)
e) Average duration of work per day (hr): ....

Questionnaire 4. Milk Recording

Name: .... s/o: .... Village: ....
Block: .... District: .... Milk recorder: ....
Animal No: ....Breed: .... Date of Birth/Age: ....
Home-bred/purchased: ....

1. Age at first service: ....
2. Order of lactation: ....
3. Age of first conception: ....
4. Date of calving: ....
5. Age/date at first calving: ....
6. Sex of calf & number: ....weaned/unweaned
7. Date of conception: ....
8. No. of services: .... Natural/A.I
9. Date of drying: ....

No	Date of recording	Milk yield			Fat%	SNF	Remarks
		Morning	Evening	Total			
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
Total							

ANNEXURE II

BREED DESCRIPTOR

I. General Description

1. Name of the breed
2. Background for such a name
3. Species name
4. Most closely related breeds
   (in appearance)
5. Since when the breed is known
6. a. Native tract of distribution in terms of longitude and latitude
   b. Approximate area of distribution (in km^2)
7. a. Communities responsible for developing the breed
   b. Description of community (farmers/nomads/isolated/tribals)
8. Native environment
   a. Soil description
   b. Average temperature (10 years record)
   c. Minimum temperature: .... month of minimum: ....
   d. Maximum temperature: .... month of maximum: ....
   e. Average humidity
   f. Minimum humidity: .... month of minimum: ....
   g. Maximum humidity: .... month of maximum: ....
   h. Annual rainfall
   i. Peak rain: .... month of peak: ....
   j. Annual duration of rain in months
   k. Annual duration of drought
   l. Annual duration of flood
   m. Elevation of land: .... mean: .... range: ....
   n. Sub-soil water depth during summer (in metres)
   o. Sub-soil water depth during rainy season (in metres)
   p. Forest area (in km^2)
   q. Wet cultivated area
   r. Dry cultivated area
   s. Uncultivated area
   t. Main cultivated cereals
   u. Main cultivated pulses
   v. Other crops

9. Feed
    a. Major fodder trees
    b. Major fodder shrubs
    c. Major native fodder grass
    d. Cultivated legume fodder and monocot grass
    e. Cultivated tubers
    f. Source of dry fodder
    g. Seed and grain feed
    h. Cakes and other concentrates
    i. Any reported deficiency of minerals in water
    j. Any reported minerals in harmful quantity and source
10. Housing
    a. Only during the day
    b. Only at night
    c. Day and night
    d. None
    e. Type of housing
11. Herd size
    a. Number of breeding females
    b. Number of replacement females
    c. Number of bullocks
    d. Number of calves
12. Mating method
    a. Natural service (%)
    b. Artificial insemination (%)

II. Physical Characters

1. *Colour*	Male	Female
a. Coat colour		
b. Skin colour		
c. Muzzle		
d. Eyelids		
e. Tail		
f. Hooves		

2. *Horns*	Male	Female
a. Colour		
b. Size		
c. Shape (straight/curved)		
d. Orientation		

3. *Ears*
   a. Length
   b. Orientation (horizontal/drooping)
4. *Head*
   a. Forehead (convex/concave/straight)
   b. General description

5. *Body*	Male	Female
a. Hump (large/medium/small)		
b. Dewlap (large/medium/small)		
c. Navel flap (large/medium/small)		
d. Penis sheath flap		
e. Basic temperament		

6. *Udder*
   a. Shape (bowl/round/trough/pendulous)
   b. Fore-udder size (large/medium/small)
   c. Rear-udder size (large/medium/small)
   d. Teat shape (cylindrical/funnel/pear)
   e. Teat tip (pointed/round/flap)
   f. Milk-vein (large/medium/small)

III. ***Performance***

1. *Body Weight* (kg)	Male	Female
a. Birth weight		
b. Pre-weaning weight		
c. 12-month weight		
d. 24-month weight		
e. Weight at first mating		
f. Weight at first calving		

2. *Body Measurements*	Male	Female
a. Chest girth		
b. Body length		
c. Height at withers		

3. *Dairy Performance*			Lactation		
	I	II	III	IV	Pooled
a. Daily milk yield					
b. Peak milk yield					
c. Days to reach peak yield					
d. Lactation length					
e. Lactation milk yield					

f. Fat %
g. SNF %
h. Milking rate (litres/min.)
i. Productive life span (month)
j. Dry period
k. Feed conversion for milk
l. Percentage of animals in different lactations

4. *Reproduction*
   a. Males
      (i) Age at first ejaculation (days)
      (ii) Age at first mating (days)
   b. Females
      (i) age at first oestrus
      (ii) oestrous cycle duration (days)
      (iii) oestrus duration (hr)
      (iv) age at first mating
      (v) age at first calving
      (vi) interval from calving to first conception
      (vii) conception rate
      (viii) No. of services per conception
      (ix) service period
      (x) calving interval and range
      (xi) gestation length and range
      (xii) twinning percentage
      (xiii) dystocia percentage
      (xiv) placental retention (%)
      (xv) abortions (%)
      (xvi) stillbirths (%)
      (xvii) post-gestational mortality (%)

5. *Type of Work*
   a. Purpose (ploughing, threshing, power etc.)
   b. Capacity for work (hard/medium/light)
   c. Average duration of work per day (hr)
6. *Drought Tolerance*
   (Allocate grades 1-5, 1= high)
7. *Heat Tolerance*
   (Allocate grades 1-5, 1= high)

8. *Diseases and Parasites*

ANNEXURE III

LIST OF PRIMERS OF SELECTED MICRO-SATELLITE MARKERS

Marker	Chromo-some	Primer sequences (5'-3')	Reference*
1. ETH 225 (D9S1)	9	GATCACCTTGCCACTATTTCCT ACATGACAGCCAGCTGTACT	Steffen *et al.* (1993)
2. ETH152 (D5S1)	5	TACTCGTAGGGCAGGCTGCCTG GAGACCTCAGGGTTGGTGATCAG	Steffen *et al.* (1993)
3. HELI 15 (D15S10)		CAACAGCTATTTAACAAGGA AGGCTACAGTCCATGGGATT	Kaukinen &Varvio(1993)
4. ILSTS005 (D10S25)	10	GGAAGCAATGAAATCTATAGCC TGTTCTGTGAGTTTGTAAGC	Brezinsky *et al.* (1993a)
5. HEL5 21 (D21S15)		GCAGGATCACTTGTTAGGGA AGACGTTAGTGTACATTAAC	Kaukinen and Varvio (1993)
6. INRA005[2] (D12S4)	12	CAATCTGCATGAAGTATAAATAT CTTCAGGCATACCCTACACC	Vaiman *et al.* (1992)
7. INRA035 (D16S11)	16	ATCCTTTGCAGCCTCCACATTG TTGTGCTTTATGACACTATCCG	Vaiman *et al.* (1994)
8. INRA063 (D18S5)	18	ATTTGCACAAGCTAAATCTAACC AAACCACAGAAATGCTTGGAAG	Vaiman *et al.* (1994)
9. MM8 2 (D2s29)		CCCAAGGACAGAAAAGACT CTCAAGATAAGACCACACC	Mommens *et al.* (1994)
10. HEL9 (D8S4)	8	CCCATTCAGTCTTCAGAGGT CACATCCATGTTCTCACCAC	Mommens *et al.* (1994)
11. CSRM60 (D10S5)	10	AAGATGTGATCCAAGAGAGAGGCA AGGACCAGATCGTGAAAGGCATAG	Moore *et al.* (1994)
12. CSSM66[3] (D14S31)	14	ACACAAATCCTTTCTGCCAGCTGA AATTTAATGCACTGAGGAGCTTGG	Barendse *et al.* (1994)

13. HAUT24 (D22S26)	22	CTCTCTGCCTTTGTCCCTGT AATACACTTTAGGAGAAAAATA	Harlizius (pers. comm.)
14. HAUT27 (D26S21)	26	TTTTATGTTCATTTTTTGACTGG AACTGCTGAAATGTCCATGTTA	Harlizius (pers. Comm.)
15. ETH3 (D19S2)	19	GAACCTGCCTCTCCTGCATTGG ACTCTGCCTGTGGCCAAGTAGG	Solinas Toldo *et al.* (1993)
\16. ETH10[4] (D5S3)	5	GTTCAGGACTGGCCCTGCTAACA CCTCCAGCCCACTTTCTCTTCTC	Solinas Toldo *et al.* (1993)
17. INRA032[5] (D11S9)	11	AAACTGTATTCTCTAATAGCAC GCAAGACATATCTCCATTCCTTT	Vaiman *et al.* (1994)
18. BM2113 (D2S26)	2	GCTGCCTTCTACCAAATACCC CTTAGACAACAGGGGTTTGG	Bishop *et al.* (1994)
19. BM1818 (D23S21)	23	AGCTGGGAATATAACCAAAGG AGTGCTTTCAAGGTCCATGC	Bishop *et al.* (1994)
20. ILSTS006 (D7S8)	7	TGTCTGTATTTCTGCTGTGG ACACGGAAGCGATCTAAACG	Brezinsky *et al.* (1993b)
21. ILSTS030 (D2S44)	2	CTGCAGTTCTGCATATGTGG GACCTGGTTTAGCAGAGAGC	Kemp *et al.* (1995)
22. ILSTS034[4] (D5S54)	5	AAGGGTCTAAGTCCACTGGC GACCTGGTTTAGCAGAGAGC	Kemp *et al.* (1995)
23. ILSTS033[2] (D12S31)	12	TATTAGAGTGGCTCAGTGCC ATGCAGACAGTTTTAGAGGG	Kemp *et al.* (1995)
24. ILSTS011[3] (D14S16)	14	GCTTGCTACATGGAAAGTGC CTAAAATGCAGAGCCCTACC	Brezinsky *et al.* (1993c)
25. ILSTS054[1] (D21S44)	21	GAGGATCTTGATTTTGATGTCC AGGGCCACTATGGTACTTCC	Kemp *et al.* (1995)

* fide FAOs' MoDAD project: Micro-satellite markers for the analysis of genetic distances in domestic animal species. *http:dad.fao.org/dad-is/data/molecula/modad.htm*

9 BREED IMPROVEMENT PROGRAMMES

In the beginning of the twentieth century it was realized that a large number of good breeds of cattle and almost all the breeds of buffaloes which could provide a good foundation stock under the improvement programmes were available in India. The Royal Commission on Agriculture recommended that since rearing of bulls would not be remunerative for the farmers, the Government should build herds of pedigree cattle for production of superior bulls in large numbers. The establishment of livestock farms was a major step in this direction. In 1938-39 there were 53 cattle-breeding farms which have now increased to about 150. The objectives of these farms are to produce and preserve pure strains of indigenous animals and to improve nucleus herds of these breeds. These farms produce superior bulls of known pedigree and performance. These bulls are not only used for production of semen under AI programme but also for distribution in the field. A number of schemes and programmes were introduced in the field for improvement of livestock.

CENTRAL HERD REGISTRATION SCHEME (CHRS)

Registration of cattle is considered to be one of the essential steps towards the improvement of their economic traits. The herd registry associations came into existence in various countries in the 19th Century and an international convention on the subject was held in Rome in October 1936. India adopted the main recommendation, viz. there should be only one herd book for a single breed in each country. This provision was made particularly to avoid conflicting standards or methods of recording within the same country, which may give different interpretation in the international exchange of animals. This also ensures uniformity in the system of recording, enabling a correct assessment of the value of animals from its records. Necessary steps are taken to lay down breed and production standards for several recognized breeds of national importance and to open their herd books.

Herd book is a list of animals which qualify the conditions of production and breed characteristics, laid down under Herd Book Rules & Regulations. Through this process of certification meritorious pure breed animals are brought on books, thus including selective breeding on a larger scale resulting in greater multiplication of superior stock. Registration is also a certificate of quality to help the breeders in sale and purchase of the breeding stock. Registration of cattle is the important part of cattle development activities and improving their economical characters.

In 1941, the Indian Council of Agricultural Research established a nucleus organization for the registration of important breeds. By 1949, herd-books had been started for Sindhi, Sahiwal, Tharparkar, Hariana, Gir, Ongole, Kangayam and Kankrej breeds of cattle, and for Murrah buffaloes. This scheme was extended to breeding tracts of important breeds during the Third Five-Year Plan to organize breeders' societies and to encourage them to take up this work through their own societies. One such unit was set up at Rohtak in 1963-64 for Hariana cattle and Murrah buffaloes covering Haryana, western Uttar Pradesh, north-eastern parts of Rajasthan and Delhi. A similar unit was set up at Ahmedabad in Gujarat in 1969 for Gir and Kankrej cows.

Registration Procedure

On receipt of the application on prescribed proforma from the breeder, the animal is primarily selected within one month of calving. Stockman records the first milk yield. He immediately informs the concerned Field Inspector and also the Assistant Registrar about his selection.

The Field Inspector is under obligation to visit the animal within 2 months of first recording for confirmation of breed characteristics and in case he is satisfied he inserts a brass bottom in the ear bearing the identification number of the animal. The Stockman thereafter continues to record morning and evening milk yield exactly at 28 days intervals till the animal becomes dry. One or two test checkings of milk yield/recording could be conducted by the Field Inspector and/or by the Assistant Registrar of the Scheme/officials of the State Animal Husbandry Directorate for individuals under recording during the entire lactation.

After approval of the Ministry the Final Registration Programme is arranged in consultation with the State Animal Husbandry Department. The Registration Committee examines the recordings and also verifies the breed characteristics and identification of the animals. The animals finally approved are branded on the horn as token of having been approved.

Formula for calculation of estimated lactation yield

$$\text{Estimated lactation} = \frac{\text{Summation or recorded yield in kg}}{\text{Total No. of recordings}} \times \begin{array}{l}\text{305 days or actual} \\ \text{number of days in} \\ \text{lactation which-} \\ \text{ever is less}\end{array}$$

Registration standards

To qualify for registration, the animal, besides being true to its breed characteristics in respect of type, colour, etc., must produce a minimum quantity of milk during a lactation of 300 days. Initially, the standards were set as: Sahiwal, 1,700 kg; Red Sindhi, 1,400 kg; Tharparkar, 1,400 kg; Hariana, 1,100 kg; Gir, 1,100 kg; Kankrej, 700 kg; Ongole, 700 kg; Kangayam, 500 kg; and Murrah, 1,400 kg.

The criteria for registration of animals have been revised from time to time taking into consideration the utility of the breed and the improvement in production levels over the years. The performance of the Central Herd Registration Scheme was reviewed in February 1998 and the following recommendations were made:

(a) It was decided that the CHRS should henceforth aim at registering elite animals only so as to identify the best germplasm. These should then be procured by the National Semen Grid or its state components for breed improvement. The revised criteria for registration as laid down by the Ministry is given in Table 14.

Table 14. Revised criteria for su pport to farmers for rearing elite indigenous bovines (1997-98)

Species	Breed	Revised criteria (milk yield in kg)	
		Category I	Category II
Cattle	Gir	3,500 & above	3,000 to 3,499
	Hariana	2,700 & above	2,500 to 2,699
	Kankrej	3,000 & above	2,700 to 2,999
	Ongole	2,500 & above	2,250 to 2,499
Buffalo	Murrah	3,800 & above	3,200 to 3,799
	Jaffarabadi	4,000 & above	3,200 to 3,999
	Mehsani	3,300 & above	3,000 to 3,299
	Surti	2,900 & above	2,700 to 2,899

(b) It was also decided that the CHRS should expand its activities and cover the entire breeding tract of a particular breed. Following incentives were also recommended for maintaining the elite calves as well as the elite mothers under registration:

Category I

-Rs 1,000 per year for the dam for 4 years to cover expenses on insurance cost, breeding inputs as well as treatment/vaccination.

-Rs 2,000 for the male calf during the first year as support towards feeding and rearing cost, health cover, insurance cost, breeding inputs as well as treatment/ vaccination.

-All subsequent male calves born out of animals falling in category I will be eligible for this support.

-The CHRS will enter into an agreement with the recipient of the support who would be required to rear male calves of elite dams up to the age of 2 years.

Category II

-Farmers whose animals are fit to be registered but do not qualify for the support money would be given consolation prizes of Rs 500 per animal.

(c) Bulls used for natural service in the area would also be registered on the basis of breed characteristics and production criteria fixed for that breed.

KEY-VILLAGE SCHEME

This scheme was launched on all-India scale in the First Five-Year Plan to meet the shortage of bulls. A key-village unit is defined as an area covering a group of contiguous villages having a population of 1,000 cows and buffaloes. All inferior males are castrated or removed and the required number of exotic bulls are located in the area. Simultaneously, measures are directed to protect animals against prevalent contagious diseases and improve feeding, management and marketing facilities to get the produce sold to the best advantage of the producer. A key-village may thus be regarded as a co-operative or a collective farm, which gives advice to the villagers. Records of breeding, feeding, milk production and disease incidence are maintained by the staff appointed by the Government.

A group of 6 to 10 such key-village units form a key-village block having an artificial insemination station. Semen is supplied from the main centre to all these units to provide better breeding facilities. At present there are 550 key-village blocks of different sizes.

INTENSIVE CATTLE DEVELOPMENT PROJECT

Cattle development programmes started earlier could not make much impact on improvement of stocks because of lack of sufficient inputs and proper marketing facilities. An area development approach, popularly known as Intensive Cattle Development Project (ICDP), was started in 1966-67 as special development programme - Crash Programme. It was envisaged to cover 0.1 million cows/she buffaloes and take under each project care of all aspects of cattle development such as breeding, feeding and health control duly supported with extension activities. Each project is linked with a dairy project to provide marketing facilities. The programme was expected to achieve a breeding coverage of about 70% of the cattle population of each project and an increase in milk production by about 30% over a period of 5 years. There are about 130 ICDPs at present.

PROGENY-TESTING SCHEME

A progeny-testing scheme was started in the Third Five-Year Plan to ensure production and identification of superior bulls tested on the basis of performance of their progenies rather than dam's yield. The tested bulls were used extensively through AI for achieving higher genetic gain. This programme was first started with Hariana and Murrah breeds at Hisar (Haryana). The following farms were selected for initiating progeny-testing programme during the Fourth Five-Year Plan:

1. State Cattle Breeding Farm, Chakganjaria, Lucknow, Uttar Pradesh	Sahiwal
2. State Cattle Breeding Farm, Durg, Madhya Pradesh	Sahiwal
3. State Cattle Breeding Farm, Bharatpur, Rajasthan	Hariana
4. State Cattle Breeding Farm, Hosur, Tamil Nadu	Red Sindhi
5. State Cattle Breeding Farm, Junagarh, Gujarat	Gir
6. State Cattle Breeding Farm, Banvasi, Andhra Pradesh	Murrah

Buffalo improvement through progeny testing was taken up at several state and central government livestock farms, e.g. for Murrah breed at Alamadi Farm, Madras (Chennai); Government Livestock Farm, Banavasi; Government Cattle Breeding Farm, Anjora; and Government Livestock Farm, Hisar (presently Central Institute for Research on Buffaloes); and Surti breed at the Government Livestock Farm, Dhamrod. Progeny-testing programmes were also started at Government Livestock Farms, Babugarh and Madhurikunj, Uttar Pradesh. At none of these farms, this programme could yield desired results mainly because of small herd size, absence of proper recording system, etc. and ultimately it was suspended.

ALL-INDIA CO-ORDINATED RESEARCH PROJECT (AICRP)

Cattle

A co-ordinated research project on cattle breeding was launched by the Indian Council of Agricultural Research with the objective of evolving high-yielding cattle breeds which could suit local environments in different agro-climatic zones and have high breeding efficiency. It involved crossing of indigenous cattle breeds like Hariana, Ongole, Gir, Tharparkar, Sahiwal, Red Sindhi and local with superior exotic breeds like Holstein-Friesian, Jersey or Brown Swiss. A Central Frozen Semen Bank was set up at Hessarghatta (Karnataka) for collection, processing, storage and transport of frozen semen. The AICRP had also the mandate for assessing the production and reproduction performance of the crossbreds in different regions, and ascertaining the effectiveness of the level of exotic inheritance and the impact of *inter-se* breeding crossbreds at different levels so as to determine the best genetic groups. The results indicated that 3/4th breeds produced from the different exotic breeds did not perform better than halfbreds due to various disease and management problems (Bhattacharya, 1984).

The crossbreds maintained between 50 and 62.5% level of exotic inheritance performed better than all other exotic crosses. Therefore, it has been recommended that crossbred progenies (F_1) should be covered with crossbred bulls having 50 to 62.5% exotic inheritance level under field conditions. Crossbreeding with superior exotic dairy breeds, especially Holstein and Jersey, is being resorted to for increasing milk production. However, in Kerala, the Brown Swiss is also being used under the cross-breeding programme.

Buffalo

The Indian Council of Agricultural Research realizing the importance of buffaloes as a dairy animal and with a view to pool the resources available to test large number of bulls at different locations, started the All-India Co-ordinated Research Project on Buffaloes in 1970 at 4 centres, viz. National Dairy Research Institute (NDRI), Karnal; Punjab Agricultural University (PAU), Ludhiana; University of Agricultural Sciences (UAS), Dharwar; and University of Udaipur, Vallabhnagar. The main objective of this programme was to identify bulls of high genetic merit through progeny testing. Young bulls produced by mating proven bulls with elite buffaloes will be distributed to various farms in the country. Ludhiana and Karnal centres were given the responsibility of the Murrah breed, and the other two centres of the Surti breed. During the V Plan major emphasis was given to transfer of technology and field units were attached to each of the 4 centres for testing of sires.

Each of the 4 centres would maintain 220 breedable females and a separate elite herd of 70 buffaloes. Prior to 1980 the technical programme envisaged evaluation of 8 bulls at each centre; of these 2 were to be finally selected for mating with an elite herd. Since 1980, 12 sires were to be used for test mating every 2 years in the 2 herds for each type of buffaloes. The best 2 bulls were to be selected for mating in the elite herds of Karnal and Ludhiana, as one unit for large-sized breed, and of Vallabhnagar and Dharwad as a unit for medium-sized breed. It was also recommended to cover a breedable female population of 3,000-4,000 animals in field units attached to each centre. Semen of each bull was to be used both in the herds and the 2 field units simultaneously. It was recommended that a minimum of 2,000 doses of semen of each bull would be frozen and 700 doses of each bull would be distributed among the 2 herds and other associated herds. The bull then should be disposed off for utilization by any other service organization. It was also recommended to intensify the sire evaluation programme by using associated herds besides the existing centres of the project on a voluntary basis. The technical programme was modified in 1985. Dharwad and Vallabhnagar centres were advised to keep only the Surti breed while the NDRI and the main centre of the Central Institute for Research on Buffaloes, Hisar were asked to co-operate in progeny-testing programme for the Murrah. The PAU, Ludhiana Centre was asked to change over to the Nili-Ravi and collaborate with the Nabha centre of the CIRB which would also maintain the Nili-Ravi in place of the existing herd of the Murrah breed.

ASSOCIATED HERD PROGENY TESTING PROGRAMME

The institutional programmes on progeny testing did not yield desired results mainly because of small herd size, thereby allowing a few sires to be tested. This problem was solved by associating in this programme different herds spread over different localities and testing sires simultaneously on all the herds. This increases the accuracy of selection and also allows more number of sires to be tested. The genotype × environment interaction is also taken care of. So far the programme has been initiated for 3 breeds, viz. the Sahiwal, under the leadership of the National Dairy Research Institute, Karnal; and the Ongole and Hariana breeds under the Project Directorate of Cattle, Meerut. The population of the Sahiwal breed in various herds is around 3,000 breeding females. The herd size varies from 50 to about 250 breeding females, spread over a number of locations. Initially 3 locations were involved. Later on some more herds were added to the programme. Most of these herds had varying levels of inbreeding, ranging from 0 to about 12%. Average milk production in 305 days was about 1,600 kg, body weight at first calving around 320 kg, and mature weight 360 kg. Calving interval is 450 days and herd life about 9 years. At present, this programme is going on in 3 herds, one each at NDRI, Karnal, State Cattle Breeding Farm, Durg, and State Cattle Breeding Farm, Chakganjaria, Lucknow. All other herds at Hisar, Meerut, Nabha and Nagpur have been left out because of small herd size.

It was decided that for the purposes of breeding, herds should be treated as one breeding nucleus and out of all the bulls in service in 1980, based on the performance of their progeny, dams and sisters, 6 bulls were selected for breeding. Their semen was frozen, and distributed among these herds. Another set of 13 young bulls was also selected. Out of these 6 bulls were selected on the basis of their growth performance and semen test. Breeding plan involves progeny testing of 6 bulls in each set and subsequently 2 best bulls are selected for nominated matings and improvement. These bulls are being used on Sahiwal pockets in the country or outside. At present the fifth set of bulls is under test. The Associted Herd Progeny Testing Programme on Ongole and Sahiwal is discussed separately under the programmes of the Project Directorate on Cattle.

MILITARY DAIRY FARMS

Cattle

The military farms of the Union Ministry of Defence maintains large herds of cattle and buffaloes for milk production. These farms function on the lines of quasi-commercial departments. The National Commission on Agriculture, 1976 reported the origin and history of military farms in India. In the latter half of the nineteenth century a large number of British troops and their families were inducted in India. The responsibility for providing rations to these people was vested with the Master General of Supplies. Milk and milk products were important articles of diet for them and these were being arranged from local sources. The incidence of diseases among the British troops and their families was high, and this was attributed to poor quality milk supplied to them. This situation forced the military establishment to start a dairy of its own in 1889 at Allahabad. The successful functioning of this farm led to the establishment of more farms in many other cantonments. On 1 April 1975 there were 24 military farms with 9,835 animals (7,231 cows and 2,604 buffaloes).

Military farms were the first to take up organized crossbreeding of indigenous cattle with European breeds on a large scale. This was found necessary because of poor milk yield of indigenous cattle as well as their late maturity and long calving intervals. The first importation of Ayrshire stock was made in 1907. Military dairy farms formed the basis for testing the merits of different imported breeds for crossbreeding work. The RCA was of the view that the military farms had effected great improvement in the milk yield of their herds, chiefly through crossbreeding and selection, although feeding and management of cattle had also contributed to this.

Crossbreeding work with European breeds was continued till 1952, when a Committee of Experts recommended that in view of dependence on foreign countries for exotic bulls crossbreeding work should be discontinued and that crossbred stock at military farms should be backcrossed with bulls of indigenous breeds. It was also recommended that herds of Indian zebu breeds of cattle should be introduced in these farms and improved by selective breeding. Crossbreeding was therefore discontinued and indigenous breeds of cows like Sahiwal, Sindhi, Hariana, Gir and Tharparkar were introduced. The ban on crossbreeding in military farms was removed in 1958 on the recommendation of the Reorganization Committee which viewed that crossbred herds should be enlarged and crossbreeding work undertaken with Friesian bulls. Maintenance of exotic inheritance at 50% level in crossbreds was suggested by this Committee.

The following cattle breeding policy was introduced in the military dairy farms:

1. Purebreeding of Sahiwal and Sindhi cows yielding or expected to yield 2,000 kg or more of milk in a single lactation of 300 days.
2. Crossbreeding of Sahiwal and Sindhi cows which yield or are expected to yield less than 2,000 kg of milk in a single lactation of 300 days, and that of Tharparkar, Gir and Hariana cows with Friesian breeds to get crossbreds.
3. Forward crossing of crossbred cows with 62.5% or less exotic inheritance with the Friesian breed.
4. Backcrossing of crossbred cows with over 62.5% exotic inheritance with the Sahiwal breed.

5. Development of a small herd of purebred Friesian cows at Meerut through use of superior Friesian bulls.

At present military farms in collaboration with the Project Directorate on Cattle, Meerut, are involved in evolving a new milch strain through interbreeding and selection of Friesian-Sahiwal crossbreds available with them. The project was inaugurated on 23 May 1985 at the Military Farm, Meerut, by the late General A.S.Vaidhya, PSVM, MVC, AVSM, ADC, the then Chief of Army staff. The main objective of the programme was to evolve a strain of Holstein-Sahiwal crossbred cattle yielding 4,000 kg of milk in a mature lactation of 300 days and with a fat content of not less than 4%. The strain has been named as 'Frieswal'.

Buffalo

Military dairy farms maintain a large numbers of buffaloes – mostly graded ones to meet the requirements of defence personnel. A policy of culling and selection is being followed for the improvement of buffaloes at these farms. Initially, the culling level for replacement stock was 1,350 kg for the first lactation. It was revised to 1,600 kg in 1966 and to 1,800 kg in 1968. In 1978, this was further revised to 2,700 kg for selection of male calves and to 2,400 kg for female calves (Dahiya, 1978). As a result of these efforts, lactation milk yield of buffaloes at military farms has increased from 1,443 kg to 2,080 kg (Dev, 1978).

GAUSHALAS

Gaushalas are in existence for the last two centuries. These are being maintained on account of religio-economic considerations. These institutions are mostly concentrated in the northern parts of the country. Considering the resources available and the scope offered by them in supplementing governmental efforts for improvement of cattle for milk production, the Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry suggested the need for their reorganization and development.

The reorganization and development of gaushalas as centres for cattle breeding and milk production started with the setting up of a Central Gaushala Development Board by the Government of India in 1949. Later, the Central Council of Gosamvardhana (CCG) was established in 1952 by the Government of India to act as the central co-ordinating and advisory body on cattle development. The CCG undertook a detailed countrywide survey to assess the resources of the gaushalas and to evolve a suitable scheme for their development.

The survey showed that there were 1,020 organized gaushalas in 21 states which maintained about 130,000 cattle, produced about 7,500 kg of milk and about 1,400 breeding bulls. About 11,000 persons were regularly employed by these institutions, and on an average, a gaushala possessed 60 ha of grazing area and about 25 ha of cultivable land. This worked out to an average of about 0.4 ha of grazing area and 0.2 ha of cultivable area per head of cattle (NCA, 1976).

The CCG sponsored an ad-hoc scheme for the development of gaushalas and pinjrapoles in the states and their smooth functioning. Some of the states appointed Gaushala Development Officers for extending technical assistance and guidance to the gaushala managements. A comprehensive Gaushala Development Scheme was included under the Second Plan for the development of 346 gaushalas. In all 242 gaushalas were assisted during the Plan period. The scheme was continued under the Third Plan for developing 168 more gaushalas. From the Fourth Plan the scheme was transferred to the state sector and this programme received very low priority in the allocation of funds.

Most of the gaushalas did not get adequate financial assistance from Central and State Governments and hence could not follow the advice and guidance rendered by State Animal Husbandry departments. As such these gaushalas could make little impact on the improvement in milk production. However, gaushalas at some places like Nasik, Uruli-Kanchan, Amritsar, Indore and Ahmednagar made a remarkable progress during these years. This shows that there is great possibility of improving the livestock wealth of gaushalas if proper assistance is provided. If planned properly, these gaushalas can become important sources for *in-situ* conservation of indigenous breeds of livestock. These can also be used for progeny testing large number of bulls as the institutional farms are not adequate for getting required number of daughters per sire. Some of these gaushalas are already participating in Associated Herd Progeny Testing Scheme. Wherever, the gaushalas have non-descript animals, these can be used for crossbreeding work to improve milk production of these animals.

PROJECT DIRECTORATE ON CATTLE

The Project Directorate on Cattle was established on 3 November 1987 at Meerut (Uttar Pradesh) to enhance milk production through crossbreeding on the one hand, and through improvement of indigenous cattle and implementation of field progeny testing programme in the country on the other hand. The mandate of the Directorate is to evolve a new breed of cattle 'Frieswal' (Friesian-Sahiwal) and other crossbred genotypes, and undertake programmes on genetic improvement of crossbred genotypes for high milk yield, and indigenous breeds of cattle for milk and draught through progeny testing using existing set up of organized herds and animals with the farmers (PDC, 1995-96).

Frieswal Project

The objective of this project has been to evolve in collaboration with Military Farms Directorate a cattle strain 'Frieswal', a Holstein-Sahiwal cross, yielding 4,000 kg milk in a mature lactation in 300 days.

Initially, crossbred females having 50% and above exotic inheritance, named higher crosses (HC), of halfbred Holstein x Sahiwal bulls were inseminated with liquid/frozen semen. The crossbred females having less than 50% exotic inheritance, called lower crosses (LC), were inseminated with imported frozen semen of proven Friesian bulls to raise the exotic inheritance of progeny above 50%.

The Frieswal females are being bred in successive generations with the frozen semen of 5/8 bulls. These bulls are the progenies of 3/8 elite cows inseminated with the imported frozen semen of proven Holstein-Friesian bulls with sire index above 9,000 kg. Further, for interbreeding of Frieswal females, the elite 5/8 Frieswal bull mothers have also been selected. Bull calves born to these females are being reared as future Frieswal bulls.

In the first phase, females (about 1,000) at the Military Farm, Meerut were included in the breeding programme. This continued till the first lactation yield became available. After the study of performance of progenies at Meerut, the second phase of the programme comprising about 4,000 females was started at military farms at: Dehra Dun, Lucknow, Jalandhar, Ambala, Panagarh, Pimpri, Secunderabad, Bangalore, Binaguri and Bareilly.

The third phase of the programme will include all the military farms covering 10,000 to 15,000 cattle. Cows with 5/8 Friesian inheritance have been designated as Frieswal.

Indigenous Breeds Project

Conservation and genetic improvement of important indigenous breeds of cattle has been taken up by the Project Directorate on Cattle in their respective breeding tracts through establishing germplasm units and a number of associated herds to be used as test herds. So far Ongole and Hariana breeds are taken up. In the next phase Gir and Tharparkar will be included.

The breeding programme for each breed envisages mating of about 75 breedable females with 4 to 5 genetically superior proven bulls for production of future young bulls. Out of the male progenies 8 to 10 bulls will be selected at maturity on the basis of their expected breeding values. About 3,000 doses of semen of each bull will be frozen. Out of these, about 1,000 doses will be used for sire evaluation at associated herds and 1,000 each will be maintained at the Germplasm Unit and the Project Directorate on Cattle. Each bull will be mated with 60 to 70 females at associated herds to get first lactation milk production records of at least 20 progenies per bull (PDC, 1995-96). Herd strength at the Germplasm Unit for Ongole was 55 adult cows and 11 bulls, and that for Hariana was 76 cows and 24 bulls with their followers on 31 March 1996. The total number of females in all the associated herds were 845 and 1,069 for Ongole and Hariana respectively. Similar programmes are envisaged on other important breeds of cattle like Tharparkar and Gir.

Breed	Germplasm Unit	Associated herds
1. Ongole	Livestock Research Station, Lam, Guntur (Andhra Pradesh)	1.Cattle Project, Livestock Research Station, Lam, Guntur (Andhra Pradesh). 2.Government Livestock Farm, Chintaladevi, Nellore (Andhra Pradesh) 3.Government Livestock Farm, Ramtheertham, Prakasam (Andhra Pradesh). 4.Government Livestock Farm, Mahanandi, Kurnool (Andhra Pradesh).
2. Hariana	CCS Haryana Agricultural University, Hisar (Haryana)	1.Government Livestock Farm, Hisar (Haryana). 2.Gaushala,Bhiwani (Haryana). 3.Kurukshetra Gaushala, Hisar (Haryana). 4.Gaushala, Jind (Haryana).

FIELD PROGENY TESTING

Progeny testing of crossbred bulls was taken up by the PDC during the VIII Five-Year Plan at 3 fields, viz. BAIF, Uruli Kanchan, Maharashtra; PAU, Ludhiana, Punjab; and Kerala Agricultural University Mannuthy, Kerala, in continuation of earlier ad-hoc schemes at these units. In each batch 30 Holstein-Friesian crossbred bulls having 50-75% exotic inheritance and a minimum of 4,500 kg dam's mature equivalent milk yield are tested during a period of 15 months. The target is to record at least 40 daughters per bull spread over different units (PDC, 1995-96).

ANAND MILK PRODUCERS' UNION LIMITED (AMUL)

Milk production in India is not well organized, and the marketing of milk is dominated by sheer exploitation by middlemen buyers and distress sale by producers. The small dairy farmers of Kaira district in Gujarat formed the first primary level milk co-operative in 1946 under the guidance of Sardar Vallabh Bhai Patel. He encouraged them by becoming the Chairman of the Union. This was the first attempt by rural milk producers to directly reach the urban market without middlemen. It was decided that milk producers' co-operative societies should be organized in each village which will federate into a district union. This gave birth to AMUL, an organizational instrument which services the rural dairy household at both ends - production as well as marketing. AMUL is the brand name adopted by the Kaira District Milk Producers' Union Limited which has its headquarters at Anand, a district town of Kaira district of Gujarat and located 425 km north of Bombay. AMUL is the abbreviation of the Anand Milk Producers' Union Limited and means priceless.

The dairy co-operative structure is a 2-tier one. The village society, the first tier, is mainly concerned with milk production and collection of milk. A milk producer becomes a member by paying Re 1 as registration fee and buying a share of Rs 10. The second tier is the district union (Kaira District Co-operative Milk Producers' Union Ltd, Anand) which represents all the village societies.

The union of milk producers, which had only 924 members of 13 village milk co-operatives and was collecting 1,136 tonnes of milk in 1948, grew over the years and had 532,670 members of 954 co-operatives collecting 229,210 tonnes of milk in 1994-95 (Vyas, 1997). As the co-operatives grew in size and number, there was a surplus of milk which the Bombay Milk Scheme was not able to handle and the farmers were again forced to sell it at low rates to the middle men. To cope up with this problem, a modern new dairy was built at Anand in 1955, with the assistance from the UNICEF, New Zealand and FAO. It was later expanded in 1958 and then in 1960. The Kaira Union in 1964, set up a balanced cattle feed plant, donated by OXFAM under the freedom from Hunger Campaign of the FAO. The Union also provides animal health care and breeding facilities. It runs a semen production centre at the ODE Farm, 18 km from Anand, to make artificial insemination facilities available to the milk producers.

OPERATION FLOOD (OF)

The Anand pattern of dairy co-operatives has shown a way of getting over many of the associated problems by effectively organizing milk production, procurement, processing and marketing. In 1963, the National Dairy Development Board (NDDB) was established at Anand in Gujarat under the aegies of the Government of India as an autonomous body with the objective of setting up milk producers' co-operatives on the Anand pattern in all the country's major milk-sheds. In 1969, the NDDB conceived and formulated a programme toward the development of dairy industry in India - the Operation Flood (Table 15). This programme was established by the Indian Dairy Co-operation (IDC). The aim was to create a 'flood' of rurally produced milk, assuring the farmer of remunerative price and a ready market to the urban consumer of wholesome milk at stable and reasonable prices. The programme was implemented in three phases.

Operation Flood-I (1970-81)

The programme laid emphasis on setting up of *Anand Pattern* rural milk producers' co-operative organizations to procure, process and market milk, and to provide some of the essential technical input services for increasing milk production. OF-I was launched in 1970 following an agreement with the World Food Programme (WFP), which undertook to provide as aid 126,000 tonnes of skim-milk powder (SMP) and 42,000 tonnes of butter-oil (BO) for financing the programme.

The programme involved organizing dairy co-operatives at the village level, providing the physical and institutional infrastructure for milk procurement, processing, marketing and production enhancement services at the Union level and establishment of city dairies. The overall objective of Operation Flood-I was to lay the foundation of a modern dairy industry in India which would adequately meet the country's need for milk and milk products. By the end of its period, about 13,300 Dairy Co-operative Societies (DCS) were organized in 27 milksheds, enrolling 1.8 million farmer members. OF-I was extended up to 31 March 1981.

Operation Flood-II (1981-85)

The background of the institutional framework of Operation Flood-II essentially comprised the successful replication of the Anand pattern, a 3-tier co-operative structure of societies, unions and federations. OF-II was designed to build on the foundation already laid in OF-I and the IDA-assisted dairy development projects in Karnataka, Rajasthan and Madhya Pradesh. The programme was approved by the Government of India for implementation during the Sixth Plan period, with an outlay of Rs 2,730 million. The project expanded the number of village co-operative societies to 34,500 covering 3.6 million farmer members. The major objectives of the Operation Flood-II were to:

(i) enable some 10 million rural milk producers' families to build a viable, self-sustaining dairy industry by mid 1985,
(ii) enable milk producers to rear a National Milch Herd of some 14 million cross-bred cows and upgraded buffaloes during the 1980s, and
(iii) erect a National Milk Grid which will link the rural milksheds to the major demand centres with urban populations totalling some 150 million.

Operation Flood-III (1985-96)

Phase III aimed at consolidation of the gains of the earlier phases. The main focus of the programme was on achieving financial viability of milk unions/state federations and adopting the salient institutional characteristics of the Anand pattern co-operatives. The programme covered some 170 milksheds of the country by organizing 70,000 primary dairy co-operative societies. Its major emphasis was to consolidate the achievements gained during the earlier phases by improving the productivity and efficiency of the co-operative dairy sector and its institutional base for its long-term sustainability. For improving the productivity of dairy cattle and thereby milk production the OF programme provided animal health and breeding facilities. Nearly 40,313 DCS have been covered with the animal health programme, and 16,280 DCS with artificial insemination facilities.

Table 15. Operation Flood at a glance

Parameters	Phase I	Phase II	Phase III			
	1981	1985	1990	1994	1995	1996
No. of milksheds	39	136	170	170	170	170
No. of DCSs (thousands)	13.3	34.5	60.8	67.3	69.6	72.7
No. of farmer members (million)	1	3	7	8	9	9
Average milk procurement (kg)	25.6	57.8	98.1	111.4	102.0	109.4
Processing capacity (II pd)						
Rural dairies	35.9	87.8	140.3	167.5	167.5	193.7
Metro dairies	29.0	35.0	37.9	38.8	52.30	72.40
Milk marketing (II pd)	27.9	50.1	72.5	86.24	94.0	93.38
Milk drying capacity (tonnes/day)	261.0	507.5	663.0	831.5	842.0	974.0
Investments (Rs million)	1,165	2,772	4,116	6,906	8,962	13,031

Source: Gupta (1997).

The year 1995-96 marked the termination of Operation Flood III, funded by a World Bank loan, EEC food aid and internal resources of the NDDB. At the conclusion of the Operation Flood III, 72,744 DCSs in 170 milksheds of the country, having a total membership of 94 million had been organized. The targets set have either been effectively achieved or exceeded.

The conditions for long-term growth in procurement were created. An assured market and remunerative producer prices for raw milk, technical input services including AI, balanced cattle feed and emergency veterinary health services have all contributed to sustained increase in milk production.

Operation Flood has been able to modernize the dairy sector to a level from where it can take off to meet not only the country's demand for milk and milk products in the next century but can also exploit global market opportunities.

CATTLE BREEDING POLICIES

Cattle rearing in India mainly centered around production of bullock power for agricultural operations and transportation. Hardly any emphasis was laid on production of milk from these cows. The Royal Commission on Agriculture (RCA) felt that the most suitable cow under these conditions would be the one capable of producing strong calf and yielding about 450 to 700 kg of milk. Since this quantity of milk would not be sufficient for meeting the requirements of urban population, the RCA anticipated that commercial dairy farms were likely to start crossbreeding for supplying milk to the cities. However, it felt that the public sector department should concentrate only on improving indigenous breeds like Sahiwal, Sindhi and Hariana. Olver (1936) noted that systematic improvement of indigenous breeds by selective breeding, better feeding and improved management appeared to be a better alternative as compared to introduction of European breeds for improving milk production. Wright (1937) and Peppevall (1945) also strongly opposed adoption of large-scale crossbreeding and suggested that steps should be taken to improve milk production potential of indigenous cattle. It was also emphasized that the breeding policy must take into consideration the environment under which these animals had to live and produce.

In 1949, the Goseva Sangh, Wardha advised the Government of India that the ultimate aim in the development of cattle should be the production of dual-purpose animals and that the buffalo might also be treated as a dual-purpose animal in those areas where male buffaloes were used for cultivation purposes. The ICAR considered the above suggestion of the Goseva Sangh and recommended adoption of the following course for the improvement of cattle in the country:

1. Since a large percentage of our cattle population comprises non-descript animals, it is essential in the interest of producing a general utility animal that it should combine in itself, draught and milk qualities to the optimum extent; in other words if in non-descript cattle these two qualities are combined to an average degree to start with the purpose will be served.
2. In areas where specific types (as distinct from well-defined breeds) exist the policy should be to effect improvement by selective breeding with a view to improving both milk and work qualities.
3. In the case of well-defined breeds, the objective should be to put in as much milk in them as possible without materially impairing the work quality.
4. In the case of well-defined milch breeds, the number of animals of which has considerably decreased after partition, the Committee is of considered view that it will be in the larger interests of the country as a whole to develop their milking capacity to the maximum by selective breeding and to utilize them principally for the development of cattle in under-developed areas.

In 1959, the Government of India set up an expert committee to review the progress of the Key-Village Scheme. The Committee recommended that no crossbreeding should be permitted in areas where specialized breeds already existed, but milk production should be increased by undertaking improvement in buffaloes and even by crossbreeding non-descript cattle with exotic cattle breeds in areas where environmental conditions are favourable. This view was recommended by the Animal Husbandry Wing at its Fourteenth Meeting in 1961.

The cattle breeding policy in general and the policy to be adopted concerning crossbreeding with exotic breeds were examined in 1961 by a Committee set up by the Central Council of Gosamvardhana. The Committee recommended that crossbreeding programmes should be taken up in an intensive manner using two or more exotic breeds in 3 selected areas, one each in the plateau, the plains and the hills. It was also suggested by the Committee that while taking up crossbreeding on a large scale in new areas, the places should be carefully selected so that crossbreeding might not conflict with the needs and preferences of the local farmers. It was further proposed that in the plains crossbreeding should be started in areas where the holdings are small, agriculture is intensive, cattle are stall-fed and farmers are interested in breeding cows for milk production.

The Scientific Panel on Animal Husbandry reviewed the cattle breeding policy in 1965 and suggested that all improvement programmes should be undertaken in an intensive and co-ordinated manner along with simultaneous provision of favourable environment. Crossbreeding was adopted as the major breeding policy in the Fourth Five-Year Plan. It was stressed that the success of crossbreeding programme would depend upon the quality of crossbred bulls used for *inter-se* mating. The Royal Commission on Agriculture in its report concluded that breeding for milk production should be concentrated in milk-shed areas that could be conveniently linked up with the dairy projects. Milk production should be attempted through a system of planned crossbreeding, selective breeding and grading up of indigenous cattle. The Commission further suggested among the indigenous breeds the following that show promise for either selective breeding or grading up cattle in other areas: Hariana for large tracts of Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Rajasthan and Bihar; the Tharparkar for Rajasthan, Madhya Pradesh and Uttar Pradesh; the Sindhi for Kerala, Tamil Nadu, Orissa, Assam and hill areas; and the Kankrej for Rajasthan, Gujarat and Madhya Pradesh. Selective breeding either through AI or natural service should be undertaken in the tracts of these breeds. This will preserve, improve and multiply animals of these breeds. Progeny-tested bulls should be used for breeding. Graded stock should be further improved through the use of superior bulls selected on the basis of their pedigree performance. Specialized draught breeds like Nagori, Amritmahal, Hallikar and Deoni should be improved for draught quality of their bullocks as the breeders in these areas derive a large income by sale of bullocks.

With the advent of AI and the introduction of crossbreeding in 1961, the official policy recognized crossbreeding of non-descript cattle with exotic donor breeds as a tool for improving milk production. The policy for crossbreeding was to use the non-descript cattle as the foundation stock and to limit the exotic inheritance to 50% - one generation of breeding of the indigenous cows with exotic breeds to create F_1 crossbreds and then to *inter-se* mate the F_1s to ensure a 50% exotic inheritance enabling both endurance and productivity. The exotic donor breeds used initially were Jersey, Brown Swiss, Red Dane and Holstein-Friesian. The choice of the exotic donor has now narrowed down to Holstein and Jersey, with Holstein predominating the market.

Crossbreeding was initially restricted to hill areas and areas with a preponderance of non-descript cattle. There was no intention to crossbreed pure Indian breeds of cattle. But the immediate economic gains lured the farmers to go for crossbreeding on a large scale. This coupled with faulty breeding plans and non-availability of indigenous purebred breeding bulls has led to the expansion of the crossbreeding programme nation-wide, even in the home tracts of the pure Indian breeds.

The policy for pure breeding the Indian breeds of cattle did not take off for various reasons: (i) improvement in production and productivity was gradual - not spectacular enough to encourage farmers to progressively support it; (ii) non-availability of proven sires among these breeds - all efforts of states to produce proven sires in their cattle farms failed; (iii) quality, coverage and effectiveness of the extension support system for breeding services were all inadequate; and (iv) above all, the absence of breeders organizations for each of these breeds in their respective home tracts, capable of providing both technical as well as advisory services required by the breeders.

Though crossbreeding was taken up on a large scale with much expectation, yet crossbreds were unable to deliver the goods under field conditions. The main reasons for the poor performance of crossbreds were: (i) non-adaptability to local agro-climatic conditions; (ii) availability of low quality feed and fodder resources; (iii) poor resistance to tropical diseases; (iv) instability of crossbred populations; and (v) non-availability of superior F_1 crossbred bulls for *inter-se* mating and more recently because of farmers' preference for buffalo milk especially in northern parts of India like Punjab, Haryana and western Uttar Pradesh. On the other hand, the indigenous breeds are evolved in this type of environment and are adapted to these conditions. They are able to survive on low quality roughage and are resistant to tropical diseases. The input-output benefit ratio goes in favour of indigenous breeds rather than crossbreds as most of them survive and produce under zero-input conditions. It is important to produce sufficient quantities of milk to meet the demands of growing human population, but simultaneously it is also important to conserve and improve indigenous breeds for future use. Under these circumstances, breeding policy should be formulated separately for each region taking into consideration the availability of infrastructure, local agro-climatic conditions and specific type of animals.

Pure Breeding

Red Sindhi, Sahiwal, Tharparkar and Gir breeds are good and efficient milk producers. If developed and bred properly, these breeds can be comparable with exotic breeds. These should be bred in pure form in their respective breeding tracts. Elite females (above 2,500 kg) should be maintained for production of future bulls. Young male calves should be selected on the basis of their dams' yield and physical appearance. These bulls should be progeny tested under field. Female and male calves should then be selected out of these bulls and brought to the elite herd to repeat the cycle. This will help in continuous supply of superior bulls and improve the breed. Surplus males should be castrated at an early age and used for draught purpose. Selective breeding should also be followed for other important dual and draught breeds. The existing farms of these breeds should be strengthened to make them bull mother stations. At least one bull mother station for each breed should be established in the breeding tract.

Crossbreeding

In areas, where resources are available in terms of feed and fodder, health cover, etc. low producing non-descript cattle should be crossed with superior exotic breeds. Exotic breed should be selected depending upon the agro-climatic conditions of the area. The Holstein-Friesian should be introduced in areas where irrigation facilities are available and fodder can be cultivated. In hilly regions, the Jersey is the best choice because of its short size and low feed requirements. In Kerala, the Brown Swiss is being used for crossbreeding.

The level of exotic inheritance should be maintained at 50%. Exotic inheritance up to 75% should only be allowed in areas where very good infrastructure facilities are available like in Punjab, some parts of Haryana and Tarai regions of Uttar Pradesh. *Inter-se* mating should be practised among F_1s. Crossbred bulls (F_1s) of superior genetic potential should be selected through progeny testing and then used extensively among crossbreds. Necessary health measures should also be taken to avoid outbreak of any epidemic.

Grading Up

Majority of the indigenous cattle survive in areas where feed and fodder resources are negligible, climatic conditions are extreme and agriculture production is very low. Crossbreds are unable to survive and produce efficiently in these conditions. Non-descript cattle of these regions should be upgraded with the superior breeds to improve their productivity. The choice of the improved breed should be according to the specific requirements of the particular region.

BUFFALO BREEDING POLICIES

India possesses the best dairy breeds of buffaloes. Hence there is no scope for introducing superior germplasm from outside as has been done for improving local cattle. Improvement in buffaloes can, therefore, be brought only through selection. With the existing range of variation from a few hundred to 4,500 kg or more of milk production, it is obvious that there is great scope for bringing about genetic improvement of the buffalo stock. To bring in genetic improvement for milk production in buffaloes, selection within superior dairy breeds such as the Murrah, Nili-Ravi, Mehsana, Surti and Jaffarabadi needs to be done, and also upgrading of low producing and non-descript buffaloes with these superior dairy breeds. The success of the breeding programme is dependent on the skills of the animal breeder in selecting superior sires and dams for future replacement and of future sires. Young males should be selected for breeding purpose on the basis of pedigree programme and then subjected to progeny testing.

Progeny testing is the most efficient method for selection of bulls because it brings maximum genetic improvement (110-140 kg) as compared to selection of bulls from high yielding dams (70-90 kg), or by selecting sons of elite dams by mating with proven bulls (110-115 kg) (Dev and Tiwana, 1978). A major limitation in this regard is the absence of any planned programme for progeny testing and availability of sufficient records per sire for estimating its breeding value with high degree of accuracy. A few institutional herds under test have limited accuracy and produce extremely small number of progeny-tested bulls. Consideration of farm recording with the recording of progenies of sires under test in the field have not yielded any additional information which could be used fruitfully. Field recording of performance data will allow testing of large number of bulls with reasonably high accuracy. But it requires standardization of techniques in terms of identification of progenies, recording of data under field conditions, etc.

Crossbreeding in Buffaloes

Except for large populations of established breeds of the buffaloes, most of buffaloes can be improved by crossing them with Murrah or Nili-Ravi. In Gujarat, farmers have been breeding Surti buffalo cows with the Murrah or Jaffarabadi bulls. The Mehsana is said to be a breed developed from the crossing of Surti buffalo cows with Murrah bulls. The Surti is well known for high reproductive efficiency and the Murrah for high milk production. The age at first calving of the Murrah × Surti crossbreds was 41.00 months compared to 41.97 and 48.20 months in Murrah and Surti heifers respectively. First lactation milk production in the crossbred buffaloes was 1,415.6 kg compared to 1,109.8 kg in the Surti. Mass selection would have taken at least 30 years to achieve this increase in milk yield. The lactation length of the crossbreds was similar to that of Murrah buffaloes but longer than of the Surti. The present increase in production in crossbreds per generation was almost 27.5% which is considerably high. The average dry period of the crossbreds was 106.67 days in comparison to 157.93 and 165.07 days in Murrah and Surti purebreds respectively. Similarly, the average calving interval of the crossbreds was 411.33 days in comparison to 468.92 and 487.84 days in Murrah and Surti breeds respectively (Basu, 1985). The crossbreds surpassed the performances of both the parental breeds. Murrah bulls/semen have been used indiscriminately for crossbreeding with almost all other breeds like the Surti, Nagpuri, Jaffarabadi, Pandharpuri and Bhadawari, thus genetically diluting these breeds. Local buffaloes of coastal areas of Andhra Pradesh have been graded up with the Murrah and the resulting animals are now called the Godavari buffaloes. Godavari is very similar to the Murrah in physical conformation and performance. Cattle and buffalo breeding policies in different states are given in Tables 16 and 17 respectively.

MULTIPLE OVULATION AND EMBRYO TRANSFER

Genetic gain of one standard deviation of selected trait per generation can be obtained if the progeny-testing programmes are well organized and supported by reliable field recording. Unfortunately, field recording of the production traits on a meaningful scale is the main obstacle and no breeding plan could be efficiently applied in the absence of sufficiently large and reliable records.

In recent years the possibility of increasing animal productivity by controlled breeding has been explored. Embryo transfer, often viewed as counterpart of artificial insemination, is one of the techniques of controlled breeding where a superior animal, i.e. a donor, is superovulated. More than one embryo can be recovered at a time and transplanted into recipient females to increase the number of progeny per female. In 1987, the Government of India initiated a National Science and Technology Project on Embryo Transfer in Cattle and Buffaloes implemented by the Department of Biotechnology, Ministry of Science and Technology, jointly with the Ministry of Agriculture and Science and the Indian Council of Agricultural Research (ICAR). The project was implemented at the National Dairy Development Board (NDDB) as the lead agency, in collaboration with the National Institute of Immunology (NII), New Delhi, the National Dairy Research Institute (NDRI), Karnal, the Indian Veterinary Research Institute (IVRI), Izatnagar, and the Central Frozen Semen Production and Training Institute (CFSP&TI), Hessarghatta, as the collaborating agencies. Under the project, 4 regional centres have been established at Nasik, Nekarikallu, Rae-Bareli and Hessarghatta. The research component is being looked after by the collaborative agencies. They are providing research input to lead implementing agency which has the responsibility to maintain a nucleus herd of superior animals for breeding purposes and

Table 16. Cattle breeding policy in different states

State 1	Breed 2	Breeding Policy 3
Andhra Pradesh	Ongole	Selective breeding in Ongole: grading up of non-descript with Ongole
	Malvi	Selective breeding in Malvi in pockets, grading up of Malvi with Tharparkar and Deoni
	Hallikar	Selective breeding in Hallikar; grading up of non-descript with Hallikar
Assam	Local cattle	Grading up with Hariana and Red Sindhi; cross breeding with Jersey
Arunachal Pradesh	Local cattle	Grading up with Red Sindhi and Hariana; cross breeding with Jersey
Bihar	Local cattle	Grading up with Tharparkar, Hariana and Red Sindhi; crossbreeding with Jersey
Delhi	Hariana	Selective breeding
	Non-descript	Grading up with Hariana and Tharparkar; cross-breeding with Holstein-Friesian
Gujarat	Gir Kankrej	Selective breeding in Gir and Kankrej; grading up of non-descript with Gir and Kankrej; cross-breeding with Holstein-Friesian and Jersey
Goa	Local cattle	Grading up with Red Sindhi; crossbreeding with Jersey
Haryana	Hariana	Selective breeding
	Sahiwal	Selective breeding
	Non-descript	Grading up with Hariana, Tharparkar and Sahiwal; crossbreeding with Jersey and Holstein-Friesian
Himachal Pradesh	Local cattle	Grading up with Hariana and Red Sindhi; cross-breeding with Jersey
Jammu & Kashmir	Local cattle	Grading up with Hariana and Red Sindhi; cross-breeding with Jersey
Kerala	Local cattle	Grading up with Red Sindhi, Kangayam and Tharparkar; crossbreeding with Jersey and Brown Swiss
	Crossbred cattle (Sunandani breed)	Selective breeding; use of F_1 crossbred bulls obtained by crossing indigenous cattle with progeny-tested Jersey, Brown Swiss and Holstein Friesian bulls
Karnataka	Deoni	Selective breeding
	Krishna Valley	Selective breeding
	Khillari	Selective breeding

Table 16. (concluded)

1	2	3
	Amritmahal	Selective breeding
	Hallikar	Selective breeding
	Non-descript	Grading up with Red Sindhi crossbreeding with Jersey and Holstein-Friesian
Madhya Pradesh	Nimari	Selective breeding
	Malvi	Selective breeding
	Kenkatha	Selective breeding
	Non-descript	Grading up with Gir, Tharparkar, Hariana, Sahiwal and Ongole; crossbreeding with Jersey
Maharashtra	Khillari	Selective breeding
	Dangri	Selective breeding
	Gaolao	Selective breeding
	Nimari	Selective breeding
	Non-descript	Grading up with breeds of the region and Hariana; crossbreeding with Jersey
Manipur	Local cattle	Grading up with Red Sindhi; crossbreeding with Jersey
Orissa	Local cattle	Grading up with Red Sindhi and Hariana; cross-breeding with Jersey
Punjab	Local cattle	Grading up with Sahiwal and Hariana; cross-breeding with Holstein-Friesian
Rajasthan	Nagori	Selective breeding
	Malvi	Selective breeding
	Rathi	Selective breeding
	Non-descript	Grading up with Hariana, Gir and Tharparkar; crossbreeding with Jersey
Tamil Nadu	Kangayam	Selective breeding; grading up with Tharparkar
	Hallikar	Selective breeding
	Umblacherry	Selective breeding
	Bargur	Selective breeding
	Non-descript	Grading up with Hallikar; crossbreeding with Jersey
Tripura	Local cattle	Grading up with Tharparkar; crossbreeding with Jersey
Uttar Pradesh	Kenkatha	Selective breeding
	Non-descript	Grading up with Sahiwal, Tharparkar, Red Sindhi and Hariana crossbreeding with Jersey and Holstein-Friesian
West Bengal	Local cattle	Grading up with Hariana, Tharparkar and Sahiwal; crossbreeding with Jersey

Source: Singh and Gurnani (1997).

Table 17. Buffalo breeding policy in different states

State	Breed	Breeding Policy
Andhra Pradesh	Ganjam	Selective breeding in Ganjam
	Local	Grading up with Murrah
Assam	Local	Grading up with Murrah
Bihar	Local	Grading up with Murrah
Delhi	Murrah	Selective breeding
	Non-descript	Grading up with Murrah
Gujarat	Jaffarabadi	Selective breeding
	Mehsana	Selective breeding
	Surti	Selective breeding, crossing with Murrah
Goa	Local	Grading up with Murrah
Haryana	Murrah	Selective breeding
	Local	Grading up with Murrah
Kerala	Local	Grading up with Surti
Karnataka	Local	Grading up with Murrah and Surti
Madhya Pradesh	Local	Grading up with Murrah
Maharashtra	Nagpuri	Selective breeding
	Pandharpuri	Selective breeding
	Non-descript	Crossing with Surti and grading up with Murrah
Orissa	Local	Grading up with Murrah
Punjab	Nili-Ravi	Selective breeding
	Murrah	Selective breeding
	Local	Grading up with Murrah and Nili-Ravi
Rajasthan	Local	Grading up with Murrah
Tamil Nadu	Local	Grading up with Murrah
Uttar Pradesh	Bhadawari	Selective breeding and grading up with Murrah
	Non-descript	Grading up with Murrah
West Bengal	Local	Grading up with Murrah

Source: Singh and Gurnani (1997).

also to take this technology to the field for benefit of the farmers. The NDDB has set up a main ET laboratory, 3 regional centres and 14 state centres (till March 1995) for achieving these objectives. The state centres are planned to be increased to 25. The ET project successfully completed its eighth year in March 1995 fulfilling most of its objectives. It has been monitored at various levels. Among its notable achievements are the birth of a cattle calf from a split embryo half at the NII, the first ever IVF buffalo calf at the NDRI and the world's first buffalo calf produced through transfer of a frozen embryo. A diagnostic kit has been developed for the detection of pregnancy/heat in cattle and buffaloes and is being commercialized.

The technique of AI has made it possible to increase the utility of a male. It has

> **"Pratham"**
>
> The first-ever buffalo calf born following *in-vitro* fertilization of oocyte and subsequent embryo transfer has been reported at the National Dairy Research Institute (NDRI), Karnal.
>
> The buffalo oocyte was 'harvested' from slaughterhouse ovaries and fertilized *in-vitro* in the laboratory.
>
> The embryo, thus produced, was transferred to a suitably prepared recepient in the first week of January 1990. The calf born with a birth weight of 38 kg was named 'Pratham'
>
> *Source:* Acharya (1992).

now also become possible to increase the influence of the genetically superior females by the use of embryo transfer. Introduction of a Multiple Ovulation and Embryo Transfer (MOET) scheme will increase the selection intensity through increased progeny per buffalo per annum in the herd.

The MOET scheme allows progeny testing of both males and females, and can increase the genetic gain per annum over what is possible by artificial insemination alone. More sires can be tested within a short period and at low cost by using the semen of the male to be tested on a few donors and transferring the embryos recovered to the required number of recipients. To test a bull 8 donors and 27 recipients with 10 recorded daughters in the first lactation are required. However, these techniques are required to be precisely standardized for practising in regular breeding programmes.

OPEN NUCLEUS BREEDING SYSTEM

The practical application of progeny-testing methodology requires that the farmers' herd size should be fairly large so that adjustment for various non-genetic factors by contemporary comparisons is possible. This condition does not exist in India as the average herd size is around 1 to 2 adult females. Milk recording under field conditions is quite expensive. Moreover, farmers are not under any obligation to retain the animals till the lactation is completed. The generation interval is also very long as it takes about 6-7 years by the time complete record on progeny is available. The net consequence of application of conventional progeny testing programmes in developing countries is that the effective genetic improvement is small. Use of the 'best' proven bulls on the elite cows, which are the best 5 to 10% of the cows in the population to generate future bulls for breeding would take further time for the benefits of genetic improvement in the population to occur. The net genetic gains in the herds, considering the 'actual' genetic improvement from various parent-offspring paths, is around 0.7% per annum. Considering the above situations in developing countries it has been proposed

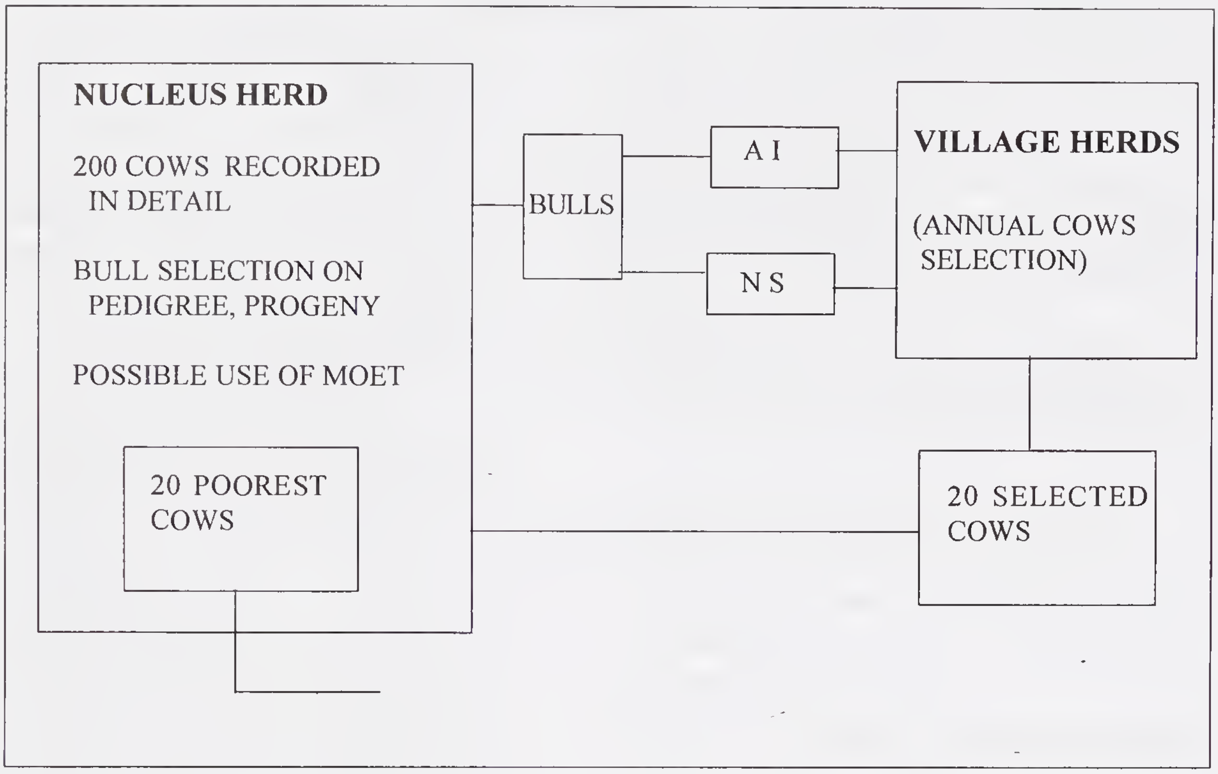


Fig. 4. Dairy selection scheme involving village herds and government nucleus herds
Source: Cunningham (1979).

that 'nucleus' herds be created where males from best cows are obtained. The 'nucleus' herds would be open in the sense that the lowest yielding cows are culled every year and are replaced by procurement of that many high-yielding cows from farmers' herds (Fig. 4). The nucleus herds are utilized entirely for production of males for breeding purposes in the population. With the availability of Multiple Ovulation Embryo Transfer Technology (MOET), the possibility of utilizing Open Nucleus Breeding Schemes (ONBS) for genetic selection of sires can be taken up with much larger advantage. A nucleus herd should not have less than 200 females. Such a scheme would require maintenance of a small number of donor and recipient females, and will allow a large number of bulls to be tested for their genetic merit. The males are to be evaluated on the basis of their pedigree information when selected at the early age of 12 months or so. This is called 'juvenile-MOET'. Then the males are selected on the basis of the expected performance of their half-sisters and full-sisters at the age of around 45 to 51 months. This system is called 'adult-MOET' (Gurnani, 1990). This reduces the generation interval and makes it possible to prove young bulls at the age of 3 to 4 years instead of 7 years in conventional breeding plans. Although accuracy of such a test is lower than progeny information but because of reduction in the generation interval, the genetic gains through the use of ONBS would be similar to that of progeny testing. Some of the advantages of ONBS-MOET schemes are:

1. Under ONBS-MOET, the evaluation and selection of males and females is conducted within the nucleus herd, so there would be greater degree of control on the determinants of genetic change, i.e. intensity of selection, generation interval and estimation of changes in levels of inbreeding.
2. Recordings of performance will be more accurate.
3. It will facilitate measurement of influence of other factors of production of economic importance like feed conversion efficiency, reproductive efficiency, disease resistance, body conformation, ease of calving and ease of milking. Such information is not easy and would be very expensive to collect in progeny testing schemes.
4. Overall cost of breed improvement programmes is reduced. Less facilities are needed to be created for storage of frozen semen doses.
5. Breed improvement programme is feasible as the recording of farmers' cows is not conducted. Recording of farmers' cows in some situations and in some seasons may be difficult due to difficulties of transportation and communication.

□

10 STRATEGIES FOR CONSERVATION

THE cattle and buffalo genetic resources of India are represented by 30 and 10 well-established and recognized breeds respectively. Most of the cattle breeds are suited for draught work but produce very little amount of milk. In recent times, several of these breeds have suffered decline and degeneration mainly due to their becoming uneconomical in the present day production system. In this age of competition, the animal breeding and production system needs to be geared up to meet the market demands. Usefulness of a breed is now judged not only on the basis of physical fitness and utility but also on monetary returns. Utility of these breeds as draught animal has decreased over the years owing to mechanization of agriculture and transport. Advances in animal breeding, especially artificial insemination technique, have changed the animal breeding scenario completely and made it much easier and quicker to introduce superior exotic breeds on a large scale. This has lead to the development of highly productive strains and breeds. Although the native breeds are better adapted to the local agro-ecological conditions of the region and are capable of producing on almost zero input, yet they are facing decline and degeneration. These breeds need to be conserved for a number of reasons. Some of these are:

1. No organized efforts have been made to improve the genetic potential of indigenous breeds. This coupled with imbalanced growth in livestock population vis-a-vis inputs and poor management has resulted in overall deterioration of these breeds.
2. Crossbreds are more productive as compared to native breeds but their tendency to wilt under Indian conditions of low input and harsh climate, susceptibility to tropical diseases, drop in production levels beyond F_1's warrant the conservation of indigenous breeds for future use.
3. Usefulness of various types of indigenous animals has not been fully explored. In such a situation, it cannot be postulated which animal type/gene would be required in future and when. Hence the need for conservation of these breeds is necessary as a part of genetic security.
4. The non-renewable sources of energy are bound to exhaust sooner or later. If this does happen, then we may have to fall back on our animal wealth for providing draught power and hence we cannot take risk of letting these breeds go extinct.
5. Various genotypes or gene combinations may be required for new technologies

like embryo transfer, sexing, cloning and gene manipulation. This requirement can only be met by maintaining a wide gene pool of animal genetic resources.

6. Some of the breeds like Sahiwal, Red Sindhi and Nili-Ravi do not have their breeding tracts within the geographical boundaries of the country but these are important to our country and deserve conservation.
7. The domesticated breeds are integral part of our eco-system, culture and heritage. Hence, these need to be preserved.

WHEN A BREED IS IN DANGER

Management and conservation of animal genetic resources need involvement and support of farmers and groups of people with active support of the government agencies, legal coverage and institutional financing. They should be need based and the measures taken should not upset the natural environment. The economic condition of the farmers vis-a-vis requirement of funds need proper balancing. The understanding of farmers and acceptance of the conservation concepts by the society are the key factor for the success of conservation.

Participation of farmers/individuals in the conservation programme is very much important. In fact the approach/initiative should come from the farmers and there participation should be effective. The degree of their participation would depend on the need of the programme. Different approaches should always be compared for assessing the benefits. The management group must know the exact nature of the farmer's participation and the activities. The conservation of animal genetic resources and needs of farmers go together. The conservation programme should have an effective legislation and regulatory framework to have maximum returns.

Population Dynamics

Population dynamics affects the degree and rate of use of natural resources. Rapid population growth puts more pressure on resources. The growth of population should be properly managed and controlled. Declining resources puts a pressure on the population. Similarly population increase or decrease will also influence conservation programme. Lack of knowledge of these factors can lead to failure in conservation initiatives. Selection and migration of animals are two major factors influencing population dynamics.

The endangered status of an animal breed can be determined by the size of breeding stock which can be expressed by the number of breeding females, sex ratio or effective population size. These may vary for different species. The estimates of minimum population size of different species for declaring endangered status have been given by various workers (Alderson, 1981; Maijala, 1982; Campo and Orozco, 1982; Pirchner, 1983;

Maijala *et al.,* 1984; Dohy, 1988). Conservation status of a breed can be determined on the basis of breeding females and estimated effective population sizes and sex ratios as given in Table 18. Due weightage should be given to the current trends in population for declaring the status at a particular time. Different population estimates suggested for consideration of endangered status of breeds in 5 species of livestock are given in Table 19. These estimates are for the developed countries where all the necessary facilities for *ex-situ* conservation are available. Moreover, these population estimates are for registered animals with Breed Societies or by Rare Animal Trusts. They can switch over to different livestock raising systems without any loss of time. Simak (1991) has given much higher numerical figures (5,000-15,000) for declaring rare breeds in West Germany. The FAO has a working rule that when breed population size approaches 5,000 breeding females (total population of about 10,000 animals), the survival risk of the breed should be studied. However, much will depend upon the local circumstances such as breed management system, extent of crossbreeding, rate of decline and overall utility of breed under the prevalent agro-climatic conditions.

Table 18. Population size and sex ratio of breeding females for determining the conservation status

Status	No. of breeding females	Estimated effective average population size				
		5:1	10:1	30:1	50:1	100:1
Normal	>10,000	33,333	18,181	6,201	3,921	195
Insecure	5,000-10,000	5,000	2,727	930	588	30
Vulnerable	1,000-5,000	1,666	909	309	196	10
Endangered	100-1,000	333	182	65	39	-
Critical	<100	33	18	7	4	-

Table 19. Population estimates for endangered status of breed

Country	Cattle	Sheep	Goat	Pig	Horse	Reference
England	750	1,500	500	150	1,000	Alderson (1981)
West Germany	7,500	15,000	5,000	-	5,000	Simak (1991)
Europe	1,000	500	200	200	-	Maijala (1982)
General*	10,000	10,000	10,000	10,000	10,000	FAO

* Number of pure breeding females is 5,000.

The situation in India is altogether different. Here even the preliminary breed-wise census has not been conducted and the breeding policies for each breed are framed generally on population estimates based on census report for the species. It is normally assumed while framing the breeding policies that all the animals in the breeding tract are of that particular breed. No consideration is given for the non-descript population or the crossbreds available in that area. However, preliminary surveys conducted on a few breeds revealed that their number may be a few thousands only. The population size for the consideration of status of a breed under Indian conditions for different species is given in Table 20 (Nivsarkar *et al.*, 1994).

Table 20. Population size of a breed for its status ('000)

Species	Normal	Insecure	Vulnerable	Endangered	Critical
Cattle	25	15-25	5-15	2-5	<2
Buffaloes	30	20-30	10-20	5-10	<5
Sheep	50	30-50	15-30	8-15	<8
Goats	30	20-30	10-20	5-10	<5
Camels	20	15-20	5-15	2-5	<2
Horses	20	15-20	5-15	2-5	<2
Pigs	10	5-10	1-5	0.5-1.0	<0.5

However, the population estimates for determining status of cattle and buffalo breeds seem to be slightly on the lower side taking into consideration low percentage of breedable females vis-a-vis population size, mortality rate, poor growth rate, late maturity, poor fertility rate, recurrent draughts, etc. These estimates may even be higher in buffaloes as compared to those of cattle because of their low conception rate, high mortality, longer age at first calving, longer calving interval, etc. The criteria recommended is given in Table 21.

Table 21. Recommended population estimates for a breed

Species	Normal	Insecure	Vulnerable	Endangered	Critical
Cattle	>30	20-30	10-20	5-10	<5
Buffaloes	>35	25-35	15-25	10-15	<10

A breed is automatically conserved if it is economically viable. Therefore, efforts should be made to improve the performance of indigenous breeds by formulating appropriate breeding plans. Breeding plans should be separate for each breed taking into consideration the utility of that breed. For draught breeds weightage should be given to draught parameters like strength of ligament of Nuchae, tendons and muscle structures, leg size and hoof qualities, along with production parameters. The existing farms should be declared as bull mother farms. Initially, young bulls should be selected on the basis of conformation traits and dam's performance. At present progeny testing is not feasible for all the breeds but wherever possible these bulls should be tested on the basis of performance of their progeny. Farmers' herds should be included in the programme to increase the number of records per sire so that the accuracy of test is increased. Efforts should be made to extend the programme of progeny testing to all breeds. Top 20% of the bulls should be selected for production of future bulls. Sufficient quantity of semen of these bulls should be frozen. These bulls should then be distributed to the development agencies/breed societies to propagate the breed in the breeding tract. About 20% of the poor performing animals at the bull mother station should be replaced by good animals from the field to minimize the level of inbreeding. This will help in simultaneous improvement and conservation of the breed.

WHY A BREED IS IN DANGER

It has been observed that most of the developing countries have rich quality biodiversity but are poor in resources and hence the potentiality of the resources can not be fully exploited. There are various factors influencing the domesticated animal diversity (DAD) causing decline in the population status of many breeds and some of these breed resources are threatened with extinction. These factors are discussed below.

Farmers' Holding and Resource Availability

The conservation of animal genetic resources under sustainable management at the farmers' door is one of the most effective and practical way of conserving the animals with minimum of inputs. This approach also does not involve large financial inputs and would be feasible under the normal conditions. The production system during the last 3 to 4 decades has completely changed due to increased human population pressure, high density and availability of low inputs. More and more land is now coming under crop production, but the land holding has started dwindling. The average herd size of cattle during earlier days was 25-30 and that of buffalo 8-10, but over the years with the reduction in the land holding and common grazing area the average herd size has reduced and now 1 or 2 buffaloes or cows are kept. Similarly, a small farmer with poor resources cannot afford to keep a bull for breed improvement and has to depend largely on the available germplasm in or around the village. In most of the cases the available bulls are not selected and in many cases the working uncastrated bullocks serve as a breeding bull. The normal practice in villages is that male and female animals are sent out together for grazing and the scrub bull(s) in the herd continue mating of females in oestrus. Thus, there is not only deterioration in the performance of the animals but also genetic dilution. It would, therefore, be necessary to make efforts for maintaining only quality animals and to provide selected bulls or semen of progeny-tested bulls under the genetic improvement programme so that the breeds become economically viable and are conserved at the farmers' doors. A breeding plan has to be developed for the genetic improvement of pure /indigenous breeds by each state/breed societies.

Breed Characterisation

India is bestowed with large number of breeds of various species of livestock and poultry. However, it is very difficult to locate the basis of categorization of these breeds, because of lot of variation between different reports. The numbers in cattle breeds reported to vary from 26 to 56, buffaloes from 7 to 15, sheep from 30 to 55 and so on for the other species. The exact source of the breed accreditation has yet to be documented but it has been reported in some literature that British army officers while conducting tours in the rural areas have described the breeds of the area on the basis of its morphometric characteristics and local names as prevalent in the area were given. Further the studies were conducted on these resources under intensive managemental conditions. The information generated on these breeds is based on a few herds maintained in the organized farms of the state and central departments/agricultural universities on small populations. It has not been properly documented and cannot be considered as a true descriptor for the breed. The performance need to be recorded on large population under extensive management condition at the farmers' door to have a correct picture in the breed number has become a serious issue as many breeds have been reported on which either little or no information is available. Possibly such breeds have come out of fascination of a few people or the local names given to a group of animals of a particular tract. There is a need for undertaking systematic studies on the livestock resources by conducting surveys and recording the information on these genetic resources. Taking the earlier available reports as base information. The recording of such observations on large and random population would help in describing norms of a breed, and descriptor for each breed can be prepared which can be subsequently used for recording the status and performance of breed. This will not only help in gaining knowledge but will also be useful in planning breed improvement and conservation programme.

Suitability of Selection of Breeds

The selection of breeds as described earlier was based on the morphometric characteristics without giving any weightage for the production performance. The selection of the genetic material was also done on the basis of the physical parameters with a very rigorous scale. This has resulted in sharp decline in the population of recognized breeds because any slight variation in these morphometric traits would result in the rejection of the animals.

It is proposed that a systematic approach be developed where in addition to the morphometric parameters, emphasis is also to be laid on the economic traits for the improvement of breeds. This would simultaneously result in genetic and economic viability of breeds, and with a possibility of sustainable management of these animals breeds.

Economical Viability and Acceptance by Farmers

There has been a major change in the management and production system of animal genetic resources after 1960. The major emphasis for selection of cattle was on its draughtability with either very little or no emphasis on the production performance. This resulted in Indian cattle being considered only as draught animals and buffaloes as milch animals. However, during the last 3-4 decades the requirement of the draught power has gone down due to large-scale mechanization and because of low milk production their utility has almost dwindled. Draught animals hence became economically unviable and farmers either accepted introduction of improver breeds/exotic inheritance for upgrading of their livestock or disposed them off. This has resulted in immense loss to the genetic purity of the indigenous breeds which were highly adaptive to tropical conditions and could survive and produce under extreme climatic conditions, zero input management and steep competition due to increased livestock density. It would, therefore, be necessary to link up the programmes of conservation with breed improvement on a large scale so that there would be improvement in the overall performance of these animals and would thus be acceptable to the farmers, failing which there is a danger of losing these breeds.

Feed and Fodder Resources

In India, most of the livestock in rural areas are maintained with zero-input system. They are sent for grazing from morning and hardly any supplement is offered excepting for bullocks and lactating animals. Fodder production in earlier years was considered a luxury and grazing was supplemented with some concentrates and crop residues. Some of the progressive farmers realized the importance of nutritional requirement for cattle and buffaloes and brought some of the land under fodder cultivation. But the overall scenario has not changed. The possible reason is the increase in human population pressure resulting in shrinking of grazing areas. In the last few decades because of steep economic competition and the higher population density, the farmers find it difficult to maintain uneconomical animals and have replaced such animals with more productive animals, as stated in earlier para, resulting in genetic dilution or replacement of breeds. It would thus be necessary to improve the management practices by bringing more wasteland under fodder production so that the animals would have enough grazing resources and availability of nutrients and these indigenous genetic resources can be maintained economically. Moreover, fodder production needs and nutrient requirements have to be linked with breed improvement programmes so that the animals can be reared at the farmer's door under sustainable management.

Changing Pattern of Agricultural Operations

There is not only change in the production and management system of animal genetic resources but large-scale changes have also taken place in the agricultural operations. This is not only because of human population pressure but also due to high economic returns by using modern agricultural farming practices which has resulted in more and more land coming under crop production. The decision of selecting a crop would depend on the need of the people and marketing facilities. This approach depends on the economic utility of the crops, which not only changes the cropping pattern but also have very large impact on the management of animal genetic resources which are largely dependent on the agricultural by-products. In the states where these changes are more evident, the farmers have totally changed the livestock management system and in certain cases have also either reduced or totally replaced the species/breeds depending upon the prevalent situation.

Legal Issues

In spite of widespread concern being raised about the decline and disappearance of domesticated animal genetic resources, there is very little emphasis on the creating of legal coverage for the conservation of these resources. Some of the legal coverages for domesticated animals have been implemented by the state and central governments but most of these legal coverage are for breed identification and breed improvement programme. The Ministry of Environment has already taken steps for giving a legal coverage to wild animals and plant species. On realization of having legal coverage it was decided to approach an agency which would help in creating a legal form and frame the bye-laws for protecting the animals and also for their conservation under the sustainable management system. It would be necessary to start with the proper identification of these resources by making a provision in the law and this should be monitored continuously and amendments if any may be incorporated. These laws should be obligatory which would help in preparing comprehensive animal biodiversity inventories. Though there will not be any insurance against the natural forces, a legal coverage can be given for protecting the animals from the artificial forces to prevent decline in the biodiversity. Biodiversity tools help the improvement programme but if misused can make drastic genetic alterations which may subsequently prove a threat to biodiversity and conservation. It should be mandatory for all the state and central departments to have an effective legal cell which would help in giving protection to such resources.

CONSERVATION METHODS

The most appropriate means of conservation is in the form the animals exist in nature, i.e. *in-situ* conservation. *In-situ* conservation of germplasm will not be practised by those engaged with commercial livestock production because of economic imperatives. This activity will shrink in terms of number of animals with farming community. However, wilfully maintained animal conservation farm would be a judicious assemblage of large segments of biodiversity of a particular breed. The *in-situ* conservation may not be appropriate for the breeds which are uneconomical and are likely to be lost due to economic pressures. The only other way to handle such a situation is through *ex-situ* conservation of sperms, oocytes, embryos, DNA and embryonic stem cells. A breed can be resurrected from the cryopreserved germplasm as and when required for production or research.

In-situ Conservation

Live animal conservation has several advantages as the breed can gradually adapt to the changing environmental conditions besides improvement by selective breeding. However, the high cost in keeping of large herds is the major limiting factor. It is very important to know the minimum population size of a breed for conservation *in situ.* Smith (1984) estimated the minimum size of a breeding unit and the number of breeding animals that would be replaced annually to keep the inbreeding levels to about 0.2% a year. Brem (1988) considered that an inbreeding level of 1.1% per generation could be tolerated. In order to continue to breed and select successfully on quantitative traits a herd size of about 100 breedable females is necessary. Institutional farms having a nucleus herd of 500 breedable females kept at 3 or 4 locations can be useful for selective breeding and improvement besides the conservation *in situ.*

Ex-situ Conservation

It is possible now to store a wide variety of living cells for long periods of time. Outstanding progress has been made with sperms of most domestic species and techniques are now routine. Embryos of several mammalian species may now be frozen and subsequently used to produce a normal animal. These techniques can be used for the conservation of endangered animal genetic resources *ex situ. Ex-situ* conservation can be done by: (i) deep freezing of sperms and oocytes, (ii) deep freezing of embryos, and (iii) storage of DNA templates.

(a) *Sperms and oocytes*: Deep freezing of semen is suitable for most of the species of domestic animals and facilities are available at many places. The technique of freezing, storing and thawing of semen is well documented for cattle and buffaloes. About 2,000 doses of semen per bull should be obtained from 15-20 bulls and stored for the conservation of a breed. Smith (1984) estimated that 25 sires of a breed are essential to prevent inbreeding when males are used rotationally on each other's daughters. Further, with the refinement of *in-vitro* fertilization technique, the cryogenic storage of oocytes side by side of semen may be very useful.

(b) *Embryos*: Cryopreservation of embryos of cows, buffaloes, sheep, goats and horses has successfully been done to produce offsprings. This is an excellent tool for conservation as all the genetic information are stored in one diploid zygote. However, it is still relatively expensive but should be used for conservation of at least endangered breeds. Brem (1988) estimated the number of frozen embryos required for conservation of a breed (Table 22).

Table 22. Number of frozen embryos per breed for preservation in cattle

Survival rate	Pregnancy rate (%)				
	20	30	40	50	60
50	616	411	308	247	206
60	513	342	257	206	171
70	440	293	220	176	147
80	385	257	193	154	129
90	343	228	171	137	114

(c) *Storage of DNA*: Cryogenic storage of DNA is another method of preservation of genetic material. It has several advantages over the live cells, avoiding the complication of spreading of disease during transportation. Within and across different countries, the storage of uncatalogued DNA is already possible but the genome maps of different farm species are not yet available. This may prevent it from becoming the normal method of preservation at present. Serious efforts are now being made in several laboratories all over the world for mapping of genes in livestock species. Nevertheless, in planning for a long-term preservation of endangered breeds, the prospects of DNA storage must be taken very seriously.

(d) Cloning of somatic cells: Cloning offers the advantage of producing series of exact replica/copy of the concerned animals. The developing embryo can also be frozen to serve as the voucher specimen to serve the need in exigency.

Presently there are two techniques for the cloning of the animals, viz. Roslin and Honolulu techniques. In both the techniques the egg cell is enucleated to eliminate majority of the genetic information. The donor cell is forced to G^0 stage of cell cycle, making its nucleus acceptable by the recipient cell, either by cell fusion or transplantation. The developing embryo is transplanted in a surrogate mother.

In Roslin technique the donor and the recipient cells are synchronized for proper acceptance of the nucleus. The donor cell is forced to remain in dormant cell stage (G^0). The donor cell (udder cell) is cultured *in vitro* to produce multiple copies of same nucleus. The donor cell is brought at G^0 stage by shutting down the active genes by selective starvation. The enucleated recipient cells and nucleated donor cell are fused by electric pulse to develop into an embryo. If embryo survives it is incubated in sheep's oviduct and finally placed in uterus of surrogate mother ewe.

In Honolulu technique the cumulus cells are used which either remain in G^0 or G^1 state. Unfertilized mouse egg cells were used as the recipient of donor nucleus. This technique has advantage as there is no need of *in vitro* culture of donor cells. The donor nuclei were taken from cells within minutes of each cell's extraction from mouse thus it is a quicker method than Roslin technique. After acceptance in new nucleus, the egg cell is grown in a chemical culture to jump start the the cell's growth mimicking the fertilization . The cytochalsin B present in the culture prevents the polar body formation. The developing embryo are transplanted in surrogate mother. The cumulus cells give most successful results and are widely being used.

(e) *Embryonic stem cells:* Embryonic stem (ES) cells are derived from culture of inner cell mass of a young blastocyst. These embryonic cells are totipotent and have potential to develop into several embryos. Unlike the cloning of somatic cells here the single fertilized zygote gives rise to many embryos which can be frozen for a very long period and subsequently can be utilized in the conservation programme.

Cell lines of ES cells are easily obtained from disaggregating morulae (Eistetter,1989). A feeder layer is generally used to isolate ES cells and to support their successive passages (Suemori and Nakatsuji, 1987). The main role of feeder cells is to provide growth factors necessary for proliferation and correlative inhibition of differentiation.

ES cells share the potentialities of the ICM cells from which they are derived. They are able to differentiate *in vitro*. When ES cells are cultured at high cell density on a non-adhesive surface (bacterial culture plastic), they form round embroid bodies showing many similarities with embryo development *in vivo* (Doetschemann *et al.,* 1985).

ES cells are maintained by repeated passage on feeder layers, usually non-proliferative mitomycin-C treated or matrix-coated substrate in conditioned medium, in order to prevent spontaneous differentiation (Wiles, 1993; Abbondanzo *et al.,* 1993). The presence of differentiation factors such as retinoids may be eliminated by the use of neutralizing antibodies (Tamura *et al.,* 1990) or by charcoal treatment (Flechon, 1997). The presence of such factors may explain the so called 'spontaneous' differentiation of ES cells.

CONSERVATION APPROACH

All strategies for conservation of biological resources in ultimate analysis should strive for their sustainable utilization. It is, therefore, imperative that conservation of animal biodiversity, particularly of our domesticated animals, should be an integral component of an overall national plan of biodiversity conservation. A number of agencies with diverse objectives directly or indirectly deal with animal genetic resources. Their activities cover breeding, maintenance, management, development, utilization, conversion into value-added products and marketing. For a meaningful conservation programme, it would be necessary to dove-tail diverse interests and generate a holistic approach. Nivsarkar *et al.* (1994) suggested a network model for conservation of animal genetic resources in India (Fig. 10).

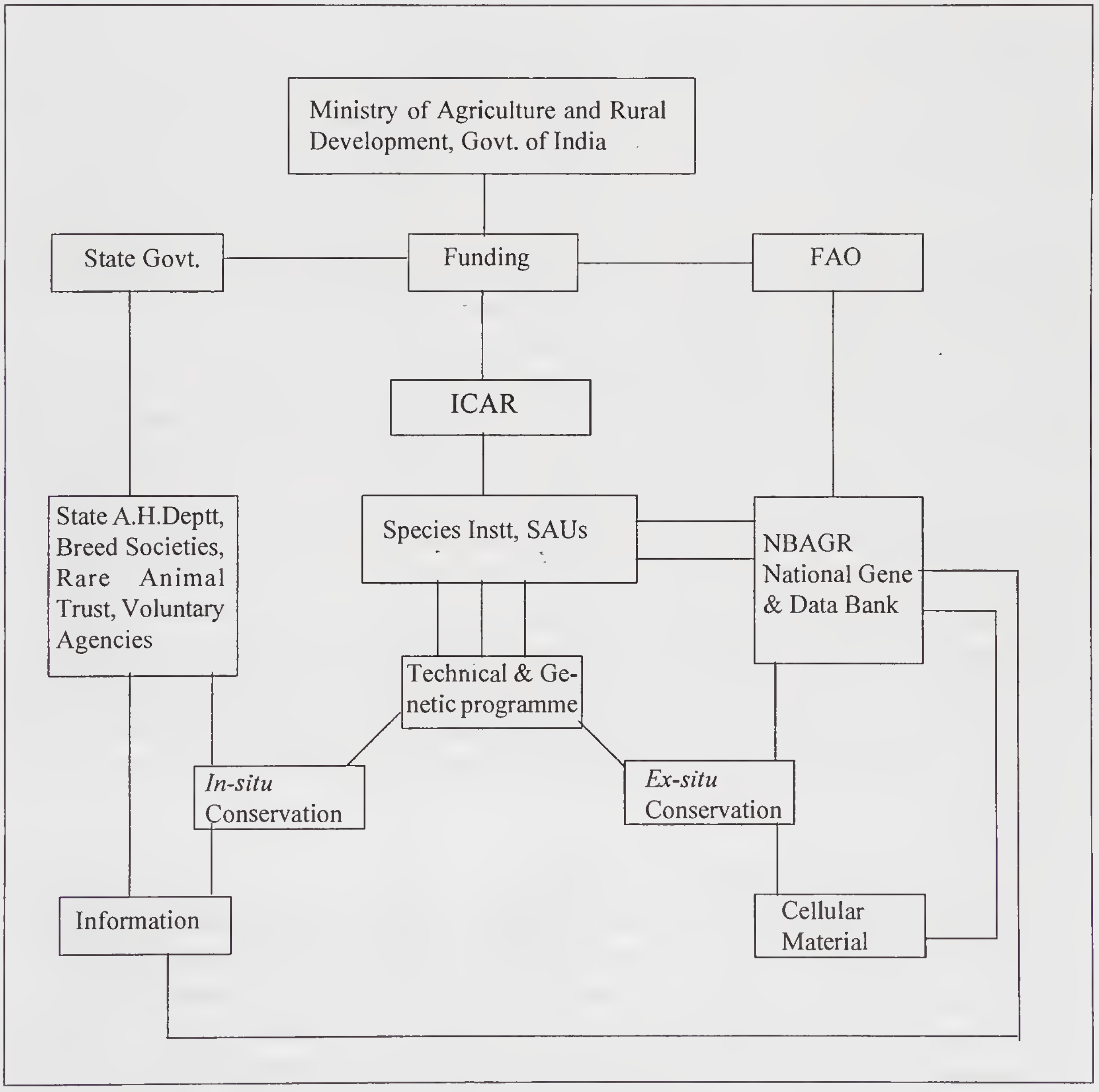


Fig. 10. Nework Model for Conservation of Animal Genetic Resources in India (Source: Nivsarkar *et al.*, 1994).

The livestock and poultry development programmes have traditionally been geared mainly for increasing production potential of animals and their overall economic value rather than to conserve and maintain the genetic purity of the breeds. Thus, dilution, degeneration or endangerment of breeds was not given due consideration in the formulation of livestock development strategies. Livestock development and conservation activities should be so oriented that they actually become complementary to each other. The following activities are recommended for conservation of indigenous breeds of livestock.

Evaluation of Genetic Resources in the Natural Habitat

So far the information available on animal genetic resources pertains to animals reared on organized farms. No information is available on the status of animals under field conditions. Quinquennial livestock census which is the only source of information regarding population is also conducted species-wise and not breed-wise. Therefore, the population of a breed in a particular geographical area is not known and this is a basic parameter to formulate any type of conservation and improvement programme. Some efforts have been made to estimate the population of different breeds from the livestock census figures on the basis of following assumptions: (i) the breeding tract was divided into central, adjacent and territorial parts, and district was considered a unit; and (ii) certain percentage of total population was considered as breed population based on reports of the state government agencies and survey studies of the National Bureau of Animal Genetic Resources (Table 23). However, these estimates may not be close to the actual population as has been revealed by preliminary estimates on many breeds. Hence, it is very essential to conduct surveys in the breeding tract to establish the status of a breed in terms of its population, management practices, physical characteristics, utility and performance, and then plan its improvement and conservation programmes. Agro-climatic conditions in breeding tract are all inter-related and should be recorded if the breeding plans are to be successful. In addition, the surveys will reveal the extent of genetic variability in the breeds including the rare variants which must be conserved at any cost.

Establishment of Livestock Conservation Boards

At present systematic records are maintained only by some organized farms. Inventories on animals in their breeding tract reared by farming community do not exist. This is an essential pre-requisite for planning any programme on animal genetic resources. Proper cataloguing, documentation and upkeep of livestock inventories should be made mandatory. A livestock conservation board should be established in each state where inventories pertaining to the entire state should be maintained in computerized form.

Table 23. Population dynamics of various breeds ('000)

Breed	Total population	Breedable females	Females bred pure	Stud bulls	Trend
Cattle					
Malvi	568	197	138	3.3	Increasing
Gir	537	154	62	3.0	Increasing
Kankrej	465	149	60	2.4	Increasing
Ongole	378	131	53	6.0	NA
Dangi	348	168	118	6.0	NA
Hariana	331	112	45	0.9	Decreasing
Gaolao	291	91	64	0.9	Increasing
Kangayam	266	71	57	1.4	Decreasing
Nimari	252	73	50	0.8	Increasing
Nagori	229	103	72	0.5	Decreasing
Amritmahal	217	75	52	1.7	Increasing
Hallikar	201	71	49	1.5	Increasing
Kenkatha	181	60	42	0.6	Increasing
Krishna Valley	175	72	50	1.1	NA
Deoni	175	52	36	1.0	NA
Bachaur	156	30	21	0.3	NA
Tharparkar	146	68	27	1.6	Increasing
Kherigarh	145	46	32	0.5	Decreasing
Khillari	128	41	29	1.1	NA
Rathi	115	45	31	0.2	Decreasing
Siri	87	19	15	0.7	Decreasing
Mewati	60	19	14	0.1	Decreasing
Bargur	49	15	11	0.2	Decreasing
Ponwar	48	12	8	0.2	Decreasing
Sahiwal	3	2	1	0.2	NA
Red Sindhi	2	1	1	0.2	NA
Buffaloes					
Murrah	1384	753	600	12.5	Increasing
Mehsana	543	296	207	1.1	Increasing
Surti	472	260	182	1.8	Increasing
Nili-Ravi	462	230	184	10.0	NA
Nagpuri	357	154	123	6.5	Increasing
Jaffarabadi	289	161	128	1.8	Increasing
Bhadawari	173	82	58	0.6	Increasing
Toda	6	3	3	0.1	Decreasing

NA: Not Available
Source: Tantia *et al.* (1994).

Establishment of a National Data Bank

A national data bank should be established to maintain complete information on all animal genetic resources of the country. Data banks at state livestock conservation boards should be linked to the national data bank through a computer network. The state livestock conservation boards will have the responsibility of updating information pertaining to their region and breeds. The national data bank will emerge as a nodal agency for all information with capabilities of linking with international organizations.

Live Animal Repositories

(a) *Breeding farms*: There are one or more breeding farms for some of the indigenous breeds. The existing farms of indigenous breeds should be declared as germplasm repositories and used for production of bulls and semen. Only purebreeding should be practised at these farms. Efforts should be made to establish at least one farm for each breed in the breeding tract.

(b) *Gaushala*: Some of the gaushalas have purebred animals of indigenous breeds but they do not have the resources for maintaining and improving these animals. Such gaushalas should be supported to maintain indigenous breeds. Semen from bull mother station and other necessary supplement inputs should be given to these gaushalas free of cost. But then these should be under an agreement not to resort to crossbreeding or other such practices which may dilute the purity of a breed.

Establishment of Breed Societies and Breed Survival Trusts

Considerable success has been achieved in European countries in the conservation of some breeds which were not economical. Their population trend is upward now. This has been possible through Breed Societies or Rare Animal Trusts. In India, livestock is raised by farmers and no data recording system is followed in the field. Therefore, proper evaluation of indigenous animals for further improvement is not feasible at present. Although India was one of the signatories in 1936 for the Herd Registration programme initiated at Rome and the Ministry of Agriculture, the Government of India launched the Herd Registration Scheme for the registration of outstanding animals of 6 breeds of cattle and 2 breeds of buffaloes in their respective home tract. Not much headway could be made. It may be very important to form breed societies in India for the conservation of rare and endangered breeds. Moreover, the improvement of indigenous livestock breeds can be taken up simultaneously in collaboration with these breed societies through selection of outstanding animals true to their breed types from the larger population maintained in the breeding tract.

Creation of Public Awareness

No enterprise can be successful unless it is accepted by the community. The endangered breeds can be popularized amongst the people of the area and some tourist interest can be created by providing wide publicity. Some special products from the endangered breed for which it is efficient may be popularized. Publicity for endangered domestic livestock may be as important as proved in the conservation of wild life. Conservation in the form of live animals was largely limited to breeds of curious appearance as hobby of individuals. In Western countries the Livestock Parks of rare breeds are growing in popularity for show to the public. Elsewhere payments are made to the owners for each animal of a recognized endangered breed which they have and breed regularly. The conservation of prolific Taihu sheep in China is an example of this method. In India also there are some farmers who consider it a status symbol in keeping the purebred animals of popular breeds of their area. Such farmers if encouraged through financial and veterinary help, may end up in success story for the preservation of endangered breeds *in situ.*

Establishment of Gene Banks

Germplasm repositories in the form of semen and embryo banks should be established in different regions/institutions/farms. Such gene banks should have co-operative linkages with live animal farms for collection of material. The existing semen banks should be strengthened to serve as gene banks. A national gene bank should also be established which will maintain half of the quantity of cellular material, the other half being maintained by regional gene banks. Rare and endangered breeds should be taken first for *ex-situ* conservation

Human Resource Development Programmes

At present, there is a dearth of trained personnel for undertaking conservation programmes. Curricula of animal and veterinary science education should be suitably revised to include course on conservation, evaluation and sustainable utilization of animal genetic resources. Training programmes should be organized for persons involved in evaluation of animal genetic resources under field conditions.

Publication of Literature

There is a paucity of information on animal genetic resources. Available information on various breeds should be published in the form of breed monograms, maps, calendars, etc. This is essentially to create general awareness and promote activities related to development and conservation. A national watch list should be published regularly to reveal about the status of different breeds. This will help in preparing immediate action plans for the threatened breeds.

□

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□

APPENDIX I

Body measurements (cm) of various breeds of cattle

Breed		Male			Female		
		Length	Height	Heart girth	Length	Height	Heart girth
1	2	3	4	5	6	7	8
Amritmahal	Mean	130	150	170	130	150	150
	No.	-	-	-	-	-	-
	Range	-	-	-	-	-	-
Bachaur	Mean	-	-	-	-	-	-
	No.	-	-	-	-	-	-
	Range	110-120	110-125	140-170	95-115	100-120	135-165
Bargur	Mean	176.6	125.6	156.2	120.5	121.6	123.8
	No.	54	54	54	150	150	150
	Range	172-201	-	140-169	98-147	-	120-148
Dangi	Mean	140	130	150	-	-	-
	No.	-	-	-	-	-	-
	Range	-	-	-	-	-	-
Deoni	Mean	130.3	135.2	165.1	120.1±2.16	122.2±1.23	151.8±1.92
	No.	781	781	781	1,007	1,007	1,007
	Range	105-150	127-164	152-201	110-139	116-132	145-165
Gaolao	Mean	118	143	180	108	125	173
	No.	-	-	-	-	-	-
	Range	-	-	-	-	-	-
Gir	Mean	150	140	180	125.5	121.2	160.4
	No.	-	-	-	527	527	527
	Range	-	-	-	-	-	-
Hallikar	Mean	-	-	-	170	118	150
	No.	-	-	-	-	-	-
	Range	190-200	132-140	170-200	-	-	-
Hariana	Mean	136.5	144.0	160.5	137.5±1.11	135.0±1.06	155.6±1.56
	No.	38	38	38	1114	1014	1114
	Range	-	-	-	128-150	126-147	134-174
Kangayam	Mean	144.9±0.87	140.1±0.97	176.5±1.65	131.9±0.76	124.9±0.58	156.1±0.85
	No.	146	178	173	353	353	349
	Range	-	-	-	-	-	-
Kankrej	Mean	148	158	194	113.6	133.6	166.2
	No.	-	-	-	27	27	27
	Range	-	-	-	-	-	-

1	2	3	4	5	6	7	8
Khillari	Mean	140	140	200	110	130	170
	No.	-	-	-	-	-	-
	Range	125-150	130-145	185-210	100-125	115-140	150-200
Malvi	Mean	150	140	200	140	130	170
	No.	-	-	-	-	-	-
	Range	-	-	-	-	-	-
Nagori	Mean	-	-	-	137.5±2.3	124.2±3.00	165.4±1.22
	No.	-	-	-	61	61	61
	Range	140-150	145-152	191-203	130-148	118-132	157-175
Nimari	Mean	145	155	175	120	135	160
	No.	-	-	-	-	-	-
	Range	-	-	-	-	-	-
Ongole	Mean	171.1±0.95	152.4±0.61	203.8±1.03	133.3±1.01	133.5±0.70	166.0±1.20
	No.	69	69	69	-	-	-
	Range	155-190	140-165	186-230	-	-	-
Punganur	Mean	113±3.9	107±4.2	151±6.9	108±0.9	97±0.65	128±0.66
	No.	5	5	5	51	51	51
	Range	-	-	-	-	-	-
Rathi	Mean	-	-	-	132.63	121.24	164.23
	No.	-	-	-	84	84	84
	Range	-	-	-	-	-	-
Red Kandhari	Mean	133	128	173	124	118	146
	No.	-	-	-	-	-	-
	Range	120-148	120-137	155-190	106-140	103-132	129-169
Red Sindhi	Mean	140	130	180	140	120	140
	No.	-	-	-	-	-	-
	Range	-	-	-	-	-	-
Sahiwal	Mean	150	170	190	130.9±1.6	124.1±2.1	163.6±0.85
	No.	-	-	-	125	125	125
	Range	-	-	-	-	-	-
Siri	Mean	121.8±16.82	119.8±14.04	147.4±15.34	119.7±11.47	118.5±8.85	147.9±8.18
	No.	40	40	40	65	65	65
	Range	-	-	-	-	-	-
Tharparkar	Mean	142	133	184	131.6	130.3	173.2
	No.	-	-	-	124	124	124
	Range	-	-	-	-	-	-
Umblachery	Mean	118.7±1.17	116.7±1.03	150.7±0.98	108.6±1.01	104.7±0.78	134.7±0.98
	No.	384	389	393	520	524	535
	Range	100-143	103-123	125-165	90-125	85-115	120-145
Vechur	Mean	108.8±1.79	98.2±1.41	132.3±3.11	93.4±0.98	89.0±0.68	122.2±1.03
	No.	12	12	12	51	51	51
	Range	-	83-105	-	-	81-91	-

APPENDIX II

Body weights (kg) of various breeds of cattle

Breed		Birth weight			Adult weight	
		Male	Female	Overall	Male	Female
1	2	3	4	5	6	7
Amritmahal	Mean	20.8	19.9		500	318
Bachaur	Mean	19.7	18.8		385	318
Bargur	Mean	18.9	18.1		340	295
Dangi	Mean	18.4	17.5	17.9	363	310
	No.	183	202	385		
Deoni	Mean	23.0	23.4±2.48		590	340
	No.		88			
	Range		20-25		620-680	432-485
Gaolao	Mean	19.3	18.5		430	340
Gir	Mean	23.1	21.3	23.9	544	309.8
	No.	186	456	13761		527
	Range	22-27	20-25	20-27		
Hallikar	Mean	21.3	20.2		340	227
Hariana	Mean	23.34	21.73	22.4±0.16	499	325
	No.	578	1435	4269		
	Range	20-25	17-24	17-25		
Kangayam	Mean	22	21	21	540	380
	No.			31		20
Kankrej	Mean	24	23	23.0		343
	No.			255		27
	Range			21-26	500-550	325-400
Kenkatha	Mean	19.2	18.9	-	350	300
Kherigarh	Mean	20.7	19.9	-	476	318
Khillari	Mean	22	21.3		499	334
	Range	18-21	17-20		450-625	300-350

1	2	3	4	5	6	7
Malvi	Mean	21	19	19.9	499	340
	No.	55	61	116		
	Range			18-21		
Nagori	Mean	17.5±0.21	16.3±0.22	16.9±0.16	362.9	317.5
	No.	48	59	107		
Nimari	Mean	19.9	18.7		390	318
Ongole	Mean	28	26	26.8	570	
	No.			883		
	Range			24-30	545-613	409-454
Ponwar	Mean	18.5	17.6	-	318	295
Punganur	Mean	12.8±0.29	11.4±0.48	12.3±0.24	244±3.5	178±3.0
	No.	43	32	75	5	51
	Range	9-18	6-18	6-18	200-270	130-200
Rathi	Mean	19.4	19.1	19.2		294.81
	No.	199	177	376		48
	Range	19-23	19-22	19-23		
Red Kandhari	Mean	20.4	18.7	20.1±0.74	430	340
Red Sindhi	Mean	22.5	21.4	21.9	450	320
	No.	396	368	764		
	Range	20-28	19-24	20-28		
Sahiwal	Mean	22.4	20.9	21.7	540	326.8±4.38
	No.	755	681	1436		298
	Range	20-25	18-23	18-25		301-360
Siri	Mean	21.2	19.9	-	454	363
Tharparkar	Mean	23.1	22.4	22.6		294.8
	No.	2375	5966	8341		48
	Range	21-25	21-25	21-25	450-500	
Umbalachery	Mean	18.6	17.9		385	325
Vechur	Mean	11.2±0.21	10.2±0.21	10.6±0.3	178.43±7.97	132.0±2.63
	No.	73	96	169	12	51
	Range	10-12	130-200	95-150		

APPENDIX III

Production performance of various breeds of cattle

Breed		Total lactation milk yield (kg)	First lactation milk yield (kg)	Lactation length (days)	Dry period (days)
1	2	3	4	5	6
Amritmahal	Mean	572±24		299±10	
Bachaur	Mean	540.4±9.15	496.0±13.6	254.34±2.49	
	No.	231	81	155	
	Range	495-605			
Bargur	Mean	350			
	No.				
	Range	250-1,300		270-310	
Dangi	Mean	529.5±17.7	486.3±33.3	268.8±3.5	189.6±3.5
	No.	221	69	221	194
	Range	32-1,228	32-1,093	100-396	0-934
Deoni	Mean	940.0		299.0±7.83	177.0±4.2
	No.	833		1,006	770
	Range	636-1,230		169-475	
Gaolao	Mean	604.2		239.7±1.84	
	No.	968		968	
	Range	470-725			
Gir	Mean	2,110	1,137.7	308	225
	No.	14,517	306	11,944	1,086
	Range	800-3,300		250-375	176-271
Hallikar	Mean	542±61		285±10	
	Range	227-1,134		210-310	
Hariana	Mean	996.87	838.95	272.12	254.90
	No.	22,990	15,564	19,262	5,679
	Range	693-1,754	529-1,334	238-330	133-571
Kangayam	Mean	640		270	174.8±5.17
	No.				170
	Range	600-800			
Kankrej	Mean	1,745.7		293.8	
	No.	15,822		7,849	
	Range	1,097-3,194		275-350	

1	2	3	4	5	6
Khillari	Mean	384.1		228	
	No.	1,228		78	
	Range	240-515		190-275	
Malvi	Mean	1,074	1,045.5±31.62	306.1	179.8±9.26
	No.	294	108	157	108
	Range	627-1,227	627-1,227	275-320	125-265
Nagori	Mean	603.30	471.29	267.2	110.03
	No.	1,271	110	1,271	581
	Range	479-905		237-299	82-155
Nimari	Mean	357.2±11.15	312.4±15.17	237.2±4.48	
	No.	175	62	175	
	Range	310-495		220-260	
Ongole	Mean	688.2±32.24	563.9±36.92	232.8±10.63	262.1±13.74
	No.	1,292	288	1,292	822
	Range	475-1,000	400-900	160-270	145-400
Punganur	Mean	546.0±30.6		263.4±16.5	232.3±19.64
	No.	45		45	36
	Range	194-1,099		98-445	83-595
Rathi	Mean	1,559.60		336.4	180.8
	No.	1,637		1,145	902
	Range	1,062-2,810		306-431	132-234
Red Kandhari	Mean	597.6±18.32		259.8±4.26	173.0±7.44
	No.	380		380	359
Red Sindhi	Mean	1,839.6	1,547.2	296.3	259.0
	No.	1,372	542	1,007	219
	Range	1,100-2,600	1,100-2,200	260-330	
Sahiwal	Mean	2,325.5±17.84	2,236±33.46	318.3	156±3.20
	No.	1,317	˙398	552	
	Range	1,600-2,750		285-375	
Tharparkar	Mean	1,748.76	1,742.66	285.98	137.63
	No.	9,919	2,724	8,377	7,063
	Range	913-2,147	803-2,167	240-377	115-191
Vechur	Mean	514±37.1		232.0±16.71	
	No.	37		37	

APPENDIX IV

Reproduction performance of various breeds of cattle

Breed		Age at first calving(days)	No. of services/ conception	Service period (days)	Calving interval (days)
1	2	3	4	5	6
Amritmahal	Mean	1,337.6±115.52			577.6±24.32
Bachaur	Mean	1,453.24±21.75	1.38±0.06		487.79±5.92
	No.	147	356		267
	Range	1,259-1,502			424-536
Dangi	Mean	1,351±38.6	1.65	185.6±9.7	474.1±10.2
	No.	54	574	256	194
Deoni	Mean	1,391.0±26.74		170.0±7.0	447.0±8.0
	No.	1,172		1,007	1,007
	Range	894-1,540		128-196	399-501
Gaolao	Mean	1,298.9		92.52±1.35	387.4
	No.				968
Gir	Mean	1,552	3.4	219.0	516
	No.	3,100	315	2,148	3,423
	Range	1,200-1,800		144-309	440-600
Hallikar	Mean	1,370±45.6			598.9±27.36
	Range	915-1,800			
Hariana	Mean	1,566.8	2.39	231.85	482.73
	No.	24,057	4,776	6,945	20,612
	Range	1,067-1,809	1.40-2.81	126-305	415-561
Kangayam	Mean	1,330			498.4
	No.	1,023			1,061
	Range	1,100-1,500			365-670
Kankrej	Mean	1,438.1±10.95		223.7	490.0
	No.	1,551		2,286	2,118
	Range	1,030-1,700			407-639
Khillari	Mean	1,427.5			450
	No.	20			
	Range	1,050-1,930			
Malvi	Mean	1,432.02		178.3	419
	No.	148		68	552
	Range	1,175-2,009		106-249	411-530

1	2	3	4	5	6
Nagori	Mean	1,440.04	1.52	172.09	460.95
	No.	453	660	1,237	1,330
	Range	1,287-1,505		121-203	423-549
Nimari	Mean	1,477			482.5±11.64
	No.	80			155
	Range				400-530
Ongole	Mean	1,473.2		191.4±6.28	500.4±11.26
	No.	220		1,126	1,069
	Range	1,150-1,820		128-310	420-720
Punganur	Mean	1,125	1.35	182.8±20.15	452.4±18.7
	No.			44	36
	Range			38-578	317-832
Rathi	Mean	1,410.6	3.34	204.72	518.8
	No.	143	359	346	775
	Range	1,104-1,581	1.5-3.7	168-208	445-617
Red Kandhari	Mean			164.7±18.03	444.15±9.62
	No.			219	359
Red Sindhi	Mean	1,323.7	1.99	148.0	442.9
	No.	1,157	47	582	1,131
	Range	972-1,560		90-175	380-550
Sahiwal	Mean	1,183.4±18.34	2.7±0.1	175.5±3.7	450.6±5.56
	No.	748	967	334	1,955
	Range	940-1,520	2.5-2.9	140-200	390-550
Tharparkar	Mean	1,247.31	1.88	127.52	431.00
	No.	11,399	4,396	3,248	11,029
	Range	1,116-1,596	1.41-2.6	108-191	408-572
Umblachery	Mean	1,593.0±12.2	.	177.0±3.0	446.0±4.0
	No.	205		205	205
Vechur	Mean	1,073±46.4			449.7±4.6
	No.	16			47

APPENDIX V

Milk composition

Breed	Fat %	SNF %
Dangi	4.3	
Deoni	4.3 (2.5-5.3)	9.69
Gaolao	5.5	
Gir	4.4	
Hallikar	5.7	
Hariana	4.5 (4.3-5.3)	9.1
Kangayam	3.88±0.07 (3-5.67)	6.96±0.05 (6.75-7.17)
Kankrej	4.8 (4.66-4.99)	
Nimari	4.9	
Ongole	4.18 (4.1-4.8)	8.45 (8.3-8.54)
Punganur	5.0 (3.11-10)	9.50±0.06 (7.69-10.56)
Rathi	3.67 (3.25-3.97)	8.88
Red Kandhari	4.57±0.03	8.62±0.01
Red Sindhi	4.5±0.16 (4.0-5.2)	
Sahiwal	4.93 (4.8-5.1)	9.12 (9.0-9.3)
Tharparkar	4.88 (4.72-4.90)	9.18 (8.87-9.67)
Umbalachery	4.94±0.06	7.80±0.03
Vechur	6.2 (5.0-7.5)	

APPENDIX VI

Body measurements (cm) of various breeds of buffaloes

Breed		Male			Female		
		Length	Height	Heart girth	Length	Height	Heart girth
Bhadawari	Mean	116.9	122.8	184.5	115.0	123.1	184.3
	No.	90	90	90	169	169	169
Jaffarabadi	Mean	127.7	126.1	207.7	132.6	129.1	200.9
	No.	58	58	58	1,419	1,419	1,422
Mehsana	Mean	153.7	133.7	200.6	141.7	127.5	189.3
	No.	55	55	55	314	314	314
Murrah	Mean	150.0	142.0	220	148.0	132.7	202.4
	No.				1,372	1,698	1,746
Nagpuri	Mean	180.0	140.0	210.0	128.6	122.8	181.8
	No.				413	413	413
Nili-Ravi	Mean	160.0	140.0	230.0	165.4	134.2	207.7
	No.				150	140	120
Pandharpuri	Mean				132.9	130	192.8
	No.				201	201	201
Surti	Mean	142.0	130.0	190.0	118.8	124.9	184.0
	No.				25	25	25
Toda	Mean				132.7	121.8	180.4
	No.				131	131	129

APPENDIX VII

Body weights (kg) of various breeds of buffaloes

Breed		Birth weight			Adult weight	
		Male	Female	Overall	Male	Female
Bhadawari	Mean	27	25	25.3±0.23	475	425.7±7.72
	No.			860		49
	Range			24-27		300-540
Mehsana	Mean	29.5±0.51	28.5±0.45	29.0	565.4	484.2
	No.	209	252	461	55	314
	Range	16-44	14-40	14-44	400-602	315-580
Murrah	Mean	31.7	30.0	30.3	567	516
	No.	2,186	6,043	8,574		1,761
	Range	28-34	26-33	26-34	450-800	350-700
Nagpuri	Mean	29.0±0.32	28.1±0.14	28.6±0.27	520	363.5
	No.			1,028		200
	Range	27-30	25-29	25-30		340-400
Nili-Ravi	Mean	35.1	34.5	34.8	567	454
	No.	182	222	404		
	Range	27-39	27-38	27-39		
Pandharpuri	Mean	28.0±0.91	25.6±0.74	26.8		416.2±10.10
	No.	17	26	43		11
Surti	Mean	26.3	24.5	25.2	500	382.6±12.14
	Range	24-30	23-29	23-30		318-414
Toda	Mean	27.9±0.60	28.0±0.59	27.9±0.43	380	380
	No.	57	43	100		

APPENDIX VIII

Reproduction performance of various breeds of buffaloes

Breed		Age at first calving (days)	No. of services/ conception	Service period (days)	Calving interval (days)
Bhadawari	Mean	1,477.44±17.63		178.98±10.60	478.7±11.55
	No.	596		724	715
	Range	1,335-1,550		83-317	390-630
Jaffarabadi	Mean	1,361.7	1.5	93.4±0.69	440.3±14.32
	No.	715	715	715	54
	Range	1,250-1,670	1-2		427-455
Mehsana	Mean	1,265.9	1.93	161.0	475.5
	No.	664	1,074	1,260	1,260
	Range	677-2,500	1.75-2.15	24-646	313-945
Murrah	Mean	1,319.0	3.93	136.3	452.9
	No.	19,991	1,074	6,209	11,083
	Range	1,214-1,647	1.40±3.75	125-187	430-604
Nagpuri	Mean	1,672.0	1.31±0.23	115.7	429.6
	No.	200	374	1,459	557
	Range			34-435	350-721
Nili-Ravi	Mean	1,359	2.38	202.2	487.7
	No.	2,459	1,318	1,739	2,620
	Range	1,216-1,617	2.1-3.4	169-290	313-945
Pandharpuri	Mean	1,255	3.0±0.39	165.0	465.0
	No.		37	34	32
Surti	Mean	1,692.70	2.81	142.6	534.7
	No.	939	13,760	400	641
	Range	1,050-1,770	1.5-3.0	93-164	430-564

APPENDIX IX

Production performance of various breeds of buffaloes

Breed		Total lactation milk yield (kg)	First lactation milk yield (kg)	Lactation length (days)	Dry period (days)
Bhadawari	Mean	903.1	780.0±25.4	271.9±3.98	190.0
	No.	1,514	931	1,028	421
	Range	658-1,142	699-1,165	140-350	145-295
Jaffarabadi	Mean	2,238.7±74.87	2,151.3±130.53	305.1±9.61	144.9±8.4
	No.	70	29	70	57
	Range	2,151-2,336		289-319	
Mehsana	Mean	1,988.0	1 940.4	316.7	166.7
	No.	1,352	713	1,219	1,260
	Range	598-3,597	598-3,221	157-513	14-656
Murrah	Mean	1,751.8	1,678.4	298.7	154.8
	No.	15,765	16,195	16,390	8,665
	Range	1,003-2,057	904-2,041	269-337	127-176
Nagpuri	Mean	1,055.4	933.3	286.4	129.1±4.85
	No.	645	126	996	374
	Range	780-1,520		263-297	80-155
Nili-Ravi	Mean	1,850.2	1,483.4	294.2	150.6
	No.	607	1,124	1,072	2,543
	Range	1,586-1,929	1,268-1,854	263-316	115-202
Pandharpuri	Mean	1,502.3±69.35	1,197.3	330.0	144.0±10.54
	No.	39	4	39	34
	Range	1,168-1,680		296-346	108-155
Surti	Mean	1,285.43	1,396.5	344.7	205.4±8.79
	No.	2,274	2,502	900	580
	Range	1,208-2,208	1,208-2,203	280-405	155-289

APPENDIX X

Milk composition

Breed	Fat %	SNF %
Bhadawari	8.58±0.63 (169), 6-12.5	9.57±0.19 (46)
Jaffarabadi	7.68±0.04, (2,060) 6.83-8.5	
Mehsana	7.0 (1,080), 5.2-9.5	
Murrah	7.34 (5,716), 6.9-8.3	
Nagpuri	7.0-8.5	10.81
Nili-Ravi	6.8(1,194), 5.1-8.0	9.1
Pandharpuri	7.0	9.28
Surti	8.27±0.25(25), 7.5-8.3	
Toda	8.22±0.08	

APPENDIX XI

State-wise Livestock census ('000)

State	Cattle						Buffaloes	
	Indigenous		Crossbred		Total		1987	1992
	1987	1992	1987	1992	1987	1992		
Andhra Pradesh	11,985	10,465	390	482	12,375	10,947	8,758	9,132
Arunachal Pradesh	288	322	22	25	310	347	12	10
Assam	7,051	10,116	228	4	7,279	10,120	623	958
Bihar	20,666	21,775	173	400	20,839	22,155	4,872	5,353
Goa	107	92	5	8	112	100	40	45
Gujarat	6,078	6,797	162	6	6,240	6,803	4,502	5,268
Haryana	1,956	1,719	242	415	2,198	2,134	3,827	4,373
Himachal Pradesh	2,084	2,034	160	118	2,244	2,152	794	701
Jammu & Kashmir	2,238	2,625	527	430	2,765	3,055	565	732
Karnataka	9,455	12,025	719	1,150	10,174	13,175	4,035	4,251
Kerala	1,707	1,529	1,701	2,000	3,408	3,529	328	296
Madhya Pradesh	28,442	28,481	108	206	28,550	28,687	7,351	7,970
Maharshtra	15,779	15,672	1,205	1,769	16,984	17,441	4,753	5,447
Manipur	705	648	65	69	770	717	140	115
Meghalaya	568	442	19	178	587	620	28	34
Mizoram	45	56	5	5	50	61	5	7
Nagaland	128	200	75	131	203	331	15	34
Orissa	13,073	13,014	563	563	13,636	13,577	1,506	1,509
Punjab	1,251	2,211	1,579	700	2,830	2,911	5,575	5,238
Rajasthan	10,847	11,547	73	119	10,920	11,666	6343	7,775
Sikkim	141	170	43	30	184	200	2	3
Tami Nadu	8,201	7,975	1,141	1,300	9,342	9,275	3,129	2,814
Tripura	766	843	61	107	827	950	16	20
Uttar Pradesh	23,734	23,136	2,586	2,495	26,320	25,631	18,240	20,086
West Bengal	19,599	16,004	712	1,450	20,311	17,454	1,163	1,011
UT's	188	98	55	156	243	254	330	299
Lakshadweep			2		1			
Pondicherry			39		89		10	
ALL INDIA	188,282	192,223	11,413	12,310	199,695	204,533	75,967	83,499

APPENDIX XII

State-wise cattle and buffalo bull population ('000)

States/U.T.s	Cattle						Buffalo		
	Indigenous			Crossbred			1987	1992	%growth
	1987	1992	%growth	1987	1992	%growth			
1	2	3	4	5	6	7	8	9	10
Andhra Pradesh	779	453	- 10.28	22	10	- 14.10	132	89	- 7.58
Arunachal Pradesh	24	19	- 4.88	4	4	- 1.36	2	1	- 20.18
Assam	404	504	4.54	6	7	2.04	77	102	5.75
Bihar	8,276	8,795	1.22	-	4	-	838	921	1.90
Gujarat	94	74	- 4.60	3	4	4.35	24	28	3.15
Goa	6	4	- 7.90	-	0	-	1	2	9.68
Haryana	44	38	- 3.11	9	13	7.06	47	78	10.61
Himachal Pradesh	32	63	14.47	6	5	- 2.41	82	5	- 42.29
Jammu & Kashmir	153	124	- 4.06	26	26	- 0.12	11	12	2.43
Karnataka	132	180	6.41	10	31	25.73	36	88	19.67
Kerala	11	11	0.70	6	6	0.70	4	4	- 1.97
Madhya Pradesh	654	1,110	11.15	5	9	11.97	255	345	6.20
Maharashtra	338	322	- 0.97	-	28	-	73	78	1.46
Manipur	55	78	7.33	12	10	- 2.67	37	22	- 9.82
Meghalaya	-	89	-	-	1	-	11	3	- 23.10
Mizoram	4	5	3.83	-	0	-	1	0	- 18.21
Nagaland	11	17	8.97	5	10	15.19	2	4	16.14
Orissa	4,609	4,996	1.63	52	60	2.76	629	646	0.54
Punjab	-	35	-	251	62	- 24.32	-	47	-
Rajasthan	200	209	0.87	-	1	-	46	55	3.47
Sikkim	20	22	1.69	9	10	1.68	-	-	-
Tamil Nadu	161	257	9.82	19	41	16.73	51	9	- 28.99
Tripura	67	78	3.02	2	3	10.20	1	1	5.16
Uttar Pradesh	330	262	- 4.51	75	66	- 2.46	336	295	- 2.58
West Bengal	4,593	284	- 42.70	48	24	- 12.92	678	27	- 47.45

1	2	3	4	5	6	7	8	9	10
Union Territories									
A&N Islands	4	1	- 20.22	-	0	-	1	1	- 5.59
Chandigarh	1	0	- 41.25	-	0	-	-	0	-
D&N Haveli	1	2	13.24	-	0	-	-	0	-
Delhi	9	0	- 54.22	-	0	-	7	1	- 37.07
Lakshadseep	-	0	-	-	-	-	-	-	-
Pondicherry	2	1	- 19.08	-	0	-	-	0	-
Daman & Diu	-	2	-	-	-	-	-	0	-
All India	21,014	18,035	- 3.01	570	436	- 5.22	3,382	2,864	- 3.27

- less than thousand, (P) provisional.

Source: Basic Animal Husbandry Statistics, 1997.

APPENDIX XIII

Trends in population of cattle and buffaloes, 1951 to 1987 (in millions)

Category	1951	1956	1961	1966	1972	1977	1982	1987	1992
Cattle									
Young stock	43.56	43.80	48.87	48.08	47.48	47.63	56.99	62.96	-
Females over 3 years	49.87	49.89	54.32	54.68	56.40	57.60	59.20	62.07	-
In milk	18.96	20.10	20.72	20.97	22.03	23.19	26.59*	29.82*	-
Dry and not calved	27.41	27.15	30.29	30.80	31.38	31.43	32.10*	31.11*	-
Cows used for work	3.50	2.64	3.31	2.91	2.99	2.98	0.51	1.14	-
Males over 3 years	61.81	64.88	72.48	73.34	74.46	74.91	72.84	74.66	-
Used for breeding	0.65	0.44	0.38	0.43	0.39	0.41	11.53	14.32	-
Working bullocks	58.47	62.48	68.60	69.18	70.57	71.24	61.05	51.33	-
Used for breeding and work	NA	NA	1.98	2.26	1.99	1.99	-	7.26	-
Not for breeding and work	2.69	1.96	1.52	1.47	1.51	1.27	0.26	1.75	-
Total	155.24	158.57	175.67	176.10	178.34	180.14	192.45	199.69	204.53
Buffalo									
Young Stock	14.75	16.07	18.45	18.59	20.12	21.79	24.72	29.37	-
Females over 3 years	21.86	22.34	25.03	26.14	29.24	31.87	32.51	39.14	-
In milk	10.22	11.81	12.58	12.92	15.07	16.96	17.99	23.15	-
Dry and not calved	10.79	9.86	11.66	12.59	13.54	14.31	14.40	15.52	-
Buffaloes used for work	0.85	0.67	0.79	0.63	0.63	0.60	0.12	0.47	-
Males over 3 years	6.80	6.50	7.67	8.19	8.06	8.37	7.95	7.46	-
Used for breeding	0.31	0.33	0.29	0.33	0.22	0.22	0.63	0.51	-
Working	6.03	5.95	6.61	6.97	7.01	7.32	-	3.76	-
Used for breeding/work	NA	NA	0.51	0.62	0.60	0.61	5.97	2.87	-
Others	0.46	0.22	0.26	0.27	0.23	0.22	1.35	0.32	-
Total	43.41	44.91	51.15	52.92	57.42	62.03	*69.78	75.97	83.00

* Difference of total are due to inclusion of projected figures for Arunachal pradesh, Punjab and Meghalaya for which data were not available.

APPENDIX XIV

Contribution of livestock to GDP (Rs millions)

Livestock	At current prices				At 80-81 prices			
	80-81	90-91	93-94	94-95	80-81	90-91	93-94	94-95
Milk group	68,840	275,080	436,940	500,510	68,840	117,110	131,910	137,450
Meat group	15,700	72,080	127,990	172,600	15,700	26,710	34,580	38,120
Dung	13,520	43,070	64,290	71,470	13,520	15,270	15,390	15,620
Eggs	3,510	13,070	22,020	26,090	3,510	7,150	8,320	8,870
Others	4,400	17,100	21,130	26,170	4,400	5,580	6,070	6,620
Total	105,970	420,400	672,370	796,840	105,970	171,820	196,270	206,680
Crops	462,780	1,286,570	1,875,840	2,216,290	462,780	633,830	666,910	701,250
Agriculture	568,750	1,286,570	1,875,840	2,216,290	568,750	805,650	863,180	907,920
GDP	1,224,270	4,756,040	7,231,030	8,541,030	1,224,270	2,112,600	2,360,640	2,510,100
Livestock output as percentage of								
Crops	22.89			35.95				29.47
Agriculture	18.63			26.45				22.76
GDP	8.65			9.33				8.24

APPENDIX XV

Information on veterinary institutions and infrastructure

Infrastructure available	North	South	East	West	Total
Cattle and buffalo breeding farms	44	38	72	29	183
Veterinary hospital/polyclinic	6,182	837	345	51	7,415
Veterinary dispensaries	5,894	4,058	3,066	1,555	14,573
Veterinary aid centres	5,316	6,985	8,139	3,242	23,682
Liquid nitrogen plants	59	37	39	16	151
Frozen semen banks	34	20	29	8	91
Semen production centres	94	34	16	4	148
Intensive cattle development projects	1	0	11	7	31
Artificial insemination centres	13,520	14,972	7,345	7,945	43,782
Gaushalas	309	35	8	335	687
Bull stations	14	33	41	4	92
Fodder seed production farms	19	18	18	6	61
Rinderpest check post	38	59	62	11	170
Milk processing factories	4	25	12	68	109
Liquid milk plants	61	83	53	50	247

Source: State Department of Animal Husbandry and Dairying (as on 31.03.96).

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