THE KANGAYAM CATTLE
A RETROSPECTIVE AND PROSPECTIVE STUDY

S.Panneerselvam and N.Kandasamy

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FOREWORD

India has a vast repository of domestic animal biodiversity with a large number of breeds of all livestock and poultry. The diversity of domesticated livestock breeds was developed due to years of evolution adapted to specific ecological niche and local need. There are 30 well-defined breeds of cattle in India which represent less than 15 per cent of the total cattle population. The share of India in terms of number of breeds in our country is 7 75 per cent of the total world cattle breeds.

Each of our breed should be regarded as a collection of special genes designated to serve specific purpose(s) in particular agro-ecological zones and a valuable genetic resource. They have been endowed with unique qualities like tolerance to high heat and humidity, resistance to diseases and ability to survive under severe nutritional stress. Nowadays, the breeds of different livestock species show serious decline in their numbers due to reduction in the need for animal draught power, more emphasis on rearing crossbred cattle and fast changing socio-economic levels and needs of farmers. The loss of diversity shall reduce the options available to the breeders to meet the unpredictable requirements of the future.

Many good things are lost to the world through lack of recording and publication. Among the draught breeds of cattle in India, Kangayam is known for its excellent draught qualities and hardiness. The monograph on Kangayam cattle is a complete record of this popular breed from the early days of its origin to the present day. It contains the entire spectrum of evolution of this breed.

The authors had conducted a survey of the breed for a period of three years in the breeding tract and had collected complete data for its characterization and evaluation and also reported the existing managemental practices. In addition, the monograph updates the compilation of all information and research works carried out on Kangayam cattle since beginning of 20th Century.

They have also reported the population status of Kangayam in the tract and reason for its decline and genetic erosion and important considerations for its conservation. The details collected and compiled elucidate better qualities and potentialities of Kangayam as a superior draught breed. With such wealth of data available it must be possible for the experts in the line to plan and programme properly and bring about rapid development of the breed.

I appreciate the efforts of the authors in collecting all the information and compilation of the monograph. I hope the monograph would provide the basis for establishing norms of the breed and serve as a ready reference for the policy planners, cattle breeders and research workers for future genetic characterization and conservation.

21-2-08

Place Chennai - 600 051
Date 21-02-2008

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PREFACE

Cattle are known to have been domesticated about 10,000 years ago and the traction power of the ox in the earliest stages of its domestication marked a turning point in the development of agriculture. Cattle are the most numerous of the domestic animals and the present population is about 1300 millions. About 800 breeds have been identified and one-quarter of them are found in Asia. One of the enduring images of Indus Valley civilization is a bull with lyre horns and now there are 30 breeds of cattle in India. The southern peninsular region has the largest number and breeds of draught cattle. Specifically, Tamil Nadu and Karnataka are the states in which draught cattle had played a pivotal role. Tamil Nadu is unique in having several breeds and varieties (ecotypes) of draught cattle.

Cattle were equated with wealth even during Sangam Age of the Tamils. Cattle were always part and parcel of "Mullai" (forest region) landscape. The prelude to wars between chieftains or kings in ancient Tamil country was the invading army taking possession or plundering of herds of cows of the enemy. Cattle wealth was a symbol of prestige though there is a steep decline in the belief. Draught cattle played significant roles during peace and war. Draught cattle are the cornerstone of agriculture although mechanization and electrification have replaced them in a significant way The Amritmahal, the progenitor of draught cattle in these states and its close cousin, the Hallikar were used for transport of cannons and equipage not only during Mysore Wars, but were also employed as far away as Afghanistan and Mesopotamia by the British army during the late 19th and early 20th Centuries.The Amritmahal and Hallikar acquitted themselves admirably Times have changed and so does the importance of draught cattle.

The main aim of this monograph is to collate all essential data and information concerning the Kangayam cattle and bring together previously non-united areas of research. Though considerable information is available on morphology and physical traits of Kangayam cattle, data on body weight at different ages are very few. Similarly concerted efforts were not made to study the phenotypic and genetic parameters of production traits. Quantitative data are lacking on draught capacity and related parameters and this needs to be addressed in future studies.

Critical studies on physiological norms, milk constituents and genetic relationship between draught capacity and milk production are needed. Detailed investigations on male reproduction and seminal attributes are also required. Marketing and movement of Kangayam cattle to Kerala, mostly through Pollachi needs comprehensive study.

The market prices of Kangayam cattle at different periods during the past 100 years have also been compiled for the purpose of comparison. The Government of Tamil Nadu issued a few orders on the breeding and conservation of Kangayam cattle and they have also been appended. Whorls or lucky marks are still important in determining the price of cattle and the prevailing beliefs as of 1936 have been included as an appendix for the purpose documentation.

Though animal genetic resources and their conservation are catch-words nowadays, it is amazing to note the insight of Major W.D. Gunn and Captain R.W.Littlewood in documenting them and Dr.D.Pattabhiraman's views on conservation of Tamil Nadu cattle breeds. Conservation is a sustained and altruistic effort and transcends artificial boundaries of Plans and government control on sanction of grants. It is a continuum in time. What is required is a holistic approach taking the entire scenario into consideration. Isolated and disjointed efforts and half-hearted attempts by any agency will not bring forth any tangible results. The participation of stake-holders is a *sine qua non* for the conservation of any breed to posterity. Conservation of the habitat and ecosystem is also equally important.

Scientific breeding of Kangayam cattle was originally initiated in 1924 and a sizeable herd was maintained at what was then known as Livestock Research Station, Hosur. It is learnt that they were subsequently moved to the District Livestock Farms, Chettinad and Pudukkottai and disappeared altogether from these farms, perhaps due to the over-emphasis on milk production by way of cross breeding. Now again a new herd of Kangayam cattle is being maintained at what is now known as District Livestock Farm, Hosur Here is a lesson for the conservationists of animal genetic resources to learn from the past.

ACKNOWLEDGEMENTS

Dr.V Ulaganathan, formerly Director, Centre for Animal Production Studies, Tamil Nadu Veterinary and Animal Sciences University, Chennai initiated a significant cycle of studies on Kangayam cattle by proposing an Indian Council of Agricultural Research *ad hoc* scheme "A survey of Kangayam cattle" The monograph is the culmination of such research activities. The authors are grateful to Professor O.Sundararama Reddi, Chairman and Managing Director, Malladi Clonetech Diagnostics Ltd., Hyderabad who generously made a gift of the personal copy of his doctoral thesis on the change of coat colour in Kangayam cattle to the Department. Dr.S.N.Sivaselvam, Professor and Head, Livestock Research Station, Kattupakkam extended unstinted help in locating the unpublished literature on Kangayam cattle scattered in various theses and dissertations.

Dr.K.Viswanathan, Dean, Veterinary College and Research Institute, Namakkal extended necessary support during various stages of the preparation and printing of the monograph. Tmt.R.Malathi, Assistant, Veterinary College and Research Institute, Namakkal did word processing of several versions of the draft.

Dr.N.Balaraman, former Vice-Chancellor, Tamil Nadu Veterinary and Animal Sciences University, Chennai was instrumental in completing the final draft of the monograph. Dr.P Thangaraju, Vice-Chancellor, Tamil Nadu Veterinary and Animal Sciences University, Chennai readily agreed for the publication of this monograph and was kind enough to write the foreword. Dr.B.Sethuraman, General Manager, National Bank for Agriculture and Rural Development, (NABARD), Mumbai, guided the authors in getting financial support. The full financial assistance for the publication of the monograph was provided by National Bank for Agriculture and Rural Development, (NABARD), Mumbai and the same is gratefully acknowledged.The final proof reading of the entire manuscript was diligently done by Dr.D.Cauveri and Dr. P Devendran Assistant Professors of the Department; however the authors are responsible for any errors or omissions in the monograph.

S.Panneerselvam
N.Kandasamy

CONTENTS

1. INTRODUCTION

India is a major livestock region of the Asian countries and is rich in animal genetic resources. There are about 30 recognized breeds of cattle native to India. Among these, majority of them belong to either dual or draught purpose cattle. Tamil Nadu ranks tenth in cattle wealth in India (Anon.,2004a) and has a population of 9 14 million cattle as per 17th Livestock Census - 2003 (Anon.,2004b). The State is endowed with a few distinct draught breeds viz. Kangayam, Umblachery, Alambadi and Bargur. Among these, Kangayam is an excellent draught breed known for its draught power and sturdiness. It is also known by the synonyms Kanganad and Kongu (Gunn, 1909). The breed derives the name from its home tract, Kangayam taluk in Erode district (formerly a constituent part of Coimbatore district). The credit for evolving this breed goes to the then Pattagar of Palayakottai Mr.N.Nallathambi Sarkarai Manradiar and his family, the Kadiyar Munsiff Monigar etc. (Gunn, 1909; Littlewood, 1936; Pattabhiraman, 1958).

The pioneer to undertake identification and description of Kangayam cattle was Gunn (1909). He traced the history of development of Kangayam breed and described its habitat, distribution and characteristics. Later, Littlewood (1936) while restating most of the observations of Gunn, opined that the breed might have undergone some changes during the 20 years preceding his study. Pattabhiraman (1958) reported on the production and reproduction characters of Kangayam cattle maintained at Livestock Research Station, Hosur and at the Palayakottai Cattle Farm.

Kangayam is a hardy breed suitable for all agricultural operations and carting. The bullocks have been identified as high power animals with maximum power availability of 0.8 hp per pair of bullocks (Surendrakumar, 1988). It is well-adapted to drought-prone areas and can thrive on scanty rations. Kangayam cows produce moderate amount of milk in harsh environment. The bullocks are in demand in southern parts of Tamil Nadu and in Kerala State as they are good workers and the breed has also been exported to Brazil, Malaysia, the Philippines and Sri Lanka for draught purposes. Earlier Kangayam bullocks were mostly used for drawing water from deep wells, ploughing and transport. Now the bullocks are mainly used for transport of agricultural produce, and sand to building construction sites. Of late, a decline in Kangayam cattle population has been observed as a result of reduction in the need for animal draught power for agricultural operations.

Under these circumstances, Government of Tamil Nadu has taken up a project for pure breeding of Kangayam cattle at District Livestock Farm, Hosur since 1992 to preserve the valuable germplasm for future use. In order to study the distribution, breed characteristics, existing management practices and utility of the breed, a detailed survey was conducted in its habitat between 1993 and 1997 by the Department of Animal Genetics, Veterinary College and Research Institute, Namakkal with full financial assistance from the Indian Council of Agriculture Research (ICAR), New Delhi Subsequently the Council also sanctioned another project "*Ex situ* conservation of Kangayam cattle" for conservation of the germplasm and it was implemented at

the Department of Animal Genetics and Breeding, Madras Veterinary College, Chennai. Recognizing the special features and its contribution to rural development by way of renewable source of energy to various agricultural activities and to focus attention towards conservation and utilization of this precious heritage, Department of Posts, Ministry of Communications and Information Technology, Government of India, New Delhi released a commemorative stamp on 20.04.2000 for Kangayam along with three other indigenous breeds of cattle.

Information on the distribution, population status, breed characteristics, and performance of this breed published over nearly a century is scattered. Hence, in order to have a broader picture about the status and performance of the breed an attempt is made through this monograph to compile all the information available on Kangayam breed as well as the one generated through the survey of the breeding tract. This would provide the basis for establishing norms of the breed and also formulating suitable programmes for conservation.

2. ORIGIN AND HISTORY

The origin of the Kangayam breed is clouded in history. Kangayam breed was reported to be in existence for nearly three centuries (Reddi, 1957) but there is no supporting evidence. Moreover, the Pattagars of Palayakottai were not keeping any records on Kangayam during the earlier phase of formation of the breed. It is understood that the parent purebred stock were developed by 33rd Pattagar of Palayakottai and subsequently improved and consolidated by his son Rai Bahadur N.Nallathambi Sarkarai Mandradiar for over a period of five decades (Mandradiar, 2001). He kept his breed pure by using sires only from his own herd. However, the appearance of some of the cows and heifers was such as to give the impression that they had a distinct strain of Ongole blood in them and the Pattagar is known to have possessed several purebred Ongole cows (Gunn, 1909). The body conformation of Kangayam also indicates the admixture of a heavy breed. Moreover, the horn and head shapes differ markedly from other Mysore breeds. Phillips (1944) also opined, perhaps based on earlier reports that Kangayam seemed to have suffered an influence of Ongole because it was larger than the other breeds of the Mysore group.

The title Pattagar means the head of the community with powers to settle their social and religious disputes. The title is hereditary and passes on to the eldest son. The main occupation of the Pattagar family then was agriculture and cattle breeding. Where smallholdings were the rule and the use of machinery for agricultural operations was not available, bullock power was indispensable. Realizing that, the Pattagar took pains to develop his herd on a large scale and in a systematic manner. The breed was initially developed in his cattle farm at Palayakottai (of the present Erode district), which was then one of the biggest cattle breeding stations in India with a total of 15,000 acres of land. Roughly half of the total area was utilized for his cattle farm of which about 5,000 acres were used as pasture and about 2000 acres were used for cultivation of fodder crops (Pattabhiraman, 1958).

2.1 Kangayam Cattle Development Schemes

To assess the milk production potential of this breed in its home tract without deteriorating its draught quality, the Indian (Imperial) Council of Agricultural Research (ICAR), New Delhi sanctioned "Kangayam Cattle Improvement Scheme" in 1942. The Pattagar's farm was selected to implement the scheme since it was the only source at which the breed was maintained in a pure form with sufficient stock. Though earlier the Pattagar identified various families / lines of breeding for the development of Kangayam, he started maintaining pedigree records only after implementation of this scheme at his farm. After implementation of the scheme, this farm produced a total of 774 breeding bulls between the years 1945-46 and 1954-55 and majority of them were supplied to various government livestock development schemes. The bulls were distributed not only in the breeding tract but also in other districts of the State for grading up the local cattle, to suit agricultural operations (Pattabhiraman, 1958). The Government of Madras also had taken steps to improve and popularise the breed since 1924 by maintaining purebred herd of Kangayam at Livestock Research Station, Hosur and distributing pedigree bulls to rural areas for improving the local nondescript cattle (Pattabhiraman, 1958).

Improvement of Kangayam cattle in the breeding tract and even introduction to adjoining areas was initiated under the Key Village Scheme and Key Village Extension Scheme. The Key Village Scheme was first implemented during 1952-53 in the First Five Year Plan and further extended in a phased manner in subsequent Plan periods. During the Third Five Year Plan (1961-1966) there were 57 Key Village Blocks in Tamil Nadu and among these 35 had been located in the Kangayam breeding tract and maintained pedigree Kangayam bulls for breeding (Anon., 1965).

In each Key Village Block area all the cows and calves born were registered and tattooed. Scrub bulls were castrated and only selected bulls were used for breeding purposes. Initially natural service was practised, but later on artificial insemination was introduced in all Key Village Blocks through artificial insemination centres sub-centres. Totally 1.2 lakh natural services and 13.98 lakh artificial inseminations were performed during the period between 1952-1964 in all the Key Village Blocks (Anon., 1965).

In 1956, Key Village Extension Scheme was introduced with the objective of utilizing the pedigree bulls produced in Key Village areas in other places, where the local nondescript cattle had to be graded up. Under this scheme, each Key Village Extension Centre had 50 breeding bulls of different breeds including Kangayam. During 1963-1964, 68 such centres were established in Tamil Nadu which maintained 3,164 breeding bulls and performed 1,16,600 natural services (Anon., 1965). However, in 1974 the scheme was replaced with Intensive Cattle Development Project (ICDP) with more emphasis on cross breeding to enhance milk production. Though the breed in its purest form and in largest numbers was previously seen in District livestock Farms at

Hosur, Chettinad and Pudukottai at present the breed is being maintained only at District Livestock Farm, Hosur in addition to the cattle farm at Palayakottai.

The Indian Council of Agricultural Research, New Delhi started herd book registration for Kangayam cattle in 1947 During that period Kangayam Cattle Breeders' Association was established at Erode, Coimbatore district of Madras state (Joshi and Phillips, 1953). In 2001, it was also recommended for setting up of Kangayam Breeders Society in a Seminar and Workshop on " Indigenous cattle and their role in the Millennium" held at Erode organized by Indian Dairy Association (Mandradiar, 2001).

3. HABITAT AND DISTRIBUTION

The habitat and distribution of the Kangayam breed comprises major area of Erode district and parts of Coimbatore, Dindigul, Karur and Namakkal districts of Tamil Nadu. Gunn (1909) observed that Kangayam cattle were bred in the southern and southeastern taluks of Coimbatore and indicated two varieties of Kangayam, large and small. The larger variety was found to be more numerous in Karur, Aravakurichi and Dindigul taluks, while the smaller variety was seen in Kangayam, Dharapuram, Udumalpet, Pollachi, Palladam and Erode taluks. Littlewood (1936) also reported the same areas as the breeding tract of Kangayam cattle and indicated that the breeding however centred round the Kangayam division of the Dharapuram taluk. Later, Pattabhiraman (1958) reported that the breed was generally seen in Dharapuram, Udumalpet, Palladam, Pollachi and Erode taluks of Coimbatore district. The breed in the purest form and in largest numbers was found only in the herd of the Pattagar of Palayakottai and at Livestock Research Station, Hosur.

The details collected during a survey (1993-1997) of breeding tract revealed that Kangayam cattle were bred in Kangayam, Dharapuram, Perundurai, Erode and parts of Gobichettipalayam taluks of Erode district; Palani and Vedasandur taluks of Dindigul district; Karur and Aravakurichi taluks of Karur district; and Udumalpet, parts of Avinashi and Tirupur taluks of Coimbatore district (Fig.1). The breeding tract is situated between latitudes 10°12' and 11°48' north and longitudes 77°12' and 78°12' east and spread over approximately 17,000 km^2 The elevation of the breeding tract ranges from 150 to 600 metres above mean sea level (Report, 1998). Whereas, Joshi and Phillips (1953) stated that the breeding tract was approximately between latitudes 10°15' and 11°18' north and longitudes 76°39' and 78°14' east. The area was on a plateau with undulations with an average altitude of about 1300 feet (396 m) above mean sea level.

The population density of Kangayam cattle was more in Kangayam, Dharapuram, Perundurai, Palani, Karur and Aravakurichi taluks and less in other areas of the breeding tract. Animals true-to-type were seen in Kangayam, Dharapuram and Karur taluks (Report, 1998).

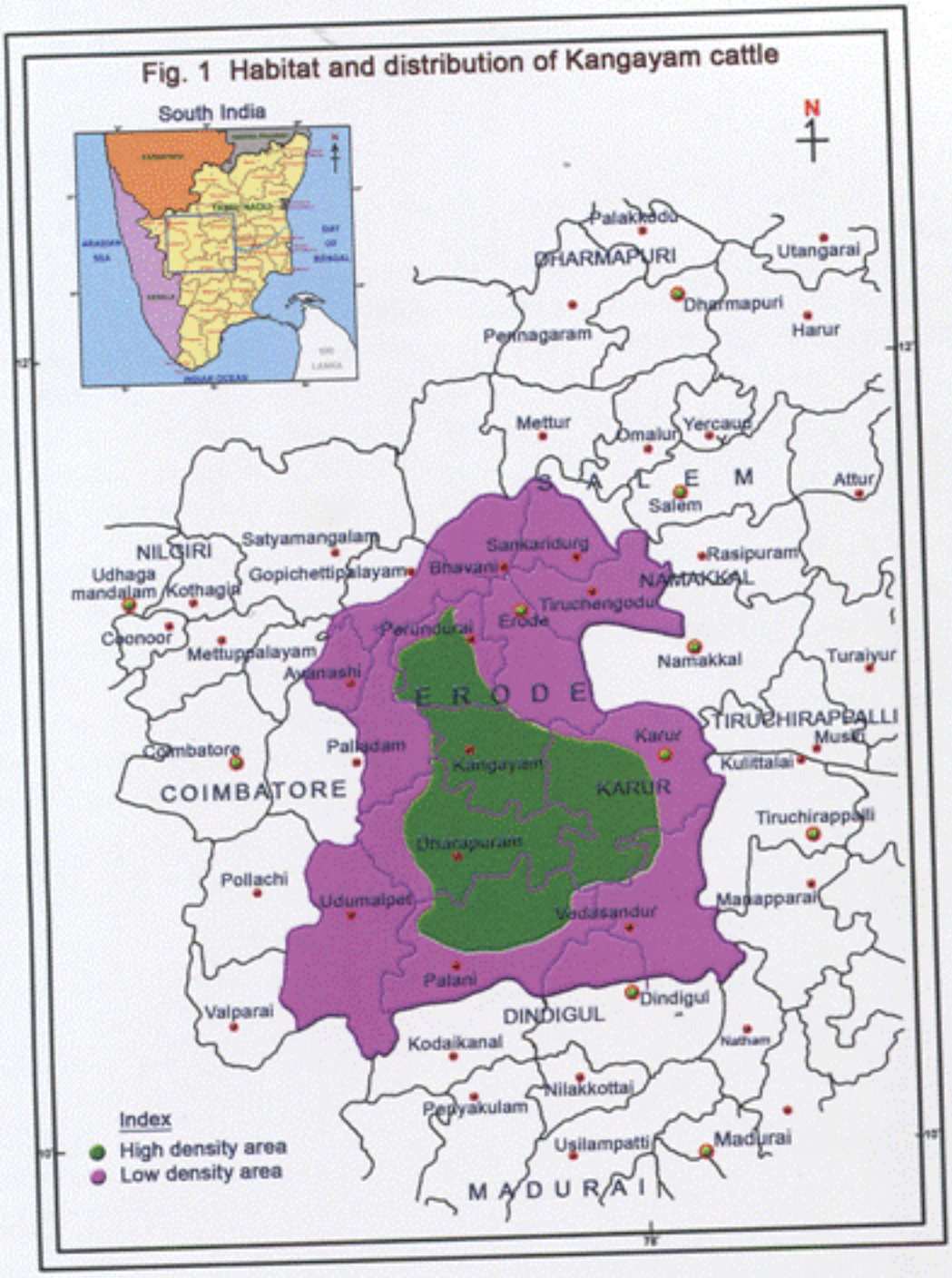


Fig. 1 Habitat and distribution of Kangayam cattle
South India
N
Palakkodu
DHARMAPURI
Utangarai
Dharmapuri
Harur
Pennagaram
Mettur
Omalur
Yercaud
SALEM
Attur
Salem
Satyamangalam
NILGIRI
Sankaridurg
Rasipuram
Udhagamandalam
Kothagiri
Gopichettipalayam
Bhavani
NAMAKKAL
Tiruchengodu
Coonoor
Perundurai
Erode
Mettuppalayam
Avanashi
Namakkal
Turaiyur
ERODE
TIRUCHIRAPPALLI
Karur
Musiri
Coimbatore
Palladam
Kangayam
Kulittalai
COIMBATORE
KARUR
Tiruchirappalli
Dharapuram
Pollachi
Udumalpet
Vedasandur
Manapparai
Palani
Dindigul
Valparai
DINDIGUL
Kodaikanal
Natham
Nilakkottai
Periyakulam
Usilampatti
Madurai
MADURAI
Index
High density area
Low density area

Table 2. Age-wise and sex-wise distribution of Kangayam cattle in the breeding tract (as of 1996)

District	Calf			Youngstock						Adultstock						Grand total
	Male	Female	Total	6-24 months			25-42 months			Male			Female			
				Male	Female	Total	Male	Female	Total	Working	Breeding	Total	In milk	Dry	Total	
Erode	36103	21454	57557	8136	20286	28422	10089	13593	23682	49377	473	49850	55395	42981	98376	**257887**
	(14.00)	(8.32)	(22.32)	(3.15)	(7.87)	(11.02)	(3.91)	(5.27)	(9.18)	(19.15)	(0.18)	(19.33)	(21.48)	(16.67)	(38.15)	**(100)**
Dindigul	3223	5778	9001	901	1252	2153	3835	3660	7495	34340	58	34398	8453	26695	35148	**88195**
	(3.65)	(6.55)	(10.21)	(1.02)	(1.42)	(2.44)	(4.35)	(4.15)	(8.50)	(38.93)	(0.07)	(39.00)	(9.58)	(30.27)	(39.85)	**(100)**
Karur	4234	5896	10130	2321	3167	5488	1098	3920	5018	5143	188	5331	10475	9816	20291	**46258**
	(9.15)	(12.75)	(21.90)	(5.02)	(6.85)	(11.87)	(2.37)	(8.47)	(10.85)	(11 12)	(0.41)	(11.53)	(22.64)	(21.22)	(43.86)	**(100)**
Coimbatore	867	1065	1932	950	364	1314	418	728	1146	11711	-	11711	3164	4650	7814	**23917**
	(3.63)	(4.45)	(8.08)	(3.97)	(1.52)	(5.49)	(1 75)	(3.04)	(4.79)	(48.97)	-	(48.97)	(13.23)	(19.44)	(32.67)	**(100)**
Namakkal	12067	3448	15515	1724	8619	10343	3447	2587	6034	8620	-	8620	13791	8619	22410	**62922**
	(19.18)	(5.48)	(24.66)	(2.74)	(13.70)	(16.44)	(5.48)	(4.11)	(9.59)	(13.70)		(13.70)	(21.92)	(13.70)	(35.62)	**(100)**
Total	**56494**	**37641**	**94135**	**14032**	**33688**	**47720**	**18887**	**24488**	**43375**	**109191**	**719**	**109910**	**91278**	**92761**	**184039**	**479179**
	(11.79)	**(7.85)**	**(19.64)**	**(2.93)**	**(7.03)**	**(9.96)**	**(3.94)**	**(5.11)**	**(9.05)**	**(22.79)**	**(0.15)**	**(22.94)**	**(19.05)**	**(19.36)**	**(38.41)**	**(100)**

Figures in parentheses are the percentages under each category

Source: Report (1998)

Gunn (1909) observed that many ryots in the breeding tract owned 10 to 20 heads of Kangayam whereas, the recent survey indicated that the average herd size was only 3.5 animals with majority of herds having 3 to 5 animals. In addition a decline in the Kangayam population in the entire breeding tract was also recorded (Report, 1998). It is understood that the following factors presumably contributed to the reduction in the Kangayam population density·

i) Reduction in the need for animal draught power for agricultural operations due to increased mechanized farm operations, particularly electrification of deep wells and use of tractors.

ii) Diversification of agricultural enterprise with more emphasis on rearing crossbred cattle and to some extent buffaloes for increased milk production. It was evident in certain taluks which were earlier reported as part of the main breeding tract. The replacement of Kangayam by exotic crosses might be due to the effect of introduction of canal irrigation, which generally results in change of land use pattern and increased availability of fodder. In dry areas of the main breeding tract farmers are changing over to sheep rearing particularly Mecheri breed for better economic returns.

iii) Absence of breed society organization for promoting breed development and improvement of Kangayam cattle.

However, the present population size does not immediately require any measures for conservation. But consolidation of the efforts made so far and steps for genetic improvement of draught capacity in bullocks and milk yield in cows are the need of the hour.

5.ENVIRONMENT OF THE BREEDING TRACT

The habitat of any breed of farm animal is the sum total of geography, soil, climate and vegetation of the region in which it originates, multiplies and spreads.

5.1 Soil

The major stretch of lands in the tract constitutes red soil followed by black soil. Red soil is shallow in depth with texture ranging from sandy to gravel with a calcareous sub-soil. The soil of Kangayam tract as assessed at Palayakottai area is indeed an asset for cattle rearing (Pattabhiraman, 1958). The sub-soil is rich in Canker and gravel. This is a calcium and phosphorus compound which by itself adds to the fertility of the soil by breaking up the continuity of the soil and thus providing aeration, greater absorption and retention of moisture, apart from enhancing the dissolved calcium and phosphorus content available for better growth of grass with high nutritive value.

5.2 Climate

It is generally hot throughout the year except during north-east monsoon season (October-December). The averages of climatic data of the tract recorded at Karur-Paramathi Observatory (10°57' N and 78°5' E; altitude 181 m) for 10 years from 1985 to 1994 are given in Table 3 The mean maximum temperature of the tract varied from 30°C to 38°C, while the mean minimum varied from 19°C to 26°C. The summer is pretty severe, the temperature touching 103°F (39.4°C) during the month of May (Pattabhiraman, 1958). One of the characteristic features of the tract is the high-wind speed (up to 11km / h) from June to August.

Kangayam breeding tract is generally a dry tract where the cultivation has to depend upon the monsoon. The average rainfall is low with varied distribution and at times not sufficient to grow cereal crops; but it is generally sufficient for the growth of grass. Pattabhiraman (1958) reported average rainfall of 28 inch (711.2 mm) for 25 years ending January 1954, which was spread over 31 rainy days. Whereas, the mean annual rainfall recorded between 1985 and 1994 was only 650 mm and the number of rainy days in a year were 37.5 Roughly about one-half of this rainfall is received during the north-east monsoon. Generally failure of monsoon rains is not an uncommon feature of the area and hence these areas are subject to drought frequently Though three rivers viz. Bhavani, Noyyal and Amaravathi are flowing through the breeding tract water is still a major constraint for agricultural production. The river Cauvery runs on the eastern side of the tract. In major parts of the tract there are large number of open wells used for domestic consumption and irrigation purposes.

5.3 Natural vegetation and cultivated crops

The predominant vegetation seen in the pasture is Kolukkattai grass (*Cenchrus setigerus* and *Cenchrus ciliaris*), Nerungi (*Tribulus terrestris*) and Cheppunerungi (*Indigofera linnaei*). Apart from these grasses and weeds, common trees noticed are Velvaelam (*Acacia leucophloea*) Karuvaelam (*Acacia nilotica*), Drumstick tree (*Moringa oleifera*), neem (*Azadirachta indica*) and palmyra (*Borassus flabellifer*).

Cereals are the main cultivated crops in the breeding tract. They are: sorghum (*Sorghum vulgare*), pearl millet (*Pennisetum typhoides*), paddy (*Oryza sativa*) and ragi (*Eleusine coracana*). Other cultivated crops noticed are groundnut (*Arachis hypogea*), chillies (*Capsicum annuum*), sugarcane (*Saccharum officinarum*) and cotton (*Gossypium hirsutum*). In addition, certain pulses viz. Naripayathankodi (*Phaseolus trilobus*), black gram (*Phaseolus mungo*), green gram (*Phaseolus aureus*), cow pea (*Vigna sinensis*), red gram (*Cajanus cajan*) and bengal gram (*Cicer arietinum*) and horse gram (*Dolichos biflorus*) are cultivated. Generally a shift in cereal cropping pattern from pearl millet to sorghum and in some areas by maize (*Zea mays*) was observed in the tract.

Table 3. Climatic profile of the breeding tract of Kangayam cattle *

Climatic variable	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual mean / Total
Maximum temperature (°C)	30.9	33.8	36.5	37.9	37.2	33.5	33.2	32.9	33.4	31 7	30.0	30.1	**33.4**
Minimum temperature (°C)	18.9	20.7	23.1	25.6	25.8	25.0	24.3	24.2	24.0	23.6	21.8	20.3	**23.0**
Relative humidity (%) at 0830h	80.9	75 1	72.8	71 1	71 7	73.4	75.1	76.7	77.2	81.3	83.2	81.8	**76.7**
Relative humidity (%) at 1730h	47.6	37 1	32.3	37 7	45.9	59.0	59.8	62.8	58.6	64.9	66.6	59.5	**52.7**
Rainfall (mm)	10.0	3.6	14.6	30.0	94.8	22.8	24.2	40.8	139.5	128.5	114.3	27.0	**650.1**
No. of rainy days	1.0	0.1	0.6	2.3	4.1	1.6	2.2	2.8	6.6	7.4	6.4	2.4	**37.5**
Wind speed (km/h)	3.2	4.4	4.6	4.6	6.5	11.4	11.8	11.0	7.0	3.0	2.2	2.5	**6.0**

* Monthly averages for 10 years from 1985 to 1994

6. MANAGEMENT PRACTICES

6.1 Housing

In the Kangayam breeding tract majority of the farmers do not have any permanent and ventilated animal sheds. During the day time animals are allowed in the pastureland and they are brought back each evening and housed mostly in the open during the night. They are tethered in the wooden pegs or trunk of trees in the close vicinity of human dwellings. Generally, farmers having 10 animals and above have separate enclosure or three side-closed temporary low-cost housing. A few farmers have simple animal sheds consisting of small wall of mud and stone of semi-permanent nature and thatched roofing. Coconut and palmyra (*Borassus flabellifer*) fronds are used as thatching materials.

Shelter against sun or rain is not provided to the animals but they are protected against strong winds (which prevail from June to August) by screens of bamboo mats or some other kind of protection. If the farmers possessed only garden/wetland they keep the animals around their house compound. During summer some farmers keep their cattle day and night in the grazing land itself.

6.2 Feeding

Kangayam cattle have been traditionally reared mainly on grazing in the pasturelands specifically maintained by the farmers for cattle and sheep. (Fig.2 and 3) The predominant grass seen in the pasture is Kolukkattai grass (*Cenchrus setigerus* and *Cenchrus ciliaris*) with Velvaelam (*Acacia leucophloea*) trees found at intermittent spaces. Cenchrus grasses have bulbous rootstock which can maintain their vitality even during the severest drought (Littlewood, 1936; Pattabhiraman, 1958). The seeds are freely dispersed and rains at any time cause rapid germination, resulting in lush green pasture, which grows to a foot or more in height within a few weeks time. Acacia trees in the pastureland provide shade for the animals and during fruiting supply pods for the cattle to eat. During the season the pods are also collected and stored and are used with concentrates. The pods have good feeding value, contain around 15% crude protein and it is believed that feeding of the pods improves the condition of coat and milk yield. The chemical compositions of Kolukattai grass and other predominant vegetation along with acacia pods in the pasture area are given in Table 4.

All the plants in the tract are rich in calcium and phosphorus, probably due to the nature of the soil. Pattabhiraman (1958) reported that the flora of the pasture area contribute almost all the nutrients that are required for the cattle and the feeding of concentrates becomes necessary only when the pasture is scanty.

Fig.2 and 3. Typical pastureland with Kolukkattai grass *(Cenchrus setigerus and Cenchrus ciliaris)*

Table 4. **Chemical composition of vegetation and acacia pods in the Kangayam tract**

Plant / Vegetation	Moisture	Crude protein	Calcium	Phosphorus	Insolubles	Ash
Kolukattai	6.95	5.02	0.36	0.19	8.54	12.20
Cheppunerungi	7.07	11.88	5.17	0.36	3.75	16.36
Naripayathankodi	6.51	9.19	1.59	0.55	0.83	6.67
Acacia pods	7.33	14.86 and Crude fibre 11.5 %	1.61	0.44	0.23	6.84

Source: Pattabhiraman (1958)

Calves are allowed to consume as much milk as they require up to the first six weeks. Later, green grass is provided for the calves depending on the availability and in due course they are allowed for grazing along with their dams. The period of suckling is gradually reduced, as the calves grow older Generally, concentrate feed or supplement is not given to calves. Bull calves are weaned later than heifer calves and given comparatively better attention with respect to suckling.

Besides grazing, animals of all age groups are also fed with dry fodder and crop residues like sorghum and pearl millet stovers, groundnut haulms, paddy straw etc. The quantity of dry fodder fed depends on the availability of grass in the grazing field. Bullocks in work are given *ad libitum* quantity of dry fodder and soaked cottonseed. During the dry season, when the grazing is scarce, concentrate feed consisting of rice bran, groundnut cake, soaked cottonseed and ground sorghum and pearl millet are given to cows in milk, breeding bulls and to the working animals. All the ingredients are crushed and fed in liquid form. The quantity varies from 0.5 to 1.0 kg per animal and also depends upon the economic status of the farmer. Addition of mineral mixture and vitamin supplementation are usually not practised. Palmyra fronds are also fed with other fodder during periods of drought.

Now, sorghum is the major fodder crop in the tract. According to Littlewood (1936) pearl millet was the principal fodder earlier. There is regular practice of raising sorghum, especially local varieties during the monsoon season as rainfed and under irrigation throughout the year by dense sowing *"Adar cholam"* (meaning close or crowded) so as to get higher yield and thinner stalk. It is harvested at peak flowering stage, dried and stocked for future use. In addition, there is a practice of 'pick-up' (steaming) feeding to animals intended for sale at cattle fairs. Blackgram, horsegram and fenugreek are soaked in water, ground into a paste and mixed along with the concentrates and fed. To improve the condition of the coat, a handful of gingelly seed powder mixed with jaggery is also given daily to animals intended for sale. It was observed during survey that Kangayam animals utilize the poor quality roughages efficiently when compared to crossbred cattle in the region.

6.3 Breeding

Both natural service and artificial insemination with frozen semen are used for breedin Frozen semen straws of Kangayam bulls are supplied by the Animal Husbandry Departmen Government of Tamil Nadu to all the veterinary hospitals, dispensaries and sub-centres in th breeding tract and Rs.15/- has been collected per insemination. Generally, farmers prefer natur mating if the insemination centre is located beyond 3 to 4 km. Depending on the need, in man villages a few promising breeders maintain one or two breeding bulls for natural service. The have adopted this as a profession for their livelihood or supplementary income and they charg between Rs.40 to 50 per service.

Selection of male for breeding is done based on their pedigree and phenotypic appearanc Particular attention is paid to the size, conformation, gait, colour and other related qualities. addition, breeders usually look for certain lucky marks, which are the lines and hairmarks o whorls on different parts of the body of the bulls. The selected males are allowed for breedin at an average age of 30 months. Based on the performance and requirement, the breeding bul in service are emasculated around the age of 5 to 6 years and put to work. They are usuall replaced with young bulls which are selected from their own stock. Pattabhiraman (1958) reporte that at Palayakottai Cattle Farm heifers were mated at three years of age. A bull was allowed a batch of 30 heifers in the grazing area for three months to cover all the heifers by natur service, whereas the cows in the farm were taken to the bull when they came to heat for the fir time after calving which was between 90 to 100 days. It was observed during the survey th those maintaining breeding bulls did not have any concept about breeding programme, managemen of breeding bulls etc. Sometimes, one bull is used by 2 to 3 villages consecutively for 4 to 5 yea resulting in inbreeding.

6.4 Other Management Practices

Kangayam cows have strong mothering instinct and so weaning of calves is never practise and the calves are allowed to suckle throughout the lactation till the cow is dried. After th morning milking (around 6.00 a.m) the cows along with youngstock, dry females and bullocks ar watered and sent to the pasture for grazing.

The pastureland is generally divided into many paddocks, which are thickly fenced wit "Mullukiluvai" (*Balsamodendron berryi*), a thorny shrub, which is highly drought-resistant an secure enough to impound cattle (Fig.4 and 5). Manure is not collected in the grazing area an the land is ploughed once in four or five years. A system of rotational and priority grazing is bein adopted in the pastureland. Within the grazing area facility for drinking water is also provided b keeping small cement water troughs. In the evening, around 5.00 p.m the animals are brough back from the pasture and watered and tethered. Usually, cattle and buffaloes are kept togethe

Fig.4 and 5. Live fence made of thorny shrub Mullukiluvai (*Balsamodendron berryi*) around the grazing land with gate made of bamboo sticks

The left over roughages, dung and urine in the sheds / open area where the animals are tied are cleaned daily. Both males and females are roped and nose-strung and tied to a peg individually after weaning.

Males not selected for breeding are castrated at an average age of 24 months, which varies from 18 to 30 months. During the time of castration ears are also pruned to improve the appearance; but it is not done in the case of females. At the age of 3 years bullocks are trained for ploughing and carting. The Kangayam cows are mainly reared for producing bullocks for draught purposes and the milk is regarded as a by-product. The milk received from the cows is rarely sold but utilized for home consumption. Adult females are also utilized for agricultural work mostly by small farmers, if need arises and during that period they are not milked. Use of cows for work and owning of small private pasture with Cenchrus grass and *Acacia leucophloea* trees which are fenced by live fencing with Mullukiluvai, are peculiar features of the Kangayam breeding tract.

7. BREED CHARACTERISTICS

7.1 Morphology

The description of the morphology of Kangayam is a judicious synthesis of the previous workers, especially Pattabhiraman (1958) with necessary additions based on the survey.

7.1.1 General appearance

It is classified as Mysore-type cattle under group IV of Indian cattle (Joshi and Phillips, 1953) though the head profile, the position, shape and thickness of the horns and shape of the body are different from other Mysore-type cattle viz. Amritmahal, Hallikar, Khillari, Alambadi and Bargur. The Kangayam is a medium-sized animal. It is strong and active with compact body and medium stout legs.

7.1.1.1 Body colour

Calves: Calves are generally red in colour at birth, with black markings over the coronets and fetlocks and sometimes on the knees. However, inside the thighs and forelegs the colour is creamy white (Fig.6). The red colour begins to change to grey from two months of age starting from sides of abdomen tending to spread downwards. Finally red colour disappears in the head and total grey colour is generally attained around six months (Fig.7). It was only the parts, which were red at births that were transformed into grey during the first six months of post-natal life (Reddi, 1957). The change in coat colour in calf seems to be a peculiar characteristic of the Kangayam breed (Benjamin and Raju, 1949). However, calves with black, fawn, red and broken colours never change to grey and remain with same colour even in adulthood. Similar change has also been observed in Umblachery (Pattabhiraman,1962?), a breed derived from Kangayam. In

new-born Kankrej calves rusty-red colour is present in poll, fore- and hindquarters which disappear later (Nivsarkar *et al.*, 2000). Yousif and Fadl El-Moula(2006) reported that in Kenana cattle, zebu breed of Sudan, calves are born with brown-red coat which changes to permanent grey from three to six months of age.

Young males: Grey in colour. Darkening of hump, fore- and hindquarters of the body occurs between 18 and 24 months (Fig.8).

Heifers: Grey or white and grey in colour (Fig.9).

Bulls: Males are generally grey with dark grey to black colouring on the head, neck, hump, shoulders and quarters (Fig.10).

Cows: Cows are grey or white and grey with black markings just above the fetlocks on all four legs and sometimes on the knees (Fig.11). Some cows have dark-grey markings on the face and body which are not desirable but do not constitute a disqualification (Pattabhiraman, 1962?).

Bullocks: The black shades present in different parts of the body of the bulls are changed into a uniform grey colour three months after castration and hence the bullocks are grey in colour (Fig.12).

Reddi (1957) made a detailed study of coat colour changes in Kangyam calves, bulls, cows and bullocks. In calves, the 17- ketosteroid output increased with advancing age of the animal and was positively correlated with the development of grey colour in hairs. While a calf with red colour excreted only 1.34 mg of 17- ketosteroids per day, a full grey calf's output was 7.8 mg per day. Grey-coloured calves gave positive reaction to tests for the presence of homogentisic acid while calves with red coat excreted negligible or no homogentisic acid.

The output of 17-ketosteroids was maximum in bulls and varied between 44.9 and 86.2 mg per day depending on the extent of darkening of the quarters. In cows and bullocks the values were 25.4 and 26.9 mg respectively. The excretion of homogentisic acid in 24 hour sample of urine was 20.3, 6.2 and 5.1 mg per 100 cc for bulls, bullocks and cows respectively.

Animals with fawn, black, red and broken-colours are observed both in adult males and females (Fig.13, 14 and 15), which constitute approximately one to two per cent of the total population. The predominance of grey and grey-white colour and the very low incidence of other colours are similar to the observations of earlier workers (Gunn, 1909; Littlewood, 1936). Grey-coloured animals are usually preferred by most of the farmers and bulls of grey colour only have been used for breeding. However, the existence of these atypical colours in the population over the years is due to the preferential selection of cows and bullocks with these colours by a few farmers and difficulty in elimination of genes controlling coat colour when they are at low frequencies.

Fig.6. Kangayam calf-red colour coat with cream colour inside the thighs and forelegs

Fig.7. A group of Kangayam calves showing progressive change in coat colour from red to grey.

Fig.8. Kangayam young bull -early stage of darkening of face, hump, fore - and hindquarters

Fig.9. Kangayam heifer - grey in colour with black markings in front of the fetlocks and on the knees

Fig.10. Kangayam bull - increased intensity of darkening of extremities. Horns - stout and thick.

Fig.11. Kangayam cow - gery in colour; tucked up udders. Dry pasture land and in the background Velvaelam *(Acacia leucophloea)* trees.

Fig.12. Kangayam bullock pair -grey in colour, black coloured fetlocks and knees with upward facing horns.

Fig.13. Kangayam bullock - fawn colour

Fig.14. A pair of grey and red coloured bullocks ploughing the field.

Fig.15. Kangayam cow - broken colour

and 6. The means for height at withers, body length and chest girth observed in calves from on month to six months of age and change in relationship among these measurements wit advancement of age are, in general, similar in these two studies. In Kangayam calves perceptibl increase in body measurements was observed in second month both in organized and farmer herds and no significant differences in body measurements were reported between sexes (Repor 1998). The coefficients of variation for the three body measurements ranged between 5.0 an 13.8 per cent in the farmers' herds.

Table 5. Mean body measurements (inch) and body weight (lb) of Kangayam calves at Palayakottai Cattle Farm (n = 52)

Age	Height at withers	Body length	Chest girth	Body weight
1 month	28.30 (71.88)	24.40 (61.98)	26.30 (66.80)	59.4 (27.0)
2 months	31.30 (79.50)	28.70 (72.90)	31.00 (78.74)	89.3 (40.6)
3 months	34.30 (87.12)	31.50 (80.01)	34.20 (86.87)	118.6 (53.8)
4 months	36.60 (92.96)	33.80 (85.85)	37.60 (95.50)	150.7 (68.4)
5 months	38.30 (97.28)	36.20 (91.95)	39.90 (101.35)	180.6 (82.0)
6 months	39.80 (101.09)	39.10 (99.31)	41.80 (106.17)	201.9 (91.8)

Figures in parentheses indicate the values in cm / kg
Source: Raju (1953a)

Youngstock : The means for body measurements of youngstock from 7 to 42 months o age are presented in Table 7. Generally, males are taller and longer than females. The coefficient of variation for the three body measurements varied from 4.2 to 9.2 per cent in the farmer herds. The growth of Kangayam calves and youngstock as indicated by an increase in the bod measurements in different groups of unequal age intervals are represented in Figure 16.

Adults : The body measurements of Kangayam bulls, bullocks and cows reported b Littlewood (1936), Pattabhiraman (1958) and the data collected during the survey (Report, 1998 are given in Tables 8 and 9.

Table 6. **Mean (± S.E) body measurements (cm) of Kangayam calves in the breeding tract**

Age	Character			
	Sex	Height at withers	Body length	Chest girth
1 month	Male	72.34 ± 0.97 (29)	64.62 ± 1.66 (29)	70.83 ±1.35 (29)
	Female	74.09 ± 0.91 (34)	64.59 ± 1.23 (34)	73.12 ± 1.15 (34)
	Pooled	**73.29 ± 0.67 (63)**	**64.60 ± 1.00 (63)**	**72.06 ± 0.88 (63)**
2 months	Male	80.85 ± 0.98 (33)	73.73 ± 1.05 (33)	81.64 ± 1.34 (33)
	Female	81.61 ± 1.58 (20)	74.25 ± 1.39 (20)	82.15 ± 1.41 (20)
	Pooled	**81.13 ± 0.85 (53)**	**73.92 ± 0.83 (53)**	**81.83 ± 0.98 (53)**
3 months	Male	87.77 ± 0.85 (30)	81.30 ± 1.15 (30)	91.40 ± 1.18 (30)
	Female	85.44 ± 0.82 (27)	79.00 ± 1.02 (27)	88.15 ± 1.07 (27)
	Pooled	**86.67 ± 0.61 (57)**	**80.21 ± 0.78 (57)**	**89.86 ± 0.82 (57)**
4 months	Male	89.63 ± 0.92 (35)	84.80 ± 1.06 (35)	94.20 ± 1.20 (35)
	Female	89.62 ± 1.16 (29)	84.97 ± 1.15 (29)	97.24 ± 1.28 (29)
	Pooled	**89.63 ± 0.72 (64)**	**84.88 ± 0.78 (64)**	**95.58 ± 0.89 (64)**
5 months	Male	94.96 ± 1.02 (28)	91.50 ± 1.05 (28)	101.00 ± 1.08 (28)
	Female	91.70 ± 0.96 (27)	85.56 ± 1.30 (27)	99.15 ±1.37 (27)
	Pooled	**93.36 ± 0.73 (55)**	**88.58 ± 0.92 (55)**	**100.09 ± 0.87 (55)**
6 months	Male	98.00 ± 1.90 (26)	92.04 ± 1.49 (26)	104.76 ± 1.92 (25)
	Female	98.16 ± 0.84 (37)	93.24 ± 1.38 (37)	103.19 ± 1.70 (37)
	Pooled	**98.10 ± 0.91 (63)**	**92.75 ± 1.01 (63)**	**103.82 ± 1.27 (62)**

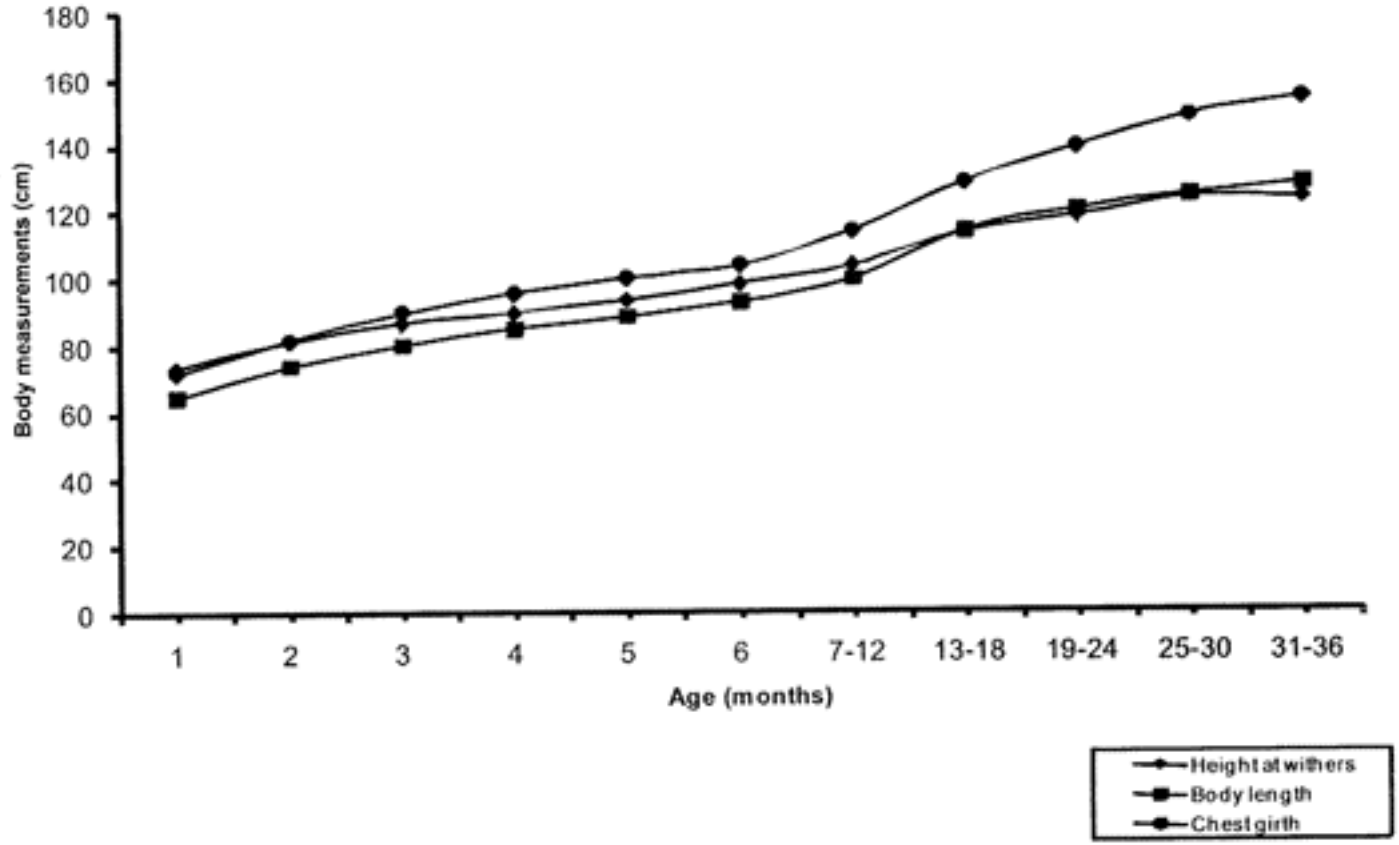
Figures in parentheses are the number of observations

Table 7. Mean (± S.E) body measurements (cm) of Kangayam youngstock of various age groups in the breeding tract

Age	Sex	Character				
		Height at withers	Body length	Chest girth	Horn length	Skin thickness (mm)
7-12 months	Male	105.03 ± 0.89 (78)	101.18 ± 1.03 (78)	115.54 ± 1.11 (78)	7.20 ± 0.48 (41)	3.95 ± 0.12 (66)
	Female	101.96 ±0.91 (63)	98.00 ± 1.13 (63)	112.32 ± 1.20 (63)	7.00 ± 0.66 (34)	4.15 ± 0.13 (52)
	Pooled	**103.65 ± 0.66 (141)**	**99.76 ± 0.77 (141)**	**114.10 ± 0.83 (141)**	**7.11 ± 0.82 (75)**	**4.04 ± 0.09 (118)**
13-18 months	Male	114.89 ± 0.97 (38)	114.70 ± 1.27 (37)	128.76 ± 1.28 (37)	12.70 ± 0.63 (38)	4.44 ±0.15 (37)
	Female	112.61 ± 0.94 (46)	113.67 ± 1.31 (45)	128.67 ± 1.40 (46)	12.49 ±0.53 (43)	5.11 ± 0.12 (41)
	Pooled	**113.64 ± 0.68 (84)**	**114.13 ± 0.92 (82)**	**128.71 ± 0.96 (83)**	**12.55 ± 0.40 (81)**	**4.79 ± 0.10 (78)**
19-24 months	Male	121.24 ± 1.08 (21)	122.24 ± 1.41 (21)	141.71 ± 1.56 (21)	18.86 ± 1.00 (21)	4.99 ± 0.18 (19)
	Female	116.50 ±0.76 (32)	119.26 ± 1.43 (31)	137.32 ± 1.21 (31)	19.77 ± 0.79 (31)	5.36 ± 0.14 (27)
	Pooled	**118.38 ± 0.70 (53)**	**120.46 ± 1.04 (52)**	**139.10 ± 0.10 (52)**	**19.40 ± 0.62 (52)**	**5.20 ± 0.11 (46)**
25-30 months	Male	130.28 ± 3.85 (9)	131.00 ± 3.65 (9)	148.00 ± 2.18 (9)	26.78 ± 2.40 (9)	5.92 ± 0.28 (9)
	Female	121.75 ± 0.80 (24)	122.42 ± 1.28 (24)	148.63 ± 1.84 (24)	24.19 ± 1.19 (21)	5.43 ± 0.18 (23)
	Pooled	**124.08 ± 1.34 (33)**	**124.76 ± 1.49 (33)**	**148.46 ± 1.45 (33)**	**24.97 ± 1.10 (30)**	**5.57 ± 0.15 (32)**
31-36 months	Male	126.20 ± 2.01 (5)	126.60 ± 3.96 (5)	147.20 ± 2.40 (5)	26.00 ± 1.95 (5)	5.36 ± 0.11 (5)
	Female	122.78 ± 1.23 (18)	128.78 ± 2.05 (18)	155.67 ± 2.32 (18)	27.74 ±1.44 (17)	5.44 ± 0.21 (16)
	Pooled	**123.52 ± 1.08 (23)**	**128.30 ± 1.79 (23)**	**153.83 ± 2.01 (23)**	**27.34 ± 1.19 (22)**	**5.42 ± 0.16 (21)**
37-42 months	Female	123.00 ±1.59 (12)	123.00 ±2.20 (12)	149.00 ± 3.39 (13)	27.66 ±1.33 (12)	5.65 ± 0.18 (10)

Figures in parentheses are the number of observations

Fig. 16. Growth pattern of Kangayam cattle from 1 to 36 months



The means of height at withers, body length and chest girth are more in bulls and bullocks than in cows. The coefficients of variation for the three body measurements ranged between 4.3 and 12.6 per cent in the farmers' herds.

Table 8. **Mean body measurements (inch) of Kangayam adult cattle at organized farms**

Character	Bulls	Cows	Reference
Height behind hump	50.50 (128.27)	47.25 (120.00)	Littlewood, 1936
	52.00 (132.08)	47.00 (119.38)	Pattabhiraman, 1958
Length from point of	57.00 (144.78)	50.50 (128.27)	Littlewood, 1936
shoulder to pin-bone	60.50 (153.67)	53.00 (134.62)	Pattabhiraman, 1958
Girth	76.00 (193.04)	65.00 (165.10)	Littlewood, 1936
	74.00 (187.96)	64.00 (162.56)	Pattabhiraman, 1958
Tail length	48.00 (121.92)	43.50 (110.49)	Pattabhiraman, 1958
Face length	21.50 (54.61)	19.00 (48.26)	Littlewood, 1936
	19.00 (48.26)	17.60 (44.70)	Pattabhiraman, 1958
Face width	7.50 (19.05)	7.00 (17.78)	Littlewood, 1936
	9.50 (24.13)	8.00 (20.32)	Pattabhiraman, 1958
Ear length	8.50 (21.59)	8.25 (21.00)	Littlewood, 1936
	8.00 (20.32)	7.50 (19.05)	Pattabhiraman, 1958
Horn length	16.25 (41.28)	16.00 (40.64)	Littlewood, 1936
	15.50 (39.37)	16.00 (40.64)	Pattabhiraman, 1958
Thickness of horn at base	11.50 (29.21)	8.50 (21.59)	Pattabhiraman, 1958

Figures in parentheses indicate the values in cm

The data recorded in the habitat (Report, 1998) indicated that there is an increase in height of 7 to 11 cm in bulls and 4 to 5 cm in cows and reduction in chest girth of 18 to 23 cm in bulls and 6 to 8 cm in cows when compared to earlier reports of Littlewood (1936) and Pattabhiraman (1958). Gunn (1909) and Littlewood (1936) stated that there were two varieties of Kangayam i.e large and small in the breeding tract. However, in a later study (Report, 1998) no significant differences in the height at withers, body length, chest girth and horn length were found between animals measured in the respective areas of the breeding tract.

Table 9. Mean (± S.E) body measurements (cm) of Kangayam adultstock in the breeding tract

Group	Character					
	Height at withers	Body length	Chest girth	Ear length	Horn length	Skin thickness (mm)
Bulls	139.50 ± 3.50 (12)	144.33 ± 4.07 (12)	169.92 ± 6.16 (12)	19.78 ± 0.61 (11)	35.58 ± 2.76 (12)	5.20 ± 0.38 (9)
Working males below 3½ years	128.07 ± 0.83 (44)	128.09 ± 1.23 (44)	151.07 ± 1.31 (44)	18.19 ± 0.44 (13)	24.66 ± 0.94 (43)	5.55 ± 0.14 (42)
Working males above 3½ years	139.81 ± 0.58 (135)	144.93 ± 0.87 (134)	175.90 ± 0.10 (133)	20.34 ± 0.26 (54)	55.33 ± 0.99 (130)	5.55 ± 0.09 (119)
Milking cows	124.56 ± 0.69 (214)	130.72 ± 0.79 (214)	155.32 ± 0.60 (210)	19.19 ± 0.09 (212)	43.81 ± 0.54 (212)	5.08 ± 0.06 (179)
Dry cows	124.88 ± 0.58 (119)	131.21 ± 0.70 (119)	156.81 ± 0.79 (119)	19.33 ± 0.14 (117)	45.14 ± 0.71 (114)	5.14 ± 0.07 (98)

Figures in parentheses are the number of observations.

The face length and width were more in males than in females. The means of face length in bulls (n = 8), bullocks (n = 97) and cows (n = 210) were 49.1 ± 1.7, 52.1 ± 0.3 and 45.3 ± 0.2 cm respectively and averages for face width were 24.3 ± 0.9, 23.5 ± 0.2 and 20.9 ± 0.1 cm respectively (Rajendran, 1995). There is a progressive increase in the measurements up to 5½ years, whereas horns continued to increase in length even after that age. In adult bullocks (above 3½ years) they grew up to 55.3 cm. The coefficient of variation for horn length in adults ranged from 16.8 to 26.9 per cent. The horn circumferences at the base in bulls, bullocks (> 5½ years) and cows (> 5½ years) were 30.8 ± 1.3, 31.1 ± 0.3 and 23.9 ± 0.2 cm respectively. The horn circumference at the base in cows is less than that in bulls and bullocks (Rajendran, 1995). The single-fold skin thickness at flank region in adult animals varied from 5.08 ± 0.06 to 5.55 ± 0.09 mm (Report, 1998). Appadurai (1971) reported average skin fold thickness at the neck of the scrotum and at posterio-lateral aspect of the scrotum of Kangayam bulls (n = 52) as 16.2 ± 0.4 and 5.4 ± 0.2 mm respectively.

The mean values reported for different body measurements in bulls and cows of Kangayam breed are higher than those reported for the other draught breeds of Tamil Nadu viz. Umblachery (Nainar *et al.*, 2000), Alambadi, Bargur and Pulikulam (Pattabhiraman, 1962?).

7.3 Body Weight

Kangayam calves born at Livestock Research Station, Hosur had an average birth weight of 46 lb (20.9 kg) for males and 42 lb (19.1 kg) for females and highest weights being 55 and 62 lb (25.0 and 28.2 kg) for bull and heifer calves respectively (Littlewood, 1936). While analyzing the birth weight data (n = 1397) of the calves born from 1941-42 to 1954-55 in the same herd Pattabhiraman (1958) reported that the birth weight of bull and heifer calves as 46.3 lb (21.0 kg) and 43.5 lb (19.8 kg) respectively. Rajagopalan (1952) studied the first lactation performance records of Kangayam cows of the same herd and reported 45.06 ± 0.59 lb (20.46 kg) as average birth weight of calves (n = 31) and 582.96 ± 9.22 lb (264.66 kg) and 590.22 ± 10.97 lb (267.96 kg) as the weight of cows (n = 31) at first heat and first calving respectively. Raju (1953a) recorded monthly body weight of calves (n = 54) at Palayakottai Farm (Table 5) and reported that the body weight of calves at first and sixth months as 59.4 lb (27.0 kg) and 201.9 lb (91.8 kg) respectively. He found an increase in body weight of 32.1 lb (14.57 kg) during fourth month and the lowest increase of 21.3 lb (9.67 kg) during sixth month.

Gopalakrishnan *et al.* (1972) studied the effects of season and sex of the calf on birth weight in the Kangayam herd of the District Livestock Farm, Chettinad and reported that birth weight of male calves was significantly heavier than the female calves. The averages were 20.57 ± 0.18 kg (n=285) and 19.67 ± 0.13 kg (n=332) for male and female calves respectively. Season had significant influence on the birth weight. Winter-born (January to March) calves were significantly heavier than the calves born during the other seasons.

According to Littlewood, (1936) the average weight of Kangayam bull was 1000 to 1100 lb (454 to 499.4 kg), and that of cow was about 800 lb (363.2 kg). The average body weights of adult bulls and cows maintained at Palayakottai Farm were 1150 lb (522.1 kg) and 750 lb (340.5 kg) respectively (Pattabhiraman, 1958). The estimated mean body weights of bulls and cows at farmers' herd based on the body measurements were 375 and 308 kg respectively (Report, 1998) and these values are lower when compared to those reported for animals in organized farms. The average body weights of bulls maintained in the *ex-situ* conservation of Kangayam cattle scheme in Chennai were 224.1 ± 7.4 (n = 15), 313.3 ± 16.6 (n = 4) and 400.5 ± 25.5 (n = 4) kg at the age of two, three and four years respectively (Report, 2005a).

8. PRODUCTION PERFORMANCE

8.1 Draught Capacity

8.1.1 Draught animal utilization in Tamil Nadu

Draught animal power is a critical component of agriculture and India is one of the major users of draught animal power. Kangayam bullocks are used for various agricultural and allied activities. In Tamil Nadu, Kangayam bullocks alone are used for transport of sugarcane from the

fields to sugar mills though other draught type Mysore breeds viz. Hallikar and Alambadi are available in the area. The performance of the Kangayam bullocks is exceptional in this type of work and is not exceeded by the other Mysore-type breeds. This quality of Kangayam bullock facilitates the cart owners to earn their livelihood solely on transport of sugarcane in and around the sugar mills.

A large percentage of the Kangayam bullocks produced in the tract are sold to the cultivators of southern districts. They buy these bullocks at high prices as they are observed to be good workers and last longer than other cattle prevalent in their area. While studying the draught animal utilization in different agro-climatic zones of Tamil Nadu, Prabaharan and Selvakumar (1992) observed that large farmer (having more than 10 acres) and medium farmer (5-10 acres) categories use their draught animals mostly for crop production activities (59 - 78 per cent) whereas the small farmers (having less than 5 acres) utilize bullocks only for 36.5 per cent for their crop production work and mostly hire out their animals for others use (Table 10).

Table 10. Draught animal utilization in Tamil Nadu

Category of farmer	No. of pairs of oxen studied	Hours of use for different activities				Total
		Crop prod.	Hired out	Social affair	Exchange gratis	
Small farmer (n = 300)	315.5	132.1 (36.5)	201.2 (55.6)	2.9 (0.8)	25.6 (7.1)	361.8 (100)
Medium farmer (n = 300)	326.0	189.8 (59.0)	103.3 (32.1)	3.3 (1.0)	25.5 (7.9)	321.9 (100)
Large farmer (n = 300)	444.5	256.0 (78.0)	57.3 (17.4)	2.0 (0.6)	13.2 (4.0)	328.5 (100)

Figures in parentheses are the percentages of the total.
Source: Prabaharan and Selvakumar (1992)

This might be due to the fact that the large farmers have to make use of available animal power for cultivating larger area of their own land, while the small farmers are in a position to spare their animals after using them for their own work. Besides the above criterion many large farmers in general did not favour hiring out their animals since they felt it was below their status to realize income through such activity. More draught animals were being exchanged for gratis by small and medium farmers than by large farmers. The overall draught animal use was found to be more in the small farmer category than in the medium and large farmer categories.

8.1.2 Measurement of draught capacity

Kangayam bullocks are very strong and active and have all the desirable physical attributes for draught purposes. The most striking characteristics of this breed are the appearance of the head and horns with thick neck, short and strong limbs and well-sprung barrel. In Tamil Nadu they are used for various agricultural activities like ploughing, harrowing, levelling, threshing,

logging, oil extraction, sugarcane crushing and hauling carts for transport of agricultural produce, manure, drinking water and house construction materials (mainly sand) and to a less extent for transport of family members (social activities) in the rural areas (Fig.14, and 17 to 23). However, limited quantitative data are available for various operations. At the age of three years bullocks are trained for ploughing and after four years they are put to carting. Bullocks of similar age and body size are paired for carting. Farmers are using two-wheeled double or single animal cart of specified design made with strong wood and steel and pneumatic tyres (Fig.17 and 18) for transport.

Joshi and Phillips (1953) stated that a pair of Kangayam bullocks would carry a load of one ton in an iron-tyred cart at the rate of about 4 miles per hour. Good specimens had carried such loads on a hard road for 38 miles in 8 hours at a stretch. Usually the bullocks were utilized for work for 8 to 10 hours a day. Surendrakumar (1988) studied the influence of different morphometric traits like body length, height and girth and physical traits like body weight, volume (size) and age of the animal on the draft produced, energy release and power output in five different genetic groups of cattle including Kangayam (Table 11). He observed that Kangayam breed differed from others in the heartbeat variation profile with respect to duration of work and loading.

The heartbeat of an animal under normal conditions was in the range of 55 to 70 beats / min. When animals were subjected to loading, the increase in the heartbeat was 42 per cent in case of medium load and 50 per cent in the case of heavy load conditions for a period of 3 hours. When load was raised to medium and heavy the heartbeat, more or less reached 70 to 98 in the first phase and 75 to 95 in the final stages of the second phase. The increase in heartbeat was rapid with respect to load in all the breeds studied; however in Kangayam the increase in heartbeat was lower and showed fewer variations in their fluctuations. The inter-relationship between age, weight and heartbeat showed that Kangayam had heartbeat profile directly proportional to the age whereas in other genetic groups it was negative linear relationship with respect to age. A curvilinear relationship between heartbeat and energy produced was observed. The energy release was increased from 1.47 MJ at heartbeat of 62 / min to 2.06 MJ at heartbeat of 69 / min.

The energetic parameters showed that there existed critical energy limit for each animal with respect to its length. Kangayam having higher body length (145 cm) produced a maximum energy of 2.57 MJ while Jersey and Malaiyan breeds having averages of 134 and 127 cm body length exerted only 1.66 MJ of energy. In Kangayam when length increased from 145 to 152 cm its power decreased from 0.33 to 0.28 hp and energy produced decreased from 2.6 to 2.2 MJ, which was in contrast to other genetic groups. In case of the height also Kangayam showed negative relationship with draft, energy and power output. When height increased from 141 to 148 cm energy release decreased from 2.6 to 2.3 MJ and power output decreased from 0.33 to 0.29 hp. However, a linear relationship existed between girth-energy and girth-power.

Table 11. Morphometric and physical traits and power capability of Kangayam and other breeds (n = 3 each for purebreds and 4 for crossbred)

Genetic group	Age (years)	Length (cm)	Height (cm)	Girth (cm)	Weight (kg)	Volume (m^3)	Draft produced (kg)	Energy output MJ	Power capability (hp)
Kangayam	7.0 – 13.0	149	144	190	498.9	0.429	55.15	2.36	0.297
Kongai	7.5-10.0	143	142	180	430.2	0.369	44.41	2.02	0.250
Malaiyan	10.0-15.0	127	125	163	316.6	0.270	34.39	1.50	0.180
Jersey	2.5-3.5	134	122	169	356.2	0.305	34.39	1.46	0.179
Jersey x Red Sindhi crossbred	4.5-8.0	146	137	182	454.1	0.388	40.80	1.93	0.236

Volume (m^3) = $\pi r^2 l$

where l = length of bullock in metre; $r = g / 2\pi$; g = girth in metre : $\pi = 22 / 7$

Draft (kg) = 6 + (Dynamometer reading x 3.579)

Total energy (MJ) = Draft (kg) x speed (km/hr) x 0.02943 MJ

Linear speed (km/hr) = 0.099 x speed of rotation of pinion (rpm) km/hr.

Source: Surendrakumar (1988)

Fig.17. Kangayam bullocks hauling sugarcane (carts fitted with pneumatic tyres)

Fig.18. A single Kangayam bullock used for transport of agricultural produce

Fig.19. Kangayam bullocks used for transport of house construction material (Sand)

Fig.20. Kangayam bullocks carrying firewood

Fig.21. Kangayam bullocks with a typical cart fitted with tank used for transport of drinking water

Fig.22. Social affairs - use of Kangayam bullocks in rural transport

Fig.23. A pair of Kangayam bullocks yoked to the cart used for **mini - cart (*Rekla*) race** - a sport of Tamil Nadu

The draft / unit weight (kg/kg) for Kangayam, Kongai and Jersey 0.112, 0.102 and 0.096 respectively. The maximum power capability / unit weight was 13.8 x 10^{-4} hp /kg. Kangayam was a hefty and high power animal with the walking speed of 1.3 to 1.8 km /hour with load [linear speed of bullock = 0.099 x speed of rotation of pinion (rpm) km/hr] and produced maximum energy of 3.3 MJ. The maximum power capabality of a pair of Kangayam bullocks was 0.8 hp. He concluded that a viable draught animal of normal stature would have a volume (size) of 0.4 m^3 with weight range of 475 kg and girth of 185 cm. All these characteristics were observed in Kangayam bullocks and the breed was exceptional in many aspects with good performance when compared to other genetic groups studied.

Sreekumar and Thomas (1990) compared Kangayam bullocks with halfbred Jersey x Red Sindhi bullocks with respect to work efficiency, adaptability, feed and water intake while ploughing on dryland under hot-humid tropical climatic conditions (Table 12).

Table 12. Effect of work on dry matter (DM) and water intakes by Kangayam and crossbred bullocks (Mean ± S.E)

Character	Kangayam (n = 2 pairs)		Crossbred (n = 2 pairs)	
	Days of work	Days of no work	Days of work	Days of no work
Total DM intake (kg)	9.38 ± 0.67	9.43 ± 0.60	10.32 ± 0.03	10.38 ± 0.03
DM intake/W $kg^{0.75}$(g)	115.0 ± 0.5	116.2 ± 0.60	93.6 ± 0.40	94.0 ± 0.40
Water intake/DM/W $kg^{0.75}$(g)	115.6 ± 1.3	153.0 ± 1.20	222.8 ± 1.80	221.4 ± 1.60

Source : Sreekumar and Thomas (1990)

They reported that Kangayam bullocks were superior in work efficiency and ploughed 15 per cent more of dryland than the crossbreds in equal times. The more area ploughed per hour by Kangayam bullocks could be attributed mainly to their faster speed (1.24 m/sec) in comparison to the crossbreds (1.05 m/sec). Kangayam bullocks consumed significantly ($P < 0.05$) more dry matter per unit metabolic body weight than the crossbreds indicating greater energy availability for work. The crossbred bullocks consumed significantly ($P < 0.05$) more water per unit dry matter intake per unit metabolic body weight than Kangayam bullocks. It indicated a better adaptability of Kangayam as they required less water turnover for evaporative thermolysis. In general, the crossbreds experienced greater stress than Kangayam bullocks and were vulnerable to thermal stress while working.

Anil and Thomas (1994) conducted similar studies to compare the draught performance of Kangayam bullocks with graded Surti buffalo bullocks and reported that Kangayam bullocks ploughed significantly more area per unit time (Table 13). During dry ploughing Kangayam had

a significantly higher speed of working than buffaloes but during wet ploughing the speed wa almost the same in both species

Table 13. Draught output by Kangayam bullocks and graded Surti buffalo males under dry and wetland ploughing (Mean ± S.E)

Draught output parameter	Kangayam (n = 2 pairs)		Graded Surti buffalo (n = 2 pairs)	
	Types of ploughing			
	Dry	Wet	Dry	Wet
Area ploughed (m^2)	702 ± 8.1	625 ± 11.6	567 ± 9.9	564 ± 8.1
Speed of walking (m/sec)	1.13 ± 0.014	0.99 ± 0.018	1.00 ± 0.020	1.00 ± 0.015
Stride length (m)	0.81 ± 0.015	0.80 ± 0.018	0.76 ± 0.016	0.77 ± 0.018
Power/team	575 ± 12	780 ± 21	587 ± 12	805 ± 23

Source : Anil and Thomas (1994)

They reported that Kangayam bullocks had longer stride length during ploughing than th buffalo. However, there was no significant difference in the tractive power developed during dr and wet ploughing between the two species and concluded that Kangayam bullocks were on par with buffalo bullocks for wet ploughing. However, on dryland ploughing buffalo bullock exhibited severe heat stress and also their work output was inferior to Kangayam when use continuously for a period of 4 hours.

Panneerselvam and Kandasamy (1999) studied the load hauling capacity of Kangayan bullocks yoked to carts with pneumatic tyres and reported that a pair of bullocks each weighin an average of 472.9 ± 3 kg body weight (n = 200) was able to pull a total load (including car weight) of 3787 ± 51 kg (n= 100) i.e. nearly 4 times their body weight over a distance of 10 to 2 km without rest (Table 14). The bullocks usually took 4 to 6 hours to cover 18 to 20 km distanc with load. The average travelling time for a single trip i.e. with load to the sugar mill and bac with empty cart to the field varied from 7 to 11 hours. The bullock pairs were capable o carrying the load even on a sunny cloudless summer day with ambient temperature of 30 t 35°C. Kangayam bullocks generally reach the maximum potential for this type of work aroun 5 years and maintain it effectively for a period of 10 to 12 years of age. Generally bullocks o similar age and body size were paired in double animal carts and the test of significance als revealed there was no significant difference between body weights of left and right bullocks o the pair.

Table 14. Mean (± SE) adult body weights of Kangayam bullocks and their load hauling capacity(kg)

Body weight			Sugarcane weight per load	Empty cart weight	Total load per cart
Left animal of the pair	Right animal of the pair	Overall mean			
475.0 ± 5.0 (100)	470.8 ± 4.0 (100)	472.9 ± 3.0 (200)	3206 ± 50 (100)	581 ± 6 (100)	3787 ± 51 (100)

Figures in parentheses are the number of observations.

8.1.3 Physiological responses during work

Sreekumar and Thomas (1990) compared the physiological indicators viz. respiratory and pulse rates and rectal temperature of Kangayam bullocks with the crossbred (Jersey x Red Sindhi) bullocks during dryland ploughing (Table 15) and reported that all of them were significantly ($P<0.05$) higher in crossbred bullocks before the start of work. The values increased significantly due to work in both Kangayam and the crossbred bullocks; however, the increase was more in the crossbreds than in Kangayam after 4 hours of ploughing during summer. The authors concluded that the crossbreds were vulnerable to thermal stress when compared to Kangayam while working in hot humid environment.

In a similar study Chandrasekaran (1991) compared the changes in physiological responses of Kangayam bullocks (n=6) with the Jersey x Red Sindhi crossbred bullocks (n = 12) in different types of work. All the bullocks were in the age group of 5 to 7 years. The mean respiratory and pulse rates and rectal temperature recorded during ploughing and carting at different stages viz. before work, after work and after rest are presented in Table 16.

Table 15. Effect of work on respiration rate , pulse rate and rectal temperature of Kangayam and crossbred bullocks (Mean ± S.E; n = 2 pairs each)

Response	Type of animal	Before start of work	Immediately after 4 hours of work	One hour after work
Respiratory rate (per min)	Kangayam	22.52 ± 0.18	87.69 ± 0.56	48.07 ± 0.45
	Crossbred	24.70 ± 0.23	97.44 ± 0.30	57.20 ± 0.99
Pulse rate (per min)	Kangayam	51.69 ± 0.32	77.67 ± 0.78	61.43 ± 0.90
	Crossbred	54.82 ± 0.38	87.15 ± 0.56	69.00 ± 0.96
Rectal temperature (° C)	Kangayam	38.42 ± 0.01	39.59 ± 0.02	38.90 ± 0.02
	Crossbred	38.69 ± 0.02	39.86 ± 0.01	39.12 ± 0.02

Source : Sreekumar and Thomas (1990)

Table 16. Physiological responses (Mean ± S.E.) of Kangayam and crossbred bullocks during ploughing and carting

Response	Time of recording	Kangayam (n=6)		Crossbred (n=12)	
		Type of work			
		Ploughing (n = 28)	Carting (n = 24)	Ploughing (n= 40)	Carting (n= 50)
Respiratory rate (per min)	Before work	21.86 ± 0.31	20.63 ± 0.31	24.88 ± 0.15	24.20 ± 0.14
	After work	50.18 ± 0.53	53.21 ± 0.86	73.53 ± 0.62	68.60 ± 0.68
	After rest	20.89 ± 0.46	19.67 ± 0.28	23.78 ± 0.20	23.24 ± 0.18
Pulse rate (per min)	Before work	51.07 ± 0.19	49.84 ± 0.38	55.05 ± 0.22	54.22 ± 0.14
	After work	71.54 ± 0.52	72.13 ± 0.33	84.70 ± 0.41	83.62 ± 0.43
	After rest	61.36 ± 0.35	61.92 ± 0.35	68.73 ± 0.37	65.96 ± 0.28
Rectal temperature (°C)	Before work	37.95 ± 0.04	38.12 ± 0.04	38.36 ± 0.06	38.76 ± 0.03
	After work	38.82 ± 0.04	38.95 ± 0.06	39.32 ± 0.05	39.67 ± 0.03
	After rest	38.35 ± 0.03	38.54 ±.0.05	38.77 ± 0.06	39.25 ± 0.03

Source : Chandrasekaran (1991)

The analysis revealed highly significant ($P<0.01$) difference between the Kangayam an crossbreds irrespective of the type of work and time of recording; between type of wor irrespective of the breed and time of recording and between the times of recording irrespectiv of the breed and type of work for all the three physiological measurements. Kangayam showe significantly ($P<0.01$) lower rectal temperature during different stages and also in different type of work. The rate of increase due to ploughing and rate of recovery due to rest was more i crossbreds than in Kangayam. The increase in the respiratory and pulse rates due to work wa also more in the crossbreds than in Kangayam and the rate of recovery of respiratory rate wa found to be faster in crossbreds in ploughing and Kangayam in carting.

Anil and Thomas (1994) compared the draught performance of Kangayam bullocks wit graded Surti buffalo bullocks under similar climatic conditions and recorded that Kangaya bullocks had significantly higher respiratory and pulse rates and rectal temperature before sta of work than the buffalo (Table 17). As a result of work the physiological parameters increase significantly in both species; however the increase in these physiological responses in buffal bullocks were much higher than Kangayam during dryland ploughing whereas, during wet ploughin buffaloes were on a par with Kangayam bullocks. It indicates high degree of heat stress i buffalo bullocks than in Kangayam during dryland ploughing.

Table 17. Effect of work on respiration rate (RR), pulse rate (PR) and rectal temperature (RT) of Kangayam bullocks and graded Surti buffaloes (Mean ± S.E.)

Time	Kangayam bullocks (n = 2 pairs)			Graded Surti buffaloes (n = 2 pairs)		
	RR/min	PR/min	RT (°C)	RR/min	PR/min	RT (°C)
Dryland ploughing						
Before start of work	16.15±0.50	62.65±0.48	38.08±0.03	14.55±0.63	61.05±0.65	37.96±0.04
Immediately after work	62.20±3.91	93.05±2.07	39.45±0.12	107.05±2.12	97.70±2.01	40.90±0.08
After one hour of rest	34.10±1.70	75.30±1.72	38.51±0.02	59.45±2.70	82.23±0.85	39.61±0.08
Wetland ploughing						
Before start of work	16.40±0.49	62.50±0.44	37.98±0.01	13.65±0.26	61.05±0.40	37.95±0.04
Immediately after work	49.45±1.57	86.30±2.44	39.26±0.06	43.75±1.08	84.25±2.59	39.43±0.11
After one hour of rest	26.60±1.30	71.30±1.61	38.57±0.38	28.05±1.26	68.25±1.91	38.45±0.04

Source : Anil and Thomas (1994)

11.4. Biochemical and haematological changes during work

The change in mean values of blood glucose, cholesterol, serum glutamic oxaloacetic transaminase (SGOT) and creatinine levels in Kangayam due to ploughing and carting in comparison with crossbred bullocks (Jersey x Red Sindhi) are presented in Table 18. The estimates revealed that Kangayam had significantly ($P< 0.01$) lower level of glucose and higher level of cholesterol and SGOT than crossbreds irrespective of the type of work and time of recording i.e. before and after work and after rest.

There was no significant difference in the amount of decrease in glucose level during work and also for the recovery rate after rest between the Kangayam and crossbreds whereas, the rate of decrease of cholesterol level due to work was significant ($P< 0.01$) between Kangayam and crossbreds. During ploughing crossbreds showed a greater decrease in cholesterol, which indicated that the crossbreds were under greater stress than the Kangayam when worked under identical conditions (Chandrasekaran, 1991). The increase in the SGOT level revealed a significant difference ($P<0.05$) between the breeds due to work and increase was found to be higher in Kangayam than in crossbreds. Generally the increase in the quantity of SGOT is related with excess muscular activity. The difference in increase of creatinine level due to work in both breeds was insignificant which indicated in both breeds there was an equal amount of breakdown of creatinine phosphate which is a major source of energy.

Table 18. Biochemical changes during ploughing and carting of Kangayam and crossbred bullocks (Mean ± S.E.)

Biochemical parameter	Time of recording	Kangayam		Crossbred	
		Type of work			
		Ploughing (n = 28)	Carting (n = 24)	Ploughing (n = 40)	Carting (n = 50)
Glucose (mg/100 ml)	Before work	44.22 ± 1.56	47.44 ± 1.46	59.60 ± 0.79	61.72 ± 0.71
	After work	39.74 ± 1.65	41.62 ± 1.48	54.72 ± 0.88	55.40 ± 0.68
	After rest	43.11 ± 1.56	45.98 ± 1.56	58.14 ± 0.79	60.07 ± 0.69
Cholesterol (mg/100 ml)	Before work	184.86 ± 1.22	185.13 ± 1.19	136.58 ± 3.16	125.99 ± 3.78
	After work	172.44 ± 1.25	169.09 ± 1.21	127.21 ± 3.25	109.53 ± 3.59
	After rest	182.81 ± 1.26	183.09 ± 1.22	134.81 ± 3.15	123.76 ± 3.79
SGOT (Units/ml)	Before work	100.44 ± 2.41	98.70 ± 2.93	71.03 ± 1.43	67.09 ± 2.06
	After work	113.45 ± 2.57	122.33 ± 3.22	80.03 ± 1.33	87.22 ± 1.57
	After rest	92.09 ± 3.87	88.33 ± 4.05	64.78 ± 1.27	57.79 ± 1.94
Creatinine (mg/100 ml)	Before work	1.28 ± 0.10	1.42 ± 0.08	1.35 ± 0.08	1.44 ± 0.05
	After work	2.49 ± 0.12	2.53 ± 0.09	2.77 ± 0.10	2.59 ± 0.07
	After rest	1.65 ± 0.10	1.74 ± 0.07	1.75 ± 0.08	1.75 ± 0.05

Source : Chandrasekaran (1991).

The mean haemoglobin content, packed cell volume (PCV), erythrocyte sedimentation rate (ESR), plasma bicarbonate and blood lactic acid content before the start of work, immediately after 4 hours of work and after one hour of rest of Kangayam bullocks are given in the Table 19. After 4 hours of work (both dry and wet ploughing) the ESR and blood lactic acid content showed significant increase whereas, the blood haemoglobin concentration, PCV and the plasma bicarbonate levels decreased significantly during the same period. One-hour rest was not sufficient to bring them to pre-exercise values (Anil and Thomas, 1994).

Table 19. Effect of work on haematological traits of Kangayam bullocks (Mean ± S.E; n = 4)

Haematological trait	Type of work	Before start of work	Immediately after 4 hours of work	After one hour of rest
Haemoglobin (g/dl)	Dryland ploughing	12.35 ± 0.09	11.08 ± 0.08	11.81 ± 0.07
	Wetland ploughing	12.31 ± 0.05	11.29 ± 0.06	11.94 ± 0.03
Packed cell volume (%)	Dryland ploughing	39.95 ± 0.27	35.25 ± 0.35	37.20 ± 0.38
	Wetland ploughing	39.80 ± 0.25	36.35 ± 0.48	37.90 ± 0.33
Plasma bicarbonate (mg %)	Dryland ploughing	26.09 ± 0.22	22.75 ± 0.31	24.17 ± 0.09
	Wetland ploughing	26.35 ± 0.20	21.77 ± 0.13	22.75 ± 0.16
ESR (mm / h)	Dryland ploughing	1.11 ± 0.07	1.93 ± 0.10	1.61 ± 0.05
	Wetland ploughing	1.13 ± 0.05	1.73 ± 0.03	1.42 ± 0.03
Blood lactic acid content (mg / dl)	Dryland ploughing	24.90 ± 0.22	42.02 ± 0.45	33.10 ± 0.42
	Wetland ploughing	24.90 ± 0.38	43.10 ± 0.13	37.32 ± 0.62

Source: Anil and Thomas, (1994)

8.2 Milk Production

8.2.1 Daily milk yield

Though Kangayam cattle are primarily bred for draught, the milk yield is not as poor as that of Umblachery or other Mysore-type breeds. Littlewood (1936) stated the average daily milk yield of foundation and farmbred Kangayam cows at Livestock Research Station, Hosur as 6.2 lb (2.8 kg) and 6.6 lb (3.0 kg) respectively with the highest daily yield of 10.9 lb (4.95 kg). While studying the different lactation records of the same herd Pattabhiraman (1958) reported an average daily first lactation milk yield of 5.2 lb (2.4 kg) which increased up to 6.7 lb (3.0 kg) at sixth lactation (Table 20). In another detailed statistical analysis on the first lactation records from1922 to 1952 of the same herd, Amble and Krishnan (1960) reported 5.62 ± 0.27lb (2.55 kg) and 5.24 ± 0.09 lb (2.38 kg) as average milk yield per day lactation of foundation stock (n = 41) and farmbred stock (n = 399) respectively (Table 21). The respective averages of milk yield per day of calving interval were 3.12 ± 0.30 lb (1.42 kg) and 3.19 ± 0.09 lb (1.45 kg) respectively. There was an increase in the average yield from the foundation stock to the first generation but this was followed by a continuous decrease from the first to the fifth generation, the average decrease in first lactation yield after correcting the records for environmental factors was 160 lb per generation. The improvement from the foundation stock to the first generation as well as the fall thereafter was attributable to environmental factors and partly due to the use of genetically inferior bulls which was identified later by analysis of their transmitting ability.

Table 20. Lactation performance of Kangayam cows at Livestock Research Station, Hosur

Lactation number	Number of records (n)	Average daily milk yield per lactation period (lb)	Average lactation period (days)	Average lactation milk yield (lb)
1st lactation	515	5.2 (2.36)	256	1403.1 (637.0)
2nd lactation	364	5.8 (2.63)	265	1547.8 (702.7)
3rd lactation	293	6.3 (2.86)	266	1676.6 (761.2)
4th lactation	241	6.3 (2.86)	266	1685.9 (765.4)
5th lactation	202	6.4 (2.91)	268	1750.2 (794.6)
6th lactation	146	6.7 (3.04)	276	1807.9 (820.8)
7th lactation	109	6.5 (2.95)	267	1673.9 (760.0)
8th lactation	85	6.4 (2.91)	273	1758.5 (798.4)
9th lactation	51	5.9 (2.68)	260	1586.8 (720.4)
10th lactation	26	6.0 (2.72)	270	1740.7 (790.3)
11th lactation	20	5.4 (2.45)	270	1454.9 (660.5)
12th lactation	10	5.3 (2.41)	257	1351.8 (613.7)
13th lactation	3	6.4 (2.91)	238	1530.8 (695.0)

Figures in parentheses indicate the values in kg

* The records were not adjusted for year, season and other non-genetic effects.

Source: Pattabhiraman, (1958)

Raju (1953b) analysed different lactation records (n = 1385) of cows at Palayakottai Cattl Farm and reported an average daily milk yield of 6.4 lb (2.9 kg) and 5.7 lb (2.6 kg) for the firs and fifth lactations respectively (Table 22). There was a slight increase in the lactation dail average and peak yield during second and third lactations over the first lactation and gradua decrease in later lactations. Pattabhiraman (1958) reported an average daily milk yield of 6.3 l (2.9 kg) for cows under Kangayam Cattle Improvement Scheme and of 5.2 lb (2.4 kg) for cow under non-scheme of the same herd at Palayakottai Cattle Farm.

Milk recording was carried out in the farmers' herds at monthly intervals in randomly selected villages in the habitat between 1994 and 1996 (Report, 1998). The calves were use not only for let down but were also allowed to consume milk before milking. Several farmer were milking in the morning alone and the cows were not milked in the evening as calves wer

Table 21. First lactation performance of Kangayam cows at Livestock Research Station, Hosur

	Average lactation milk yield (lb)	Average daily milk yield / day of lactation (lb)	Average lactation period (days)	Average daily milk yield / day of calving interval (lb)	Calving interval (days)
Foundation stock	1376 ± 104 (41) [624.2]	5.62 ± 0.27 (41) [2.55]	237 ± 11 (41)	3.12 ± 0.30 (40) [1.42]	486 ± 34 (40)
1st generation	1651 ± 83 (95) [748.9]	6.02 ± 0.20 (95) [2.73]	268 ± 6 (95)	3.71 ± 0.22 (86) [1.68]	473 ± 11 (86)
2nd generation	1567 ± 54 (121) [710.8]	5.47 ± 0.16 (121)[2.48]	282 ± 4 (121)	3.40 ± 0.14 (101) [1.54]	514 ± 15 (101)
3rd generation	1264 ± 54 (118) [573.4]	4.84 ± 0.17 (118) [2.19]	258 ± 7 (118)	2.85 ± 0.14 (85) [1.29]	532 ± 17 (85)
4th generation	1092 ± 56 (56) [495.3]	4.54 ± 0.20 (56) [2.06]	239 ± 7 (56)	2.37 ± 0.11 (39) [1.08]	507 ± 16 (39)
5th generation	844 ± 139 (7) [382.8]	4.11 ± 0.35 (7) [1.86]	212 ± 30 (7)	2.32 ± - (4) [1.05]	437 ± - (4)
Overall farm - bred stock	1416 ± 33 (399) [642.3]	5.24 ± 0.09 (399) [2.38]	264 ± 3 (399)	3.19 ± 0.09 (317) [1.45]	506 ± 8 (317)

Figures in round brackets are the number of observations
Figures in square brackets indicate the values in kg
Source: Amble and Krishnan (1960).

Table 22. Lactation performance of Kangayam cows at Palayakottai Cattle Farm

Lactation number	Average daily milk yield per lactation period (lb)	Average lactation period (days)	Average lactation milk yield (lb)	Peak yield (lb)
1st lactation	6.4 (2.91)	305.9	2027.7 (920.6)	10.1 (4.59)
2nd lactation	6.8 (3.09)	289.1	1980.9 (899.3)	11.3 (5.13)
3rd lactation	6.6 (3.00)	284.6	1873.9 (850.8)	11.4 (5.18)
4th lactation	6.4 (2.91)	288.9	1791.9 (813.5)	10.3 (4.68)
5th lactation	5.7 (2.59)	293.3	1664.5 (755.7)	9.9 (4.50)

Figures in parentheses indicate the values in kg
Source: Raju, (1953b)

allowed with cows for grazing. Milking was also done while the calf was consuming milk from one of the quarters. As the milking was not complete and the milk was shared by the farmer and calf, the milk yield data were considered as daily partial milk yield (Okantah, 1992).

The average for overall daily partial milk yield (two-time milking) was 1.99 ± 0.05 kg (Table 23) and the individual yields ranged from 0.5 to 5.65 kg. The yields recorded for cows up to 11 months of lactation did not reveal any definite pattern, though there was progressive increase up to the third month. One of the main reasons is the practice of allowing the calves to consume liberal quantity of milk at young age and less as the age advanced. The overall average daily partial milk yield for one-time milking (morning) was nearly half of two-time milking yield (0.93 ± 0.28 kg) and it ranged from 0.2 to 2.2 kg (n = 166).

Table 23. Mean (± S.E.) daily partial milk yield and milk constituents of Kangayam cows at farmers' herds

Month of lactation	Daily partial milk yield (kg)	Fat content (%)	SNF (%)
Overall	**1.99 ± 0.05 (300)**	**3.93 ± 0.07 (311)**	**7.21 ± 0.05 (311)**
1st month	1.63 ± 0.16 (17)	3.00 ± 0.18 (26)	7.49 ± 0.13 (26)
2nd month	1.81 ± 0.11 (39)	3.34 ± 0.14 (39)	7.24 ± 0.16 (39)
3rd month	2.05 ± 0.11 (47)	3.63 ± 0.13 (49)	7.21 ± 0.13 (49)
4th month	1.95 ± 0.11 (56)	3.83 ± 0.15 (47)	7.25 ± 0.14 (47)
5th month	2.08 ± 0.12 (52)	3.96 ± 0.16 (50)	7.19 ± 0.10 (50)
6th month	2.11 ± 0.15 (33)	4.47 ± 0.18 (41)	7.27 ± 0.12 (41)
7th month	2.03 ± 0.14 (22)	4.31 ± 0.21 (28)	7.02 ± 0.17 (28)
8th month	2.18 ± 0.20 (18)	4.83 ± 0.34 (16)	6.79 ± 0.20 (16)
9th month	1.83 ± 0.19 (8)	4.54 ± 0.52 (5)	7.27 ± 0.19 (5)
10th month	2.36± 0.19 (4)	5.03 ± 0.43 (4)	7.66 ± 0.17 (4)
11th month and above	1.50 ± 0.47 (4)	5.63 ± 0.34 (6)	7.22 ± 0.15 (6)

Figures in parentheses are the number of observations

SNF: Solids-not-fat

8.2.2 Lactation milk yield

Littlewood (1936) reported variation in the average milk yield of Kangayam cows from 1493 lb (678 kg) in foundation stock to 1615 lb (733 kg) in farmbred cows at Livestock Research Station, Hosur. Later, Rajagopalan (1952) carried out a study on Kangayam herd of the same farm and reported that the average milk yield during first lactation (n = 31) was 1413.09 ± 98.4 lb (641.5 kg). There was significant positive correlation between milk yield with age of the animal at first heat (0.82), age of the animal at first calving (0.61), and weight of the animal at first calving (0.55). Subsequently Pattabhiraman (1958) studied 2065 records of completed lactations of cows of the same herd and reported 1605.9 lb (729.1 kg) as average lactation milk yield of Kangayam cows. There was an appreciable increase in milk yield from the first lactation to the sixth lactation (Table 20) and then there was a decrease except in the tenth lactation, which might be due to small sample size. The maximum milk yield in a cow and maximum number of lactations recorded were 6254 lb (2839 kg) and 13 respectively. Later, Amble and Krishnan (1960) analysed the first lactation records and reported that the average first lactation milk yield of foundation stock (n = 41) was 1376 ± 104 lb (624.7 kg) and that of farmbred stock (n= 399) was 1416 ± 33 lb (642.86 kg). The average lactation milk yield of Kangayam cows at Palayakottai Cattle Farm was 2027.7 lb (920.6 kg) for first lactation (Table 22) and 1664.5 lb (755.7 kg) for fifth lactation (Raju, 1953b). The analysis also indicated that there was a gradual reduction in the milk yield at every successive lactation from the first to the fifth lactation. Pattabhiraman (1958) compared the average annual milk production of scheme and non-scheme cows in the same farm and reported 2111.5 lb (958.6 kg) and 1831.4 lb (831.5 kg) as average annual milk production of cows in the scheme and non-scheme respectively.

The total estimated partial milk yield of lactation for cows in the farmers' herds was 540 kg (Report, 1998). The average daily and lactation milk yield recorded for the cows in the farmers' herds are generally lower when compared with the earlier reports based on the institutional herds which set a range of 2 to 3 kg as average daily milk yield and 642 to 921 kg as lactation milk yield for the Kangayam cows. In the farmers' herds, cows are maintained mainly on grazing and generally no concentrate supplement is given. Depending on the need cows are also put to farm and transport work. These factors might have contributed to the low yield of milk in the farmers' herds. Pattabhiraman (1958) opined that milk production in Kangayam cows is rather latent and there is a possibility of increasing the milk production in Kangayam cows as milk production in some of the cows was over 5000 lb (2270 kg) in a single lactation and the heritability of the trait in Kangayam was found to be 0.3 to 0.4.

Effect of non-genetic factors

Amble and Krishnan (1960) examined the influence of non-genetic factors such as orde of lactation, preceding dry period, service period, age at first calving, season of calving an management in different years on milk production traits and also worked out lactation correctio factors for converting later records to first lactation basis for the Kangayam herd at Hosur Lactation yield showed an increasing trend from the first lactation to the third, yields in the thir and fourth lactation were nearly equal and steadily decreasing trend was indicated beyond th fourth up to the eight lactations. The peak yield was in the third lactation for which an increas of about five per cent over the first lactation performance was observed. The performance i the eighth lactation was about 18 per cent lower than that in the first lactation. Milk yield per da of lactation registered a steady increase from the first to the fourth lactation and showed steady decreasing trend after the fifth.

There was no association between preceding dry period and lactation yield. The influenc of service period on lactation yield was not substantial except for the fact that the low yielde giving 1000 lb or less milk in their first lactation had service period generally shorter than seve months. The influence of age at first calving on first lactation yield indicated a progressive decreas in average lactation yield for cows having longer age at first calving up to the age group 49 -5 months. The respective average first lactation yields for age at first calving intervals of 28 - 32 33 - 36, 37 - 40, 41 - 44, 45 - 48, 49 - 52, 53 - 60 and above 60 months were 1848, 1755, 1484 1420, 1309, 949, 1272, and 1486 lb. The season of calving did not show any influence on the firs lactation milk yield.

8.3 Lactation Length

The mean lactation lengths recorded for Kangayam cows in different lactations in th organized farms are presented in Tables 20, 21 and 22. The estimates ranged from 238 to 27 days for cows at Livestock Research Station, Hosur whereas, it was from 285 to 306 days fo cows at Palayakottai Cattle Farm. Amble and Krishnan (1960) reported a steady decrease i lactation length from first to eighth lactation, the lactation length in the latter being about 13 pe cent lower than the former in the Kangayam herd at Hosur. The data collected from the farmer herds revealed that Kangayam cows are capable of producing milk for a lactation period of 9.3 ± 0.18 months (n= 130), which is comparable to the value of 264 days already reported b Pattabhiraman (1958) for the organised farm.

8.4 Dry Period

Dry period in Kangayam cows is fairly long. Littlewood (1936) reported an average dr period of 184 days for Kangayam cows at Livestock Research Station, Hosur. The mean dr

period for all parities for cows belonging to the farmers in the habitat was 5.75 ± 0.17 months (Report, 1998).

4.5 Milk Constituents

The mean fat, solids-not-fat (SNF), protein and total solids per cent in the milk of Kangayam cows reported by various authors are presented in Tables 23 and 24.

Table 24. Mean (± S.E.) of milk constituents of Kangayam cows

Trait	Mean / Range	n	Reference
Fat content (%)	5.0 to 5.7	1385	Raju, 1953b
	3.4 to 5.1	197	Pattabhiraman, 1958
	3.2 to 4.4	-	Report, 1958-59
	3.93 ± 0.07 / 3.0 to 5.63	311	Report, 1998
SNF (%)	7.21 ± 0.05	311	Report, 1998
Total protein (%)	3.21± 0.03	306	Rajendran, 1995
Total solids (%)	10.91 ± 0.09	305	Rajendran, 1995

The fat percentage in Kangayam cows ranged from 3.0 (Report, 1998) to 5.7 (Raju, 1953b). Raju (1953b) reported a gradual reduction in the fat percentage from 5.7 to 5.0 per cent from the first to the fifth lactation in Kangayam herd at Palayakottai Cattle Farm. In the same farm Pattabhiraman(1958) observed reduction in the fat percentage from 5.1 to 3.4 from the foundation stock to third generation. The estimates of fat and SNF percentages from milk samples obtained from farmers' herds were 3.93 ± 0.07 and 7.21 ± 0.05 respectively. Fat per cent increased from 3.0 at first month of lactation to 5.63 at eleven and above months of lactation (Report, 1998).

In general, the estimates obtained for fat and SNF percentages for cows in the habitat were lower when compared to the average values for *Bos indicus* cattle. The lower fat percentage obtained might be due to the collection of samples from partial milking in which calves were allowed to suck considerable amount of fat-rich milk left over after milking. Inadequate feeding during lactation, which was generally noticed during the survey, might be the other possible reason for the low SNF record. The percentage of protein and total solids in Kangayam milk

samples as recorded by Rajendran (1995) are 3.21 and 10.91 respectively. Detailed studies o fat and other constituents based on larger sample size of 24-hour composite milk should b carried out. Effects of season, level of feeding, stage of lactation and parity must also be take into consideration.

9. REPRODUCTION

9.1 Female Reproduction

9.1.1 Age at breeding

The reproductive performance of Kangayam heifers and cows is summarised in Table 2 The average age at first oestrus of Kangayam heifers maintained at Livestock Research Statio Hosur was 1115 days (37 months) and in farmers herds it ranged from 29.49 to 33.08 month Rajagopalan (1952) reported a significant correlation (0.66) between age and weight of th animal at first heat. The average age at first mating of Kangayam heifers in farmers' herd ranged between 29.76 and 33.13 months (Rajendran, 1995; Report, 1998). There is only margin difference between age at first oestrus and age at first mating as most of the heifers are general known to have been mated in the first observed oestrus itself.

9.1.2 Age at first calving

The average age at first calving of Kangayam cows in organized farms ranged from 38 45 months (Littlewood, 1936; Amble and Krishnan, 1960) and for animals maintained in farme herds it ranged from 40 to 43 months (Rajendran, 1995; Report, 1998). Generally, the estimat reported for cows under farmers' herds are lower than the values reported for cows und organized farm conditions. Pattabhiraman (1958) reasoned that seasonal variations, mainly th level of rainfall and the availability of greens in the pasture play a major role in influencing th age at maturity and the age at first calving of the animals maintained under semi-intensi conditions. Rajagopalan (1952) reported a significant positive correlation (0.61) between ag and weight of the animal at first calving.

Table 25. Reproductive performance of Kangayam heifers and cows

Character	Mean ± S.E.	n	Location / Farm	Reference
Age at first oestrus	1114.75 ± 45.9 days	31	Livestock Research Station, Hosur	Rajagopalan, 1952
	33.08 ± 1.08 months	53	Breeding tract - Farmers' herds	Rajendran, 1995
	29.49 ± 0.4 months	195	-do-	Report, 1998
Age at first mating	33.13 ± 1.80 months	23	Breeding tract - Farmers'herds	Rajendran, 1995
	29.76 ± 0.37 months	166	-do-	Report, 1998
Age at first calving	38 months		Livestock Research Station, Hosur	Littlewood, 1936
	1447.5 ± 60.2 days	31	-do-	Rajagopalan, 1952
	44.1 ± 0.4 months	477	-do- (Farmbred stock)	Amble and Krishnan, 1960
	45.4 ± 1.0 months	47	(Foundation stock)	- do -
	1372 days	559	-do-	Pattabhiraman, 1958
	44.5 months	294	Palayakottai Cattle Farm, Palayakottai	Pattabhiraman, 1958
	43.17 ± 1.05 months	52	Breeding tract – Farmers' herds	Rajendran, 1995
	39.99 ± 0.38 months	199	-do-	Report, 1998
Calving interval	14 months		Livestock Research Station, Hosur	Littlewood, 1936
	16 .7 ± 0.3 months	317	-do-	Amble *et al.*, 1958
	471 days	1660	-do-	Pattabhiraman, 1958
	486 ± 34 days	40	-do- (Foundation stock)	Amble and Krishnan, 1960
	506 ± 8 days	317	(Farmbred stock)	-do-
	478 days	389	Palayakottai Cattle Farm, Palayakottai	Pattabhiraman, 1958
	15.34 ± 0.23 months	112	Breeding tract – Farmers' herds	Rajendran, 1995
	15.62 ± 0.16 months	260	-do-	Report, 1998

9.1.3 Calving interval

Gestation period: Bhattacharya *et al.* (1950, cited by Joshi and Phillips, 1953) studied the average gestation period for 590 calvings amongst 143 Kangayam cows and reported that it was 288.21 days for the male births and 285.35 days for female births, the sex ratio was 102.75 males : 100 females. While studying the effects of season and sex of the calf on gestation period in Kangayam cattle at District Livestock Farm, Chettinad, Gopalakrishnan *et al.* (1972) reported an average gestation period of 284.07 ± 0.48 days (n=617) and there was no significant influence of sex of the calf and season of calving on gestation period.

The average calving interval for Kangayam cows ranged from 14 months (Littlewood, 1936) to 16.7 months (Amble *et al.*, 1958). The mean calving intervals reported for cows under organised farm conditions are comparable with the values obtained for cows in the farmers' herds though there were variations in managemental practices reported (Pattabhiraman, 1958; Report 1998). For the cows maintained under the Kangayam Cattle Improvement Scheme at Palayakottai, the calving interval ranged from 322 to 584 days (Pattabhiraman, 1958). The lactation-wise average calving intervals for cows maintained at Livestock Research Station, Hosur are presented in Table 26. The estimates revealed that the maximum calving interval was after the first lactation, which gradually declined up to the fourth lactation. Amble and Krishnan (1960) also reported steadily shortened calving intervals from the first to third lactation, the interval in the third being about 10 per cent lower than the first. From the third to the fourth lactation it was more or less steady and beyond which there was a steady increase up to the seventh lactation. The distribution of calvings in different months in the same herd over 30 years indicated an uneven distribution of calvings over different months; there was a greater concentration of calvings from April to June as against fewer calvings in December and January.

In the habitat, calvings were found to be distributed throughout the year. Some farmers use the females predominantly for agricultural work and hence they are not breeding their cows regularly. The average number of calvings was nine but cows with 10 to 15 calvings were not uncommon (Report, 1998). Twinning is rare in the breed; however twinning was observed in two cows out of 308 cows (0.6 per cent) surveyed (Report, 1998). Amble *et al.*, (1958) reported that the mean generation interval for Kangayam herd at Hosur was seven years.

Table 26. Lactation-wise average calving intervals of Kangayam cows at Livestock Research Station, Hosur

Lactation number	n	Average calving interval (days)
1st lactation	391	513
2nd lactation	306	461
3rd lactation	254	453
4th lactation	205	446
5th lactation	162	468
6th lactation	121	466
7th lactation	92	449
8th lactation	63	445
9th lactation	31	492
10th lactation	18	465
11th lactation	11	460
12th lactation	6	471

Source: Pattabhiraman, (1958)

9.2 Male Reproduction

9.2.1 Biometry of testes

Well-fed male calves are ready for service when they are about 2½ years of age (Littlewood, 1936). Appadurai (1971) observed that the averages of testicular length and width were 110 and 60 mm respectively (n = 52) for 3 to 12 years age group of Kangayam bulls. He also reported that the average testicular lengths of Tharparkar, Red Sindhi, Jersey and Murrah bulls were 127, 122, 125 and 107 mm while the testicular widths were 68, 65, 67 and 58 mm respectively. The testicular size of Kangayam was smaller than those of other Indian and exotic breeds of cattle. While studying the testicular biometry and seminal attributes of Kangayam breeding bulls in artificial insemination programme, Veerapandian *et al.* (1992) reported (Table 27) mean testicular length of 10.75 ± 0.31 cm and width of 6.08 ± 0.08 cm of left testes and the corresponding values for right testes were 10.50 ± 0.45 and 5.92 ± 0.16 cm for bulls of more than 84 months age. They also suggested that while evaluating Kangayam bulls for breeding soundness, the smaller testicular size, the characteristic of this breed should be kept in mind.

9.2.2 Seminal attributes

Kangayam bulls are quick servers and remain in good breeding condition for a period of 10 years (Joshi and Phillips, 1953). While studying the sexual health of 367 breeding bulls of various breeds including Kangayam (n = 56) used for artificial insemination, Appadurai (1971) also reported that Kangayam bulls were quick servers when compared with Red Sindhi and Murrah bulls.

Mean reaction time was lower for Kangayam bulls with 70 ± 12 seconds (n = 52) as compare to Red Sindhi and Murrah bulls with 116 ± 22 (n = 61) and 123 ± 15 (n = 131) seconds respectivel The per cent frequency distribution of non-servers in Kangayam bulls was at 3.4 per cent where it was high (46.6 per cent) in Red Sindhi and Murrah bulls.

Table 27. Biometry of testes and seminal attributes (Mean ± S.E.) of Kangayam bull in different age groups

Character	Group I (< 60 months) (n = 5)	Group II (60 – 84 months) (n = 5)	Group III (> 84 months) (n = 6)
Biometry of testes Scrotal circumference(cm)	27.60 ± 1.47[a]	30.60 ± 1.29[b]	32.08 ± 0.67[b]
Left testis – Length (cm)	10.60 ± 0.40	10.30 ± 0.47	10.75 ± 0.31
- Width (cm)	5.40 ± 0.29	5.90 ± 0.33	6.08 ± 0.08
Right testis – Length (cm)	10.60 ± 0.40	10.40 ± 0.43	10.50 ± 0.45
- Width (cm)	5.40 ± 0.29	5.90 ± 0.19	5.92 ± 0.16
Seminal attributes			
Volume (ml)	3.55 ± 1.22	5.28 ± 0.61	4.66 ± 0.60
Initial motility (%)	62.00 ± 3.74	60.00 ± 4.08	59.00 ± 5.10
Concentration (million / ml)	1092.00 ± 109.05	1350.75 ± 279.03	1363.60 ± 122.00
Live sperm count (%)	85.32 ± 4.71	81.87 ± 5.32	80.13 ± 7.02
Sperm morphology			
Primary abnormalities	3.80 ± 1.59	3.73 ± 0.74	1.92 ± 0.46
Secondary abnormalities	6.20 ± 1.02	8.43 ± 2.46	9.00 ± 1.98
Total abnormalities	10.00 ± 1.79	12.15 ± 3.18	10.92 ± 1.96

Differences between groups in all parameters except scrotal circumference were not statistically significant (P>0.05)

Source: Veerapandian *et al.* (1992)

In another study on collection of semen for conservation, it was observed that Kangayam bulls started donating semen from 17 to 29 months of age (Report, 2005a). The quality of semen samples was poor during the training period and only 24.8 per cent of ejaculates were fit for preservation. The same trend was noticed in later semen collections also and only 31.2 per cent of ejaculates were fit for preservation. In comparison with exotics and crossbreds, the number of rejected samples were more in Kangayam (Report, 2005a).

The seminal attributes of the Kangayam semen samples reported (Table 28) revealed that 83 to 90 per cent of the samples were creamy white in colour and 41.4 to 45.8 per cent were medium in consistency. The volume of semen per ejaculate in Kangayam bulls maintained at bull stations for artificial insemination varied between 3.55 ± 1.22 and 5.28 ± 0.61 ml (Veerapandian *et al.*, 1992) whereas the mean values for young Kangayam bulls kept at conservation scheme were 2.32 ± 0.05 and 2.54 ± 0.16 ml (Table 28). The averages of mass activity and initial motility ranged between 1.14 ± 0.63 and 4.14 ± 0.12 (1 - 5 scale) and 40.00 ± 9.05 and 68.48 ± 2.04 per cent respectively. The mean sperm concentration varied between 774 ± 12 (Report, 2005a) and 1363.6 ± 122.0 million per ml (Veerapandian *et al.*, 1992). The live sperm percentage reported in Kangayam bull semen was generally good with values above 80 per cent and the abnormal sperm percentage was also within the permissible limits (Veerapandian *et al.*, 1992;Report, 2005a).

Table 28. Characteristics (Mean ± S.E.) of liquid and frozen semen of Kangayam bulls

Character	Batch I (n = 4)	Batch II (n = 8)
Age at which semen collection was started (months)	17 - 27	20 – 29
Age at which the semen was fit for preservation (months)	22 - 27	23-29
Colour of semen:		
White (per cent)	9.77 (532)	17.14 (70)
Creamy white (per cent)	90.23 (532)	82.86 (70)
Consistency (per cent): Thick Medium Thin Watery	27.82 45.86 23.50 2.82 (532)	28.57 41.43 22.86 7.14 (70)
Volume / ejaculate (ml)	2.32 ± 0.05 (532)	2.54 ± 0.16 (70)
Mass activity (1-5)	3.35 ± 0.06 (532)	2.61 ± 0.18 (70)
Initial motility (per cent)	56.26 ± 1.12 (532)	47.0 ± 3.40 (70)
Sperm concentration (million /ml)	774 ± 12 (435)	882 ± 26 (39)
Live sperm (per cent)	85.14 ± 0.73 (78)	
Abnormal sperm (per cent)	10.01 ± 0.33 (80)	
Pre-freeze motility (per cent)	66.75 ± 0.42 (166)	62.73 ± 1.35 (22)
Post-thaw motility (per cent)	36.20 ± 0.79 (166)	38.75 ± 2.21 (16)
Post-thaw motility of conserved samples (per cent)	41.71 ± 0.35 (117)	42.31 ± 1.22 (13)

Figures in parentheses are the total number of ejaculates

Source : Report (2005a).

The mean pre-freeze motility of spermatozoa ranged from 62.7 to 66.7 per cent. Sample having only 60 per cent pre-freeze motility were selected for processing and those having minimum of 40 per cent post-thaw revival rate were selected for conservation. It was reported that out of 16530 doses in the first batch and 1720 doses in the second batch frozen, only 69.5 per cent and 78.5 per cent respectively were fit for conservation. In young Kangayam bulls about 3 per cent of ejaculates are likely to be rejected due to the stress of freezing and thawing. The quality of semen and its freezability showed improvement only after 2½ years of age (Report 2005a).

Rengarajan (2004) studied the effect of three different cooling rates during freezing of Kangayam semen viz. slow cooling (-5°C / minute up to 5 to 20°C), medium (-10°C / minute up to 5 to 20°C) and fast (-15°C / minute up to 5 to 20°C) on post-thaw progressive motility, acrosomal and plasma membrane integrity and *in vitro* fertilizing capacity based on hamster egg penetration test (Table 29). He reported highly significant difference ($P< 0.01$) between slow cooling rate with medium and fast cooling rates. The results indicated that medium cooling rate was found to be more beneficial in retaining acrosomal and plasma membrane integrity. However, there were no significant differences in *in vitro* fertility test assessed with hamster oocytes for three cooling rates. Highly significant ($P< 0.01$) positive correlations were found between post-thaw progressive motility and acrosomal integrity (0.75) and plasma membrane integrity (0.67).

Table 29. Effect of different cooling rates on post-thaw motility, acrosomal and plasma membrane integrity and fertilization capacity (Mean ± S.E.) of Kangayam spermatozoa

Cooling rate	Progressive motility (%) (n = 40)	Intact acrosomes (%) (n = 40)	Plasma membrane integrity (Tail curling %) (n = 40)	Fertilization percentage (n = 8)	Fertilization Index (n = 8)
Slow	34.28 ± 0.82^{a}	81.06 ± 0.19^{a}	42.35 ± 0.39^{a}	59.92 ± 2.00	0.75 ± 0.02
Medium	39.86 ± 0.93^{b}	82.20 ± 0.12^{b}	43.71 ± 0.36^{b}	62.67 ± 1.58	0.79 ± 0.01
Fast	39.47 ± 0.93^{b}	81.82 ± 0.01^{b}	43.70 ± 0.32^{b}	61.10 ± 2.52	0.75 ± 0.03

Means with different superscripts within classes differ significantly ($P<0.01$)
Source: Rengarajan (2004)

10. GENETIC PARAMETERS

10.1 Repeatability

Repeatability coefficients of lactation milk yield, lactation period, milk yield per day of lactation, milk yield per day of calving interval and calving interval were estimated for Kangayam cows by Amble and Krishnan (1960) and they were 0.62 (1232 records; 422 cows), 0.31, 0.54, 0.50 (1013 records; 332 cows) and 0.08 respectively. Rajendran (1995) estimated repeatabilities of daily partial milk yield, fat and protein percentages by recording milk yield and collecting samples at approximately monthly intervals in Kangayam cows in the farmers' herds. The respective estimates based on successive recordings were 0.66 ± 0.05 (271 records; 75 cows), 0.45 ± 0.06 (276 records; 98 cows) and 0.38 ± 0.07 (271 records; 96 cows) respectively. For milk yield traits the repeatability estimates were higher than 0.5 indicating that there is scope for genetic improvement of these traits through selection.

10.2 Heritability

The estimated heritabilities for different production and reproduction characters of first lactation of Kangayam cows at Livestock Research Station, Hosur (Amble and Krishnan,1960) are given in Table 30.

Table 30. Heritability estimates for different production and reproduction characters of Kangayam cattle

Character	Intrasire degrees of freedom	Heritability ± S.E.
Lactation yield	304	0.58 ± 0.10
Milk Yield / day of lactation	304	0.52 ± 0.10
Milk Yield / day of calving interval	223	0.34 ± 0.09
Lactation period	304	0.13 ± 0.13
Calving interval	223	0.11 ± 0.19
Age at first calving	281	Negative

The heritability estimates were high for lactation yield and milk yield per day of lactation Further, they were only slightly lower than the repeatability estimates indicating that the two characters, heritable to the greatest extent, had not been very much affected by environmental factors of permanent nature. The heritability estimates for lactation period and calving interval were low and were not significantly different from zero.

11. CYTOGENETIC STUDIES

The chromosome profile of Kangayam breed was studied by Kumaraswamy *et al.* (2006) from blood samples (n= 28) collected from different villages in the breeding tract. The diploid chromosome count was 60 (2n= 60), comprising 29 pairs of autosomes and a pair of sex chromosomes. All the autosomes were acrocentric in morphology whereas, the X-chromosome was submetacentric and was the largest in the chromosome complement and Y-chromosome was small acrocentric, which resembled 27th pair of chromosomes. The relative length of the chromosomes was determined to establish the genomic contribution of each pair. The first autosomic pair was the largest acrocentric with a relative length of 5.11 per cent and the smallest was 1.75 per cent. The relative length of X-chromosome was 5.16 and Y-chromosome was 1.95 per cent. The arm ratio and centromeric index of X-chromosome were 2.157 and 0.31 respectively.

12. BIOCHEMICAL AND MOLECULAR CHARACTERIZATION

12.1 Blood Proteins and Enzymes

Electrophoretic studies on certain blood proteins and enzymes of Kangayam cattle revealed the existence of genetic polymorphism at loci controlling them. The normal variants of proteins (including milk proteins) and enzymes are known to be inherited in a simple Mendelian manner with codominance except alkaline phosphatase in which Akp^A is dominant over Akp^O. The distributions of different allele frequencies of the biochemical traits are summarised in Table 31.

Haemoglobin : Three haemoglobin phenotypes (HbA, HbB and HbAB) which are controlled by two Hb alleles (Hb^A and Hb^B) have been recorded. The estimated frequency of Hb^A (0.6) by Harikrishnaraj *et al.*, (2001) is in accordance with earlier reports on Kangayam cattle (Mangalraj *et al.*, 1968; Singh and Bhat 1980e). Among the breeds of Mysore-type cattle, Khillari exhibited higher frequency (0.49) of Hb^B allele (Naik *et al.*, 1965) than Kangayam cattle, whereas, Amritmahal and Hallikar breeds exhibited lower frequency (0.31 and 0.32 respectively) of Hb^B (Jayashankar *et al.*, 1984).

Table 31. Distribution of allele frequencies of different blood proteins and enzymes in Kangayam cattle

Protein / Enzyme	n	Allele frequency ± S.E.					Reference
		Hb^A	Hb^B				
Haemoglobin	22	0.680	0.320				Mangalraj *et al.*, 1968
	110	0.645 ± 0.030	0.355 ± 0.030				Singh and Bhat 1980e
	200	0.600 ± 0.025	0.400 ± 0.025				Harikrishnaraj *et al.*, 2001
		Alb^A	Alb^B	Alb^C			
Albumin	108	0.037 ± 0.013	0.940 ± 0.016	0.023 ± 0.010			Singh and Bhat, 1980c
	200	0.143 ± 0.018	0.858 ± 0.018	-			Harikrishnaraj *et al.*,2001
		Cp^A		Cp^C			
Ceruloplasmin	108	0.977 ± 0.010		0.023 ± 0.010			Singh and Bhat, 1980b
		Tf^A	Tf^B	Tf^F	Tf^E	Tf^{A1}	
Transferrin	100	0.066 ± 0.017	0.040 ± 0.014	0.535 ± 0.035	0.349 ± 0.034	0.005	Singh and Bhat, 1980d
	200	0.110 ± 0.016	0.088 ± 0.014	0.535 0.025	0.268 0.022	-	Harikrishnaraj *et al.*, 2001
		Am^B		Am^C			
Amylase	106	0.995 ± 0.004		0.005 ± 0.004			Singh and Bhat, 1979
		Akp^O		Akp^A			
Alkaline phosphatase	97	0.995 ± 0.005		0.005 ± 0.005			Singh and Bhat, 1980a

Albumin : In Kangayam cattle Singh and Bhat (1980c) recorded three albumin variants Alb^A, Alb^B and Alb^C in only three phenotypic combinations viz. AlbB, AlbAB and AlbBC whereas, Harikrishnaraj *et al.* (2001) observed only two albumin variants, Alb^A and Alb^B in three phenotypic combinations (AlbA, AlbAB and AlbB). They reported a higher frequency for Alb^B variant (0.858), which is in close agreement with an earlier report on Kangayam cattle.

Ceruloplasmin: Two ceruloplasmin alleles viz. Cp^A and Cp^C in three different combinations (CpA, CpC and CpAC) were observed in Kangayam cattle and it was also found that the gene frequency of Cp^A allele was maximum (0.997). Singh and Bhat (1980b) reported that the incidence of Cp^A allele was high among all indigenous breeds of cattle, which varied from 0.781 (Sahiwal) to 0.997 (Kangayam).

Transferrin : Singh and Bhat (1980d) observed four transferrin variants Tf^A, Tf^B, Tf^F, Tf with one rare allele Tf^{A1} in eight phenotypic combinations viz. TfF, TfE, TfAF, TfAE, TfBF TfBE, TfFE and rare type TfA1F. However, Harikrishnaraj *et al.* (2001) did not observe th rare variant Tf^{A1} in their study on Kangayam cattle. The study revealed the existence of fou transferrin variants Tf^A, Tf^B, Tf^F and Tf^E in nine phenotypic combinations consisting of only thre homozygotes (TfA, TfF and TfE) and all possible heterozygotes (TfAB, TfAF, TfAE, TfBF TfBE and TfFE). The observed frequency of Tf^F (0.535) was the highest among transferri alleles, followed by Tf^E (0.268). Singh and Bhat (1980d) also stated that the frequency of Tf (0.535) for Kangayam was the highest among Indian breeds of cattle studied Harikrishnaraj *et al.* (2001) stated that the frequency of zebu-specific transferrin allele Tf (0.088) observed in their study was higher than that reported earlier for Kangayam (0.04) a well as for other Indian breeds (Singh and Bhat, 1980d).

Amylase: Amylase polymorphism in Kangayam cattle revealed the presence of two variant viz, Am^B and Am^C. Singh and Bhat (1979) found high Am^B allelic frequency of 0.995 in Kangayan cattle and they also noted the predominance of Am^B allele among all indigenous breeds and it frequency varied from 0.828 in Red Sindhi to 0.995 in Kangayam.

Alkaline phosphatase: Serum alkaline phosphatase polymorphism in Kangayam catt revealed the presence of two variants, Akp^O and Akp^A with allele frequencies of 0.995 and 0.00 respectively. Singh and Bhat (1980a) observed that all indigenous breeds of cattle wer characterized by high Akp^O allele frequency, which varied from 0.938 in Gir to 0.995 in Kangayan

12.2 Milk Proteins

Electrophoretic studies on milk proteins in Kangayam cattle revealed the existence o genetic polymorphism of α_{s1}-casein, β-casein, α-lactalbumin and β-lactoglobulin (Singh and Bha 1980f; Singh and Bhat, 1981a; Jeichitra *et al.*, 2003). The distributions of allele frequencies o the four milk proteins are summarised in Table 32.

Caseins: Among caseins, α_{s1}-casein revealed the presence of three phenotypes, α_{s1} casein B, C and BC determined by B and C alleles. Indian breeds of cattle are characterized b a very high (0.91 to 0.97) frequency of α_{s1}-casein C allele (Jairam and Nair, 1983). Jeichitra *al.*, (2003) also reported very high frequency of 0.923 for α_{s1}–casein C allele in Kangaya cattle. For β-casein three phenotypes, β-casein A, B and AB controlled by two alleles, β–case A and B were identified. The estimated high allele frequency of β-casein A (0.92) in Kangaya cattle is in accordance with the earlier studies on majority of Indian breeds (Singh and Khanna 1972; Singh and Bhat, 1981a).

Table 32. Allele frequencies of milk protein variants in Kangayam cattle

Protein	n	Allele frequency ± S.E.			Reference
		α_{s1} - Cn^B		α_{s1}-Cn^C	
α_{s1} -Casein	156	0.077 ± 0.015		0.923 ± 0.015	Jeichitra *et al.*, 2003
		β-Cn^A		β - Cn^B	
β-Casein	52	0.923 ± 0.026		0.077 ± 0.026	Singh and Bhat, 1981a
	156	0.926 ± 0.015		0.074 ± 0.015	Jeichitra *et al.*, 2003
α- Lactalbumin	156	α- La^A		α -La^B	Jeichitra *et al.*, 2003
		0.622 ± 0.028		0.378 ± 0.028	
		β- Lg^A	β-Lg^B	β-Lg^C	
β-Lactoglobulin	56	0.018 ± 0.012	0.938 ± 0.022	0.045 ± 0.019	Singh and Bhat, 1980f
	156	0.074 ± 0.015	0.914 ± 0.016	0.013 ± 0.006	Jeichitra *et al.*, 2003

α–lactalbumin: Jeichitra *et al.* (2003) reported presence of three α– lactalbumin phenotypes A, B and AB determined by two α– lactalbumin alleles in Kangayam cows. The estimated frequencies of α-La^A and α-La^B alleles were 0.622 and 0.378 respectively. However, relatively higher frequency of α– lactalbumin A allele (0.622) in Kangayam is contrary to the earlier reports on Hariana, Sahiwal (Bhattacharya *et al.*, 1963), Tharparkar, Red Sindhi (Jairam and Nair, 1983) and Ongole (Rao *et al.* 1990; Jairam *et al.*, 1994) in which the frequency of α–lactalbumin B was found to be higher (0.62 to 0.84).

β-lactoglobulin: The whey protein, β-lactoglobulin revealed five phenotypes viz. β–lactoglobulin A, B, AB, AC and BC with three alleles β-Lg^A, β-Lg^B and β-Lg^C in Kangayam cattle (Singh and Bhat, 1980f; Jeichitra *et al.*, 2003). Of the three alleles, β-lactoglobulin B is the most common one with high frequency in Kangayam. The estimated high allele frequency of β-lactoglobulin B in Kangayam is in good agreement with earlier findings in different Indian breeds of cattle (Singh and Bhat, 1980f; Jairam *et al.*, 1994).

12.3 Heterozygosity

The heterozygosities estimated by Singh and Bhat (1981b) for various biochemic polymorphic traits among eight indigenous breeds of cattle are presented in Table 33. Th heterozygosities for haemoglobin, albumin, ceruloplasmin, transferrrin, amylase, serum alkalin phosphatase, β-casein and β-lactoglobulin loci of Kangayam cattle were 45.8, 11.5, 4.6, 58.6, 1.(1.0, 22.6 and 11.9 per cent respectively. Harikrishnaraj *et al.* (2001) observed that the populatio of Kangayam cattle in its breeding tract was under genetic equilibrium for the haemoglobi albumin and transferrin loci studied. The estimated heterozygosities for haemoglobin, albumi and transferrin loci were 48.0, 24.4 and 62.3 per cent respectively. The average heterozygosit estimated over three loci was 44.9 which was higher (19.6) than that reported earlier for Kangaya cattle (Singh and Bhat, 1981b).

Jeichitra *et al.* (2003) reported the heterozygosities for the α_{s1}-casein, β-casei α-lactalbumin and β-lactoglobulin loci in Kangayam cattle at the breeding tract as 14.2, 13.7 53.0 and 16.0 per cent respectively. The mean heterozygosity estimated over all four milk protei loci was 24.2. Among the eight Indian breeds of cattle studied (Singh and Bhat, 1981b), a revealed high heterozygosity at both β-casein and β-lactoglobulin loci except Tharparkar (11.4 and Kangayam (11.9) breeds respectively.

12.4 Characterization of Kangayam Cattle

With the results of the blood and milk protein variants, Kangayam can be differentiate from other Indian breeds of cattle by comparatively higher frequencies of both zebu-specifi transferrin alleles, Tf^B and Tf^F and by the conspicuous absence of Tf^D allele. In addition Kangaya can be characterized by the high allele frequencies of Cp^A, Am^B, Akp^O, α_{s1}-Cn^C, β-Cn^A an β-Lg^B and a relatively higher frequency of α-La^A allele.

Singh and Bhat (1981b) studied the phylogenetic relationship between eight Indian cattl breeds by utilizing gene frequency data pertaining to eight different blood and milk protei polymorphic systems. Based on the standard genetic distance estimated (Table 33), they surmise that the grey cattle breeds, viz. Hariana, Kangayam, Ongole and Tharparkar were closer. Ongol and Hariana diverged first from the phylogenetic tree whereas, Kangayam and Tharparkar wer closer to each other on genetic distance scale. Harikrishnaraj (1996) reported the standard genetic distance between Kangayam and other grey cattle breeds viz. Tharparkar, Ongole, Hariana an Kankrej were 0.0260, 0.0313, 0.0330 and 0.0902 respectively. He found that among the gre cattle breeds, the lyre-horned breed, Kankrej stood distinctly different from others whereas among short-horned grey cattle, Tharparkar was closer to Kangayam on genetic distance scale.

Table 33. Heterozygosity for various biochemical polymorphic traits among indigenous breeds of cattle and standard genetic distance between Kangayam and other indigenous breeds

Breed	Heterozygosity at locus (per cent)								Standard genetic distance from Kangayam
	Haemo -globin	Albumin	Cerulo -plasmin	Transferrin	Amylase	Alkaline phosphatase	β-casein	β-lacto -globulin	
Kangayam	**45.8**	**11.5**	**4.6**	**58.6**	**1.0**	**1.0**	**22.6**	**11.9**	
Hariana	49.0	15.0	28.9	64.5	4.8	1.8	28.4	33.2	0.013
Ongole	37.5	18.9	25.9	66.5	7.7	5.9	18.9	45.0	0.016
Tharparkar	39.3	6.4	12.3	69.1	2.1	2.2	11.4	29.1	0.007
Kankrej	47.2	3.8	2.8	53.9	11.7	7.5	56.9	64.8	0.064
Gir	49.8	23.2	8.7	68.1	12.2	11.6	23.2	53.1	0.029
Red Sindhi	49.4	23.4	27.9	71.2	28.5	5.7	12.9	50.0	0.031
Sahiwal	31.2	43.3	31.9	68.5	6.0	2.8	27.3	57.2	0.037

Source: Singh and Bhat (1981b)

However, the number of loci examined, number of alleles per locus and sample size used in these studies are smaller to draw valid conclusions. Hence, further studies utilizing more genetic markers of blood and milk proteins including enzymes and microsatellites of DNA (deoxyribonucleic acid) are needed for reliable characterization of Kangayam cattle and for studying the relationship of Kangayam breed with other breeds of Indian cattle.

12.5 Molecular Genetic Studies

Maurya (1999) employed three microsatellite primers viz. ETH 225, HBB and ILSTS 030 for genetic analysis of three south Indian cattle breeds viz. Kangayam (n = 30), Ongole (n = 28) and Umblachery (n = 19). The number of alleles, mean allele size and allele frequencies for all three breeds are given in Table 34.

Table 34. Number of alleles, mean allele size and frequency of three microsatellite primers in Kangayam, Umblachery and Ongole cattle

Primer	Breed	No. of alleles	Mean allele size (bp) (± S.E)	Frequency (± S.E.)	Heterozygosity
ETH 225	Kangayam	7	147.36 ± 3.20	0.148 ± 0.048	0.751
	Umblachery	10	146.20 ± 2.44	0.100 ± 0.018	0.871
	Ongole	8	148.75 ± 2.34	0.125 ± 0.032	0.820
HBB	Kangayam	8	173.25 ± 2.32	0.125 ± 0.050	0.737
	Umblachery	7	177.14 ± 1.99	0.143 ± 0.054	0.727
	Ongole	8	177.00 ± 1.73	0.125 ± 0.032	0.819
ILSTS 030	Kangayam	3	155.00 ± 1.16	0.334 ± 0.164	0.504
	Umblachery	4	152.00 ± 1.29	0.250 ± 0.146	0.494
	Ongole	3	156.33 ± 2.40	0.333 ± 0.193	0.442

Source: Maurya (1999)

In Kangayam, microsatellites ETH 225, HBB and ILSTS 030 showed 7, 8 and 3 alleles and their respective allele sizes (bp) ranged from 135-159, 164-182 and 153-157. Among the three breeds, Kangayam had three breed-specific alleles at HBB locus and their sizes were 164, 166 and 168 bp with the frequencies of 0.03, 0.18 and 0.07 respectively. Kangayam showed one specific allele of 135 bp at ETH 225 locus with a frequency of 0.07 and another specific allele of 157 bp at ILSTS 030 locus with a frequency of 0.02. The average heterozygosity (diversity)

within Kangayam was 0.66 for all three loci studied while for Umblachery it was 0.70 and for Ongole it was 0.69. The diversity among breeds was measured as coefficient of gene differentiation (GST) and it was 0.08 for all the three loci studied.

Thiagarajan (2000) studied the genetic variation among Kangayam (n= 22), Umbalachery (n= 30), Red Sindhi (n= 20), Ongole (n= 20) and Jersey crossbreds (n= 30) using five Random Amplified Polymorphic DNA (RAPD) primers ILO 1127, ILO 526, ILO 868, ILO 876 and BG 85 and eight microsatellite primers ILSTS 005, ILSTS 006, ILSTS 008, ILSTS 010, ILSTS 011, ILSTS 012, ILSTS 013 and ILSTS 014.

The DNA samples of different breeds were amplified with the random primers and band-sharing analysis was carried out. The mean band sharing values among individual animals within the breed, intrabreed polymorphism percentage for different genetic groups and per cent difference of Kangayam with other breeds are presented in Table 35. Kangayam showed breed specific fragment at 1.0 kb, 1.1 kb, 1.6 kb, 0.88 kb and 1.3kb for the respective five RAPD primers. The mean percentage difference among breeds using the five random primers was 75.91 ± 5.29 which indicated existence of greater genetic divergence between breeds. The phylogenetic trees constructed with genetic distances between breeds showed two clusters consisting of Kangayam and Red Sindhi for ILO 868 primer and Kangayam and Jersey crossbred for ILO 526 and BG 85 random primers.

The eight microsatellite primers amplified with DNA samples of the five genetic groups were found to be highly polymorphic (Table 36). In Kangayam, the number of alleles varied from 7 (ILSTS 014) to 16 (ILSTS 006 and ILSTS 008) and the allele sizes ranged from 95 bp (ILSTS 012) to 414 bp (ILSTS 006).

Microsatellite analysis of Kangayam, Umblachery, Ongole and Amritmahal cattle using markers i.e. ILSTS 005, ILSTS 006, ILSTS 011, ILSTS 030, ILSTS 033, ILSTS 034, ILSTS 054, ETH 010, ETH 152. ETH 225, INRA 005, INRA 032, INRA 035, INRA 063, HEL 001, HEL 005, HEL 009, BM 1818, BM 2113, MM 8, HAUT 024, HAUT 027, CSSM 066 and CSRM 060 recommended by the FAO (Food and Agriculture Organization

Table 35. The band sharing values and per cent differences of Kangayam with other genetic groups for the five RAPD primers

RAPD Primer	Band sharing values	Kangayam (n= 22)	Umbiachery (n= 30)	Ongole (n= 20)	Red Sindhi (n= 20)	Jersey cross (n= 30)
ILO 1127	Mean	0.138 ± 0.04	0.088 ± 0.03	0.056 ± 0.03	0.162 ± 0.03	0.061 ± 0.02
	Range	0 - 0.750	0 - 0.462	0 - 0.400	0 - 0.600	0 - 0.364
	Intrabreed polymorphism (%)	86.18	91.23	94.44	83.78	93.87
	Per cent difference with Kangayam		74.60	66.20	85.19	77.14
ILO 526	Mean	0.074 ± 0.03	0.062 ± 0.02	0.374 ± 0.04	0.207 ± 0.05	0.101 ± 0.04
	Range	0 - 0.400	0 - 0.400	0 - 0.615	0 - 0.727	0 - 0.714
	Intrabreed polymorphism (%)	92.62	93.83	62.59	79.31	89.89
	Per cent difference with Kangayam		77.42	84.62	77.36	75.00
ILO 868	Mean	0.266 ± 0.04	0	0.133 ± 0.03	0.071 ± 0.03	0.101 ± 0.03
	Range	0 - 0.667		0 - 0.461	0 - 0.421	0 - 0.500
	Intrabreed polymorphism (%)	73.35	100	86.87	92.92	89.95
	Per cent difference with Kangayam		88.00	77.78	65.22	80.49
ILO 876	Mean	0.264 ± 0.06	0.118 ± 0.03	0.082 ± 0.03	0.104 ± 0.03	0.139 ± 0.03
	Range	0 - 0.714	0 - 0.353	0 - 0.476	0 - 0.333	0 - 0.444
	Intrabreed polymorphism (%)	73.62	88.20	91.77	89.56	86.09
	Per cent difference with Kangayam		50.00	58.90	58.06	81.82
BG 85	Mean	0.139 ± 0.06	0.104 ± 0.04	0.041 ± 0.03	0.147 ± 0.03	0.031 ± 0.02
	Range	0 - 1.000	0 - 0.444	0 - 0.500	0 - 0.500	0 - 0.400
	Intrabreed polymorphism (%)	86.08	89.60	95.93	85.28	96.91
	Per cent difference with Kangayam		84.62	84.00	94.59	100.00

Source: Thiagarajan (2000)

Table 36. Number of alleles, allele size and more frequent alleles for different microsatellite primers in Kangayam cattle

Microsatellite primer	No. of alleles	Allele size (bp) (range)	More frequent alleles (bp)
ILSTS 005	14	194 - 247	202 (0.14), 205 (0.14), 223 (0.11)
ILSTS 006	16	275 - 414	334 (0.09), 340 (0.09), 355 (0.09), 370 (0.11)
ILSTS 008	16	102 - 157	128 (0.09), 136 (0.14), 138 (0.09)
ILSTS 010	15	151 - 215	172 (0.16)
ILSTS 011	10	304 - 354	308 (0.16), 346 (0.18)
ILSTS 012	8	95 - 112	107 (0.23)
ILSTS 013	8	142 - 159	148 (0.27)
ILSTS 014	7	142 - 159	144 (0.16), 148 (0.18), 156 (0.20), 159 (0.18)

Figures in parentheses indicate the respective frequency of the allele.
Source: Thiagarajan (2000)

of the United Nations) was conducted at Core Laboratory, Network Project on Animal Genetic Resources, Chennai (Report, 2005b). All the microsatellite loci studied were found to be polymorphic in four breeds of cattle except ETH 152 locus being monomorphic in nature. The allele sizes of microsatellite loci screened were in the range of 89 to 316 bp. The number of alleles in Kangayam ranged from one (ETH 152) to 24 (BM 1818) whereas the number of alleles varied from 1 (ETH 152) to 19 (CSSM 066) in Umblachery; 1 (ETH 152) to 8 (INRA 035) in Amritmahal and 1 (ETA 152) to 21 (ETH 010) in Ongole cattle. The polymorphism information content (PIC) values ranged from 0.69 to 0.81 among different breeds studied and in Kangayam the PIC values ranged from 0.49 (INRA 063) to 0.87 (ILSTS 054) with a mean of 0.77.

13. INCIDENCE OF DISEASES AND MORTALITY

Pattabhiraman (1958) reported average annual mortality of 4.6 per cent for Kangayam cattle maintained at Livestock Research Station, Hosur during 1925 - 1955. The infectious diseases recorded in this farm were rinderpest, black quarter and foot and mouth disease. Though foot and mouth disease appeared very often, the mortality due to that was negligible in the farm. He also reported that decline in the rate of mortality ranging from 5.7 to 1.9 per cent over the years though the farm is located outside the home tract. While studying the age-wise mortality pattern of the same herd Amble and Krishnan (1960) observed average calf mortality of 6.8 per cent and total mortality of 3.3 per cent for above one year age group. The rate of mortality did

not differ significantly either between the sexes or among the calves belonging to different generations. In the breeding tract, animals are vaccinated against black quarter and foot and mouth disease in the face of outbreaks. Deworming of animals is not practiced at regular intervals.

Information collected from farmers and veterinary institutions in the breeding tract (Report, 1998) revealed the occurrence of outbreaks of foot and mouth disease. Incidence of diseases like rinderpest, black quarter, trypanosomiasis, babesiosis, coccidiosis were also recorded in Kangayam animals in the tract. In addition, diseases such as ephemeral fever, pneumonia and mastitis were also reported. However, the severity of the above diseases was not much when compared to the exotic crosses maintained by the same farmers. Incidence of ephemeral fever was reported to be more frequent in Kangayam bullocks which needs further detailed study. Data collected revealed that calf and adult mortality is found to be negligible and the breed is found to be hardy and well-adapted.

14. GENERAL INFORMATION

14.1 Marketing

The markets for Kangayam cattle in the home tract consist of regular weekly markets (shandies) and annual cattle fairs. Local panchayat or municipal authorities organize them and fee is levied on each animal brought for sale. The details of cattle fairs in which Kangayam animals brought for sale are given in Appendix II. In all these fairs mainly Kangayam young males and bullocks predominate and the female stocks are generally less (Fig. 24 and 25). There is great demand for Kangayam bullocks from outside the breeding tract, especially from southern districts of Tamil Nadu as also stated by Gunn (1909) and Littlewood (1936).

Kangayam bullocks are priced higher than the other breeds in the region. The prices of various categories of Kangayam cattle for nearly a century are given in Appendix III. A typical pair of mature Kangayam bullocks fetched a maximum price of Rs. 78,500/- as of 2008. In addition to morphological characteristics, lucky marks or whorls on cattle are also looked into prior to the purchase due to certain beliefs and prevailing opinion among farmers. Littlewood (1936) observed that Pattagar of Palayakottai maintained a herd of about 2000 head of stock in his farm and sold annually about 300 breeding bulls and bullocks to ryots in the home tract and also in southern districts of Tamil Nadu.

Aged animals are mostly sold in the weekly markets to butchers or traders. The traders generally sell the aged animals as a lot for disposal in the cities to the butchers. It is learnt that most of the animals sold are ultimately transported to Kerala state.

Fig.24. A view of annual cattle fair held at Kannapuram

Fig.25. Purchased young males and bullocks transported through truck.

14.2 Breeds Evolved from Kangayam

14.2.1 Manaparai

This is one of the local cattle breeds reported to have originated from a cross between Kangayam bulls and the local cows of Manaparai in undivided Tiruchirappalli district and now in Karur district of Tamil Nadu. The origin of the breed is rather peculiar. Subramanyam (1947) reported that the place Manaparai was famous for weekly cattle markets and animals from the adjoining areas were brought to this market for sale. Among them a few Kangayam bulls were always available for sale and these were purchased by the ryots of Manaparai and its surrounding locality for the purpose of cultivation or with the specific purpose of breeding alone. These bulls were maintained in their village for varying length of time until they could fetch good profit when they were exposed for sale at the next or any of the succeeding weeks shandies. During the period of maintenance, these bulls were allowed to serve the local cows. The so called Manaparai breed was the result.

It is a well known breed among the farmers of the adjoining districts of Kangayam tract viz. Tiruchirappalli, Madurai and also Thanjavur and Pudukottai districts. Manaparai cattle are mostly grey in colour, have more or less short symmetrical horns directed upwards and slightly curved inwards. The body is well-developed with small hump, short head, dark eyes and large ears. This breed is mainly used for draught.

14.2.2 Umblachery

It is a medium-sized draught type cattle distributed in the present Thiruvarur and Nagapattinam districts of Tamil Nadu. There is a general belief that the breed might have developed by crossing Kangayam with local animals. Gunn (1909) stated that Umblachery animals possessed all the chief characteristics of the Kangayam except the appearance of the head. Nair (1952) also reported that Kangayam had been used to sire the local scrubs to a great extent in the formation of this breed. But the degree of amelioration with Kangayam had not gone long enough to give the distinct Kangayam animals.

14.2.3 Jellicut / Pulikulam

This is one of the famous local breeds of the past in Tamil Nadu and is virtually disappearing at present. These cattle are found in many parts of undivided Madurai and Ramnad districts and maintained as nomadic or migrating herds. Pulikulam is a trotting type evolved for the purpose of quick transport work, which included prestige. The bulls of this breed are ferocious and they are trained and kept for the purpose of bull fighting or rather 'bull baiting' and are known as Jellicut.

Gunn (1909) reported that these animals resembled the small-sized variety of the Kangayam and opined that they had in them a strain of the Mysore blood. Pattabhiraman (1962?) also

reported that this breed was similar to Kangayam in many points except in size and the muzzle, eyes and hooves, which were brown or brownish-tinged.

14.3 Kangayam in Other Countries

Kangayam is one among the several Indian breeds of cattle such as Ongole, Gir, Kankrej, Hariana, Red Sindhi, Tharparkar, Krishna Valley, Malvi, Mewati etc., that had been introduced into other countries (Payne and Hodges, 1997). Kangayam cattle were imported mainly by Brazil, Sri Lanka, the Philippines and Malaysia for development of breed(s) for beef and for draught purposes due to their good body conformation and hardiness.

Brazilians imported Kangayam at the beginning of this century and were absorbed in the formation of the Brazilian Nellore (Nelore) to which it has contributed, in characterization and also muscling. Kangayam has uniform carcass harmony with a very well-distributed strong musculature and these features also contributed to the success of Nellore in Brazil and in addition Kangayam also gave its horn shape. In 1962/1963 again one bull and six cows were imported by two Brazilian breeders and were kept with racial purity with a Genealogical Registration from 1988. The National Centre of Genetic Resources (Cenargen), Brazil has shown interest in the preservation of Kangayam (Santos, 1998, 2000).

In Malay, Kangayam was introduced along with Hallikar and Ongole for the creation of new composite breed now called Local Indian Dairy (LID) and in addition they have been imported for use as draught animals in the Malay plantations (Payne and Hodges, 1997). Kangayam cattle were also exported to Sri Lanka for draught purposes. Littlewood (1936) reported that the Pattagar of Palayakottai supplied Kangayam cattle to the then Ceylon Government and the present status of their descendants is not known.

15. STRATEGIES FOR IMPROVEMENT AND CONSERVATION

Since Kangayam breed is known for its draught qualities, tolerance to diseases and adaptation to poor nutrition and drought conditions, steps should be taken to check the decline in its population and to preserve the special adaptive traits and the genetic variability. The breed improvement and conservation strategies should therefore, consider the following aspects:

i) The future of Kangayam breed depends on the awareness among the farmers about the special qualities of the breed. Therefore, the farmers rearing the Kangayam should be identified and encouraged to rear such animals in substantial numbers in order to arrest decline of germplasm in the breeding tract. Some form of incentives should be offered to them for maintaining this breed in pure form and they should be involved in breed improvement plans.

ii) Kangayam Breeders Association and Breed Society formed in the breeding tract should be supported with sufficient financial assistance for taking up development activities effectively. Coordination should be established with the Animal Husbandry Department and Tamil Nadu Veterinary and Animal Sciences University to undertake breed improvement and research programmes.

iii) Herd registration scheme should be revived. The breeders' association should insist all the farmers owning Kangayam cows for enrolment and performance recording. Superior animals should be identified and utilized for further propagation of the breed.

iv) Establishment of a breeding farm in the habitat is a long-felt need for the breed though a nucleus herd is maintained at the District Livestock Farm, Hosur. The climate, ecology and vegetation of the farm are quite dissimilar to those found in the home tract. The envisaged farm in the home tract will be useful for initiating Open Nucleus Breeding Scheme by associating the herds in and around so that rapid genetic improvement could be achieved.

v) Elite females should be selected from the farmers' herds and brought to the nucleus farm and their male calves should be selected for future use in the breeding tract. While selecting young males and breeding bulls, more emphasis should be placed on draught characters.

vi) State government support can be in the form of supply of frozen semen and establishing sufficient number of artificial insemination centres in each and every village of the breeding tract. Where artificial insemination is not feasible, supply of good quality breeding bulls may be made at a nominal cost. To ensure genetic variability and to minimize inbreeding exchange of breeding bulls among the farmers at different locations must be emphasized and encouraged.

vii) Farmers in the main breeding tract must be advised and discouraged from resorting to crossbreeding indiscriminately.

viii) Regular cattle shows/camps should be organized wherein the importance of the breed, feeding, reproduction and health care should be highlighted. Problems of the farmers should be discussed in depth and necessary remedial measures suggested for such problems.

ix) Though the draught capacity of the Kangayam bullock is well known, quantitative data on various indicators of draught qualities and adaptation are limited. Therefore, evaluation of draught efficiency and power potential of the Kangayam cattle under controlled conditions is essential for devising suitable selection criteria. Simultaneously the milk yield has to be optimized without sacrificing the draught qualities under the existing management so that rearing of Kangayam cows becomes economically sustainable.

x) Unraveling of the cattle genome is fast becoming a reality and therefore steps have to be taken to identify the loci responsible for the unique characters of the breed using microsatellites and other molecular markers.

xi) As the population is declining in the habitat both *in situ* and *ex situ* conservation programmes should be augmented. The Tamil Nadu Veterinary and Animal Sciences University had implemented a project on "*Ex situ* conservation of Kangayam cattle" with financial support from the National Bureau of Animal Genetic Resources, Karnal.

xii) All the information on Kangayam breed should be computerized in the form of a data bank. Appropriate format and packages should be devised to store and retrieve the information. Such information would be useful in characterizing the breed and planning for future breeding and developmental programmes.

In the final analysis it is the farming community responsible for the breeding and maintenance of the Kangayam cattle over a century that must be entrusted with the conservation of the breed. Furthermore, there must be adequate monetary and technical support from the government and scientists to make it into a reality.

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APPENDIX - I

BREED DESCRIPTOR OF KANGAYAM CATTLE

I GENERAL DESCRIPTION :

1.	Name of the breed	:	Kangayam (Syn. Kanganad and Kongu).
2.	Background for such a name	:	The name derived from its habitat, Kangayam taluk in Erode district, Tamil Nadu, India.
3.	Species name	:	*Bos indicus*
4.	Most closely related breeds (in appearance)	:	a) Umblachery b) Manaparai c) Pulikulam
5.	a) Native tract of distribution in terms of longitude and latitude	:	Between 10°12' and 11°48' N latitude Between 77°12' and 78°12'E longitude
	b) Approximate area of distribution	:	17,000 square kilometre
	c) Estimated population size	:	4,79,000 (as of 1996)
	d) Use	:	Draught and Milk for home consumption
6.	Communities responsible for developing the breed	:	Developed by the then Pattagar of Palayakottai, N.Nallathambi Sarkarai Manradiar and his family, Kadiyar Munsif Monigar.
7.	Native environment		
	a) Soil description	:	The major stretch of land in this tract constitutes red soil followed by black soil. Red soil is shallow in depth with texture ranging from sandy to gravel with a calcareous sub-soil.
	b) Average temperature	:	28°C
	c) Mean minimum temperature	:	23°C Month of min. January
	d) Mean maximum temperature	:	33°C Month of max. April
	e) Mean relative humidity at 0830h (%)	:	77 Month of max. November

f) Mean relative humidity at 1730h (%)	:	53 Month of min. March
g) Annual rainfall	:	650 mm
h) Peak rain	:	139.5 mm, Month of peak- September
i) Annual duration of rain in months	:	1 month and 8 days
j) Elevation of land	:	150-600 metre above mean sea level
k) Main cultivated cereals	:	*Sorghum vulgare, Pennisetum typhoides, Oryza sativa* and *Eleusine coracana*
l) Main cultivated pulses	:	*Phaseolus trilobus, Phaseolus mungo, Phaseolus aureus, Vigna sinensis, Cajanus cajan, Cicer arietinum* and *Dolichos biflorus*
m) Other crops	:	*Arachis hypogea, Saccharum officinarum, Gossypium hirsutum* and *Moringa oleifera*

8. Feed

a) Major fodder trees	:	*Acacia leucophloea* and *Acacia nilotica*
b) Cultivated tubers	:	*Tapinanthus bangwensis*
c) Source of dry fodder	:	Paddy (*Oryza sativa*), sorghum (*Sorghum vulgare*), pearl millet (*Pennisetum typhoides*) stover, groundnut (*Arachis hypogea*) haulms. *Cenchrus setigerus* and *Cenchrus ciliaris* mainly found in the grazing land.
d) Seed and grain feed	:	Sorghum (*Sorghum vulgare*), pearl millet (*Pennisetum typhoides*) and cotton seed. (*Gossypium hirsutum*).
e) Cakes and other concentrates	:	Groundnut cake, sunflower cake and rice bran
f) Others	:	Palmyra (*Borassus flabellifer*) fronds used as fodder during periods of acute fodder scarcity.
g) Grazing method	:	Fenced grazing area
h) Water supply of pasture	:	Rainfed

9. Housing : Open housing.
(Animals are housed only during night).

10. Herd size : Average herd size 3.5;
Per cent composition: 19.6 calves, 6.9 male youngstock, 12.1 female youngstock, 0.2 bulls, 38.4 cows and 22.8 bullocks.

11. Mating method : Both natural service and artificial insemination

II PHYSICAL CHARACTERS

1. Colour

a) Coat colour : Red at birth which changes to grey colour around 6 months. Bulls are grey with dark colour in hump, forequarter, hindquarter, face and legs. Bullocks are grey in colour. Heifers and cows are grey or white and grey in colour. The face is dark grey in majority of cows.

b) Skin colour : Black

c) Muzzle : Black

d) Eyelids : Black

e) Tail : Black (switch)

f) Hooves : Black

2. Horns

		Bull	Bullock	Cow
a) Colour	:	Black	Black	Black
b) Size at maturity	:	Medium	Large	Medium
c) Shape	:	Curved	Curved	Curved

d) Orientation : Horns take backward and outward sweep, then inward with tips tending to meet each other, to form crescent shape. Backward and forward pointing tips are also seen.

3. Ears		Bull	Bullock	Cow
a) Length (cm) ± S.E.	:	19.8 ± 0.6	20.3 ± 0.3	19.2 ± 0.1
b) Orientation	:	Horizontal	Horizontal	Horizontal

4. Head

a) Forehead : Broad and level with a shallow groove at the centre

b) General description : Straight face. In bulls, the face is dark-grey and reduced intensity in cows.

5. Body		Bull	Bullock	Cow
a) Hump	:	Large	Large	Medium
b) Dewlap	:	Small	Small	Small
c) Navel flap	:	Small	Small	Small
d) Penis and sheath flap	:	Small	Tucked up	-
e) Basic temperament	:	Tractable	Tractable	Tractable

6. Udder

a) Shape : Mostly tucked up

b) Fore-udder size : Small

c) Rear-udder size : Small

d) Teat shape : Cylindrical

e) Teat tip : Round

f) Milk vein : Small

III PERFORMANCE

1. Body measurements		n	Mean	S.D.	Range
a) Height at withers (cm)					
Bulls	:	12	139.5	12.1	126 to 163
Bullocks (> 3 ½ yrs)	:	135	139.8	6.7	121 to 159
Cows (in milk)	:	214	124.6	10.1	107 to 162

b)	Body length (cm)					
	Bulls	:	12	144.3	14.1	119 to 163
	Bullocks (> 3 ½ yrs)	:	134	144.9	10.1	122 to 169
	Cows (in milk)	:	214	130.7	11.6	109 to 159
c)	Chest girth (cm)					
	Bulls	:	12	169.9	21.3	142 to 213
	Bullocks (> 3 ½ yrs)	:	133	175.9	11.5	149 to 209
	Cows (in milk)	:	210	155.3	8.7	128 to 194
2. Dairy performance			**n**	**Mean**	**S.D.**	**Range**
a)	Average daily partial milk yield (g) (Pooled over lactations)	:	300	1986	779	500 to 5650
b)	Lactation length (months)	:	130	9.35	2.05	5 to 20
c)	Fat (%)	:	311	3.93	1.23	1.6 to 7.7
d)	SNF (%)	:	311	7.21	0.88	5.23 to 9.48
e)	Productive life span (Average no. of calvings)	:	88	8.98	2.22	5 to 15
f)	Dry period (months)	:	170	5.75	2.21	2 to 12
g)	Percentage of animals	:	Lactation 1 (15%), 2(18%), 3(26%), 4(18%) and 5 and above (23%)			
h)	Lactation milk yield (Estimated value)	:	540 kg in partial milking			

3. Reproduction

a) Males

i) Age at first mating	:	30 months (range 24-36 months)
ii) Age at castration	:	24 months (range 18-30 months)
iii) Abnormalities	:	Rare occurrence of cryptorchids

b) Females		**n**	**Mean (months)**	**S.D.**	**Range**
i) Age at first oestrus	:	195	29.49	5.57	18 to 42
ii) Age at first mating	:	166	29.76	4.71	18 to 42
iii) Age at first calving	:	199	39.99	5.36	28 to 54
iv) Calving interval	:	260	15.62	2.50	12 to 24

v) Twinning percentage : 0.6

vi) Abortions and stillbirths : Rare

4. Type of work

a) Purpose : Carting, ploughing and threshing (Carting for transportation of agricultural produce, manure, house construction materials like sand, etc. and drinking water)

b) Capacity for work : Hard

c) Average duration of work per day : 7-8 hours daily during peak season

5. Drought tolerance : High

6. Heat tolerance : High

7. Diseases and parasites :

Diseases like trypanosomiasis, babesiosis, cutaneous filariasis, coccidiosis, pneumonia, black quarter, ephemeral fever, foot and mouth disease, rinderpest and mastitis have been recorded. Economic loss due to these diseases is generally negligible. Among the diseases, ephemeral fever is more prevalent in bullocks. Generally, tolerance to diseases is found to be higher as indicated by negligible calf and adult mortality.

8. Conservation status : Not at risk

IV BIOCHEMICAL POLYMORPHISM

1. Blood protein	Variant	Allele frequency ± S.E.
a) Haemoglobin (Hb)	Hb^A	0.600 ± 0.025
	Hb^B	0.400 ± 0.025
b) Albumin (Alb)	Alb^A	0.143 ± 0.018
	Alb^B	0.858 ± 0.018
c) Transferrin (Tf)	Tf^A	0.110 ± 0.016
	Tf^B	0.088 ± 0.014
	Tf^F	0.535 ± 0.025
	Tf^E	0.268 ± 0.022
2. Milk protein		
a) α_{s1}- Casein (α_{s1}-Cn)	α_{s1} - Cn^B	0.077 ± 0.015
	α_{s1} - Cn^C	0.923 ± 0.015
b) β-casein (β-Cn)	β - Cn^A	0.926 ± 0.015
	β - Cn^B	0.074 ± 0.015
c) α-lactalbumin (α-La)	α - La^A	0.622 ± 0.028
	α - La^B	0.378 ± 0.028
d) β-lactoglobulin (β-Lg)	β - Lg^A	0.074 ± 0.015
	β - Lg^B	0.914 ± 0.016
	β - Lg^C	0.013 ± 0.006

The population was under genetic equilibrium with respect to the above all loci except α-lactalbumin locus.

APPENDIX -II
DETAILS OF WEEKLY FAIRS

Location of the fair	District	Week day	Approximate no. of Kangayam cattle assembled
Anthiyur	Erode	Monday	2000 - 2500
Dharapuram	Erode	Tuesday	400 - 500
Erode	Erode	Thursday	250 - 500
Gobichettipalayam (Modachur)	Erode	Saturday	600 – 800
Kangayam	Erode	Monday	500 – 800
Kunnathur	Erode	Monday	500 – 600
Mulanur	Erode	Wednesday	300 – 500
Perundurai	Erode	Sunday	700 – 1000
P.Puliampatti	Erode	Thursday	750 - 1000
Siruvallur	Erode	Tuesday	300 – 400
Sivagiri	Erode	Friday	700 – 900
Narikkalpatty	Dindigul	Saturday	500 - 1000
Salaiputhur	Dindigul	Saturday	800 – 1000
Thoppampatty	Dindigul	Friday	500 - 800
Upidamangalam	Karur	Sunday	2000 – 3000
Annur	Coimbatore	Saturday	500 – 600
Pulavadi	Coimbatore	Friday	500 - 1000
Thudialur	Coimbatore	Monday	500 – 700
Tiruppur	Coimbatore	Tuesday	700 – 1000
Udumalpet	Coimbatore	Monday	1000 - 1500

DETAILS OF ANNUAL CATTLE FAIRS

Location of the fair	District	Month and duration	Approximate no. of Kangayam cattle assembled
Anthiyur	Erode	July/August - 7 days	18,000
Kannapuram	Erode	April - 7 days	15,000
Thambikalai Ayyan	Erode	April - 7 days	5,000
Ammapatty	Dindigul	July - 5 days	3,000
Athikombai	Dindigul	June - 8 days	10,000
Thoppampatty	Dindigul	July/August - 5 days	5,000
Vadamadurai	Dindigul	July/August - 7 days	3,000
Andipattikottai	Karur	May - 7 days	3,000
Thennilai	Karur	April - 5 days	2,000
Avinashi	Coimbatore	June - 7 days	3,000
Karamadai	Coimbatore	February - 10 days	4,000
Tiruppur	Coimbatore	May/June - 7 days	10,000

APPENDIX - III

PRICES OF VARIOUS CATEGORIES OF KANGAYAM CATTLE DURING DIFFERENT PERIODS

Period	Category of Kangayam cattle	Price (Rs.)	Reference
1909	Cow	40/-	Gunn, 1909
	A pair of bullocks	40 – 70 /-	
1936	Cow	150 – 250/-	Littlewood, 1936
	A pair of average bullocks	300 – 450/-	
	A pair of good bullocks	400 – 600/-	
1947	A pair of good bullocks	1,000 – 1,500	Subramanyam, 1947
1997	*A pair of bullocks*		Report, 1998
	a) 2 – tooth	7,000 – 10,000/-	
	b) 4 – tooth	8,000 – 15,000/-	
	c) 6 – tooth	10,000 – 18,000/-	
	d) Full mouth	10,000 – 20,000/-	
	Kangayam bull		
	a)Young bull	2,000 – 2,500/-	
	b) Adult	5,000 – 20,000/-	
	Kangayam cow		
	a) In milk	4,000 – 6,000/-	
	b) Dry	2,500 – 4,000/-	
	Kangayam heifer		
	a) 6 – 24 months age	1,500 – 2,500/-	
	b) 24-36 months age	2,500 – 4,000/-	
2003	A pair of good bullocks (Maximum price at Kannapuram Cattle Fair)	24,500/-	N.Kulandasami (Personal communication)
2004	-do-	32,000/-	
2005	-do-	42,000/-	
2006	-do-	75,000/-	
2007	-do-	80.000/-	
2008	-do-	78,500/-	

APPENDIX - IV

GOVERNMENT ORDERS ON KANGAYAM CATTLE

COPY OF:

Government of Tamil Nadu

Abstract

Animal Husbandry Department - Cattle Development Breeding Policy in Tamil Nadu - Recommendations of Committee on Reorganisation of Livestock Farms - Orders issued.

Agriculture (AH.IV Department)

G.O.Ms.No: 713 Dated: 20.3.1982

Read again: -

1. G.O.Ms.No.1182, Agriculture, dated: 02.07.1974.
2. G.O.Ms.No.1500, Agriculture, dated: 11.09.1978.

Read also: -

3. From the Director of Animal Husbandry, Madras letter Roc.No 22150/D2/80, dated: 06.07.1981.

ORDER:

In the G.O. first read above, Government laid down the broad outlines of the Breeding policy for cattle in the State of Tamilnadu. With increasing advances in the technology of genetic upgradation, it was considered necessary to define the policy with regard to breedings, more clearly. Government accordingly in their orders second read above, issued orders prescribing the following breeding policy to be adopted in Tamilnadu.

i) The upgradation of cattle for purposes of milk production will be carried out by cross-breeding with exotic breeds. The breeds to be utilised, will, in respect of hill area of Nilgiris, Kodaikanal and Kanyakumari Districts be the Holstein Friesian. In respect of the rest of the state, upgradation of milch cattle will be carried out by cross-breeding with Jersey breed.

ii) In respect of buffaloes the local buffaloes will be upgraded with Murrah or Surti in addition to selective breeding with Murrah breed will continue.

iii) In respect of work cattle selective breeding of Kangayam cattle will be carried out in all the tracts of the State except that in respect of the appropriate tract in Thiruthuraipoondi in Tanjavur District, selective breeding of Umblacherry animals will be carried out.

2. The Director of Animal Husbandry and the Managing Director, Tamilnadu Dairy Development Corporation have suggested certain modification to the existing cattle breeding policy with particular reference to procedure laid down in item (i) in para 1 above. They are of the opinion that in respect of upgrading of local cattle for the purpose of milk production, crossing of the local cows initially with exotic bulls either Jersey or Holstein Friesian as the case may be will be carried out and further crossing will be done with first generation bulls.

3. The Committee on Reorganisation of Livestock Farms of Animal Husbandry Department constituted by the Government has gone into the breeding policy laid down by the Government and suggested that if there is local demand and preference for other exotic breeds from any Livestock breeder or organisation, the Department need not discourage them but support them. The Department need not produce every breed other than exotic breeds for the present. If there is any private body or breeder who comes forward in favour of other exotic breeds of cattle, the Government have to support their enthusiasm and effort to produce the other exotic breeds which are not mentioned in the breeding policy of the State. So the committee has recommended that the present breeding policy adopted may be continued. The other exotic breeds also may be allowed whenever there is a demand from the public. Based on the above recommendations of the committee, the Director of Animal Husbandry has sent proposals for revision of breeding policy of the State.

4. The Government examined the proposals of the Director of Animal Husbandry with reference to the recommendations of the Committee on Reorganisation of the Livestock Farms, and accept the proposals of the Director of Animal Husbandry.

5. In partial modifications of the orders issued in the G.O.second read above, the Government direct that the following breeding policy for cattle be adopted in Tamilnadu.

i. The selective breeding of Kangayam, Sindhi, Umblacherry and Hallikar will be carried out in their respective tracts of the state viz. Hallikar in Dharmapuri District, Kangayam in Salem, Trichy and Coimbatore Districts, Umblacherry in Thanjavur District, Sindhi in Chingleput, South Arcot and North Arcot Districts.

ii. The cross breeding of the local cattle to upgrade them will be carried out at the stage with the first generation of crossbred bulls in order to maintain the disease resistance capacity in them to tropical diseases. Thus 50% of exotic breed and 50% of the Indian breed will be useful in getting higher milk production and higher disease resistance in upgrading of the local cattle for the purpose of milk production.

iii. In respect of buffaloes the local buffaloes will be upgraded with Murrah or Surti in addition to selective breeding with Murrah breed.

iv. In respect of work cattle, selective breeding of Kangayam cattle will be carried out in all the tracts of the State, except in the approptiate tract of Thiruthuraipoondi in Thanjavur District where selective breeding of Umblacherry animals will be carried out. Similarly in the Hallikar tracts, the Hallikar breed will be utilised for selective breeding.

v. In respect of upgrading of local cattle for the purpose of milk production, crossing of the local cows, initially with exotic bulls either Jersey or Holstein Friesian as the case may be will be carried out and further crossing will be done with first generation bulls.

6. The Committee on Reorganisation of Livestock Farms of Animal Husbandry Department has also suggested that instead of maintaining too many varieties each farm may be recommended to concentrate on a particular variety of breeding suited to the area. The Committee considered that this would be also bring down the expenditure in maintaing many unnecessary breeds which are mostly a liability. The committee therefore suggested the types of breeds to be maintained in each of the Livestock Farms and also recommended that the breeding policy approved by the Government may be implemented. The Committee has also indicated the classes of breed to be maintained in each of the Livestock Farm besides other animals and birds. The Government consider that this recommendation of the committee should be examined in detail with reference to the financial commitment involved. The Director of Animal Husbandry is therefore requested to examine this recommendation of the Committee on Reorganisation of Livestock Farms taking into consideration of the financial status, potentiality and infrastructure of each of the livestock farms and also the financial commitment involved in the implementation of this recommendation and to send necessary proposals to Government in due course.

/ By order of the Governor /

Sd/-Ms. RAMESH

Commissioner and Secretary to Government.

//True copy//

Sd/- xxxxxxxxxxxxxx
28.6.82
Joint Director of Animal Husbandry (Statistics),
Directorate of Animal Husbandry,
Madras - 600 006

COPY OF :

Government of Tamil Nadu

Abstract

Animal Husbandry Department - Centrally sponsored scheme for development of indigenous breeds of Cattle and Buffaloes during 1991-92 to be implemented in District Livestock Farm, Hosur - Sanction - Accorded - Orders issued.

ANIMAL HUSBANDRY AND FISHERIES DEPARTMENT

G.O.Ms.No.116. **Dated: 23.3.1991**

Read : -

1. From the Government of India Ministry of Agriculture, New Delhi Lr.No.73-2/86, dated 6.9.90 and 18.9.90.
2. Govt. letter No.32907/AH-4/90-5, dated 25.1.91.
3. From the Government of India, Ministry of Agriculture, New Delhi Lr.No.3-15 / 91-LT-2, dated 27.2.91.

-oOo-

ORDER:

1. The breeding tract of Kangayam breed of cattle, which is well known for its draught abilities and capacity to sustain under harsh environments in Tamil Nadu. This breed of Kangayam cattle was being bred by farmers in the districts of Coimbatore, Periyar and Salem for the past three or four decades. However, with the introduction of high yielding exotic dairy breeds in the breeding programme of the State, many of the farmers in the Kangayam cattle breeding tract, have resorted to cross breeding the local Kangayam cattle with the result the elite Kangayam breed of Tamil Nadu is facing the threat of extinction. It has therefore become the responsibility of the State Government to take up pure breeding of Kangayam cattle and thus preserve the valuable germplasm for future use.

2. A proposal at a cost of Rs.10.00 lakhs for development of indigenous breeds of cattle and buffalo at District Livestock Farm, Hosur for taking up breeding of Kangayam cattle during the year 1990-91 on 50% - 50% funding basis was drawn in consultation with Director of Animal Husbandry and sent to Government of India for approval.

3. In the letter third read above, the Government of India has conveyed the sanction of Rs.5.00 lakhs being Central share to the Government of Tamil Nadu during the year 1990-91 for implementing the above mentioned scheme at District Livestock Farm, Hosur.

4. The Government accord sanction for implementation of the above mentioned scheme at District Livestock Farm, Hosur for taking up breeding of Kangayam cattle during 1990-91 at a total cost of Rs.10.00 lakhs as detailed in the Annexure to this order. (Rs.5.00 lakhs Central share + Rs.5.00 lakhs Tamil Nadu Government share).

5. The Director of Animal Husbandry, Madras-6 is authorised to draw and utilise the sum and necessary expenditure statement may be sent to the Government and Government of India.

6. The Expenditure should be debited to the following head of account:

"2403-00 Animal Husbandry 102 Cattle and Buffalo Development - VIII[th] Five year plan - State and Centre equally shared - UB Development of Indigenous Breeds of Cattle and Buffaloes - 09 Grants in Aid (DPC 2403-00 102 UB 0903)"

7. This order issues with the concurrence of the Planning and Development/Finance Department vide their U.O.No.123/S/91, dated 19.3.91 and 1486/PS/91, dated 21.3.91.

/By Order of the Governor/

Sd/-R.A.SEETHARAM , IAS.,
SPECIAL COMMISSIONER & SECRETARY TO GOVERNMENT.

To
The Director of Animal Husbandry, Madras.6.
The Deputy Director, DLF, Hosur.
The Secretary to Government of India, Ministry of Agriculture, New Delhi.
The Accountant General, Madras 18/35.
The Treasury Officer, Dharmapuri.
Copy to Planning and Development Department, Madras-9.

APPENDIX - V
POSTAGE STAMP RELEASED FOR KANGAYAM CATTLE

APPENDIX – VI

TESTIMONIES

Extracts from the visitors' book at the Palayakkottai Farm

27*th November*, 1919.

It is extremely agreeable to me to mention here the beautiful impression made on me by this visit to the establishment of the cattle farm of the Pattagar of Palayakottai, noble cavalier of advanced spirit, from which progress of Indian Cattle, especially cattle breeding in the Madras Presidency, should much expect.

Rearing and selecting the bovine race " Kangayam," one of the best known of the continent by beauty of form and qualities which are appreciable in work—this by itself constitutes a title of glory which most distinguished farmers of Nations where pure breed is appreciated would be proud.

If I could draw up in due form, a wish of mine would be that the well-known chief of Palayakottai should go on without disheartening in his role and that his magnificent example may benefit the progress of *agropastoral* of this admirable country.

ANTONINO NEVES
(Translated from French) *of Rio De Zenero, Brazil, South America.*

3*rd October*, 1920.

A few hours can be profitably and fully spent at the " Kangayam Cattle " Farm at Palayakottai. I regret that my visit was of such short duration. However, through the excellent arrangement made by the Pattagar of Palayakottai the time was full of interest. After the recent rains, the ' Kolukkattai ' grass pastures looked fresh and green and the sight of the fine herd of Kangayam cattle grazing in the fields was one to gladden the heart of the serious stockman.

The improvement of the South Indian breed of cattle carried out in the Pattagar's own practical way is an object lesson to all who wish to see the Madras Livestock Industry prosper. What has been done and achieved should not be difficult to imitate. I have no doubt equal results will be gained by those who tackle the problem with the same energy and foresight shown by this owner. Personally I am much indebted to the Pattagar for the delightful hospitality extended during my visit.

R. C. BROADFOOT
Deputy Director of Agriculture

17*th October*, 1935.

Although the very useful work which was being carried out by Mr. Pattagar in the way of cattle breeding was not unknown to me, this is the first time I visited his estate in the course of my duties to advise him on the scheme for starting a dairy farm in conjunction with his present cattle breeding activities. Every moment of my time spent here, since my arrival, has been one of great interest. All that I saw came up to my expectations which I had based on the accounts given to me. The work he does should certainly prove an object lesson to all interested in this important industry and would be a revelation to those who think that sound principles of cattle breeding are not understood and practised in this country. Every animal seen in the herd was a product of sound animal husbandry and the herd as a whole could compare very favourably with the best of herds seen in this country. Mr. Pattagar's skill as an expert stock-breeder is reflected not only in the first class herd he has built up but also in the grass land and pasture areas, the like of which are seldom to be seen in this country. Through his foresight he now realizes that with the advent of mechanical transport and electricity in rural areas, breeding cattle merely for draught requirements cannot be the best proposition and this work must therefore be associated with dairy farming. I fully concur with him in this view and I wish him all success, in the project under consideration and which I consider quite sound. I shall always be happy to be of further help and guidance to him in the matter.

J. A. P. R. KOTHAVALA
Imperial Dairy Expert, Bangalore.

19*th December*, 1942.

It is nearly 22 years since I first visited this estate and I have been visiting it on and off for the last 20 years and I very much regret that this is my last visit as I am due to retire very soon. It is always a pleasure to come here and see the excellent herds of cattle and the way they are maintained. I think the Pattagar has greatly improved his herd of cattle in the time I have known it and I sincerely hope that he will continue in these lines. The experiment which is being conducted under the I.C.A.R. to find out if it is possible to evolve a higher milking cow without impairing the draught qualities of the bullock should be closely watched and it is to be hoped that it will prove a success.

This must be one of the largest farms in India farmed by an individual and the reclamation which the Pattagar has done is a credit to him. He is an excellent farmer and devotes his life to agriculture and it is very much regretted that other large Zamindars do not copy him.

I wish the Pattagar further success and my best wishes.

It looks as if there will be a shortage of fodder in this District this year as the rains failed at the proper time and if this occurs I hope the Pattagar will be given some assistance to purchase fodder in the cheap markets as his excellent herd must be maintained.

Well. Good-bye, Pattagar. I thank you for your kindness. I hope I have been of assistance to you.

R. W. LITTLEWOOD
Livestock Development Officer

5th March, 1944.

It is a real pleasure to record my visit to Palayakottai and also to record my deepest appreciation for the kind hospitality extended by the Pattagar and his family and staff. It is obvious that the Pattagar has an "eye" for cattle, and that he has consistently selected and bred towards a definite ideal. This is the essence of success in any attempt at Livestock Improvement ; and the farm and its owner are to be commended for the success thus attained, and for the coincident service to the cultivators of Southern India by supplying improved working bullocks.

RALPH W. PHILLIPS
Bureau of Animal Industry
U. S. Department of Agriculture
Washington, D.C., U.S.A.

31*st July*, 1949.

The Pattagar is carrying out a very valuable breeding of the Kangayam breed. This work not only helps Animal Husbandry but also crop husbandry, which is the backbone of the country.

I spent only a day on the farm and during the short stay gained valuable practical points in breeding work.

I enjoyed very much the hospitality of the Pattagar and I am very grateful to him.

I wish the Pattagar all success in his undertaking.

I. KANAKARATNAM
Fed. Experiment Station,
Department of Agriculture Surgery, Beri
Malaya.

27*th January*, 1952

I have travelled over 9000 miles in India during a 3 month tour and this is the only farm I have visited where proper records are kept and a well-planned scheme for improvement of a breed is being carried out with energy and vision. Very much of the credit for the planning of the work is due to Mr. Pattabhiraman, whose intimate knowledge of the stock is most striking. I have greatly enjoyed my visit and am delighted to have had the opportunity of seeing this famous farm. Finally, I offer my thanks to the Pattagar, who is the driving force behind the work begun by his father.

J. P. MAULE
Director of Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh

27*th August*, 1953.

This is a wonderful cattle farm indeed. It is the largest I have seen and the most efficiently run. The success achieved in producing a dual purpose breed is remarkable and of great value both to agriculture and animal husbandry. The Pattagar of Palayakottai is a charming person who combines the best traditions of an old aristocracy with modern scientific development. His farm is a monument of enterprise and service.

JAYAPRAKASH NARAYAN

8th October, 1953.

I am very glad indeed to have an opportunity of visiting the Pattagar's Farm once again, after a lapse of about 17 years. It was a pleasure to see that the Pattagar was maintaining the high traditions of his illustrious father. Even though young in years, he has an excellent " eye " for an animal, and has the same keenness and enthusiasm of his father.

I was shown round the whole herd. All animals were in good condition, and what struck one straightaway was the uniformity in type, which speaks volumes for the labour and care taken in laying down breeding plans. If we could have a few more breeders like the Pattagar, the problem of cattle development in the country could be greatly solved.

While at Palayakottai, I took the opportunity of inspecting in detail the working of the I.C.A.R. Scheme, which aims at putting in more milk in the herd without detriment to the draft qualities. Inspite of the fact that the last few years have been " scarcity of fodder " years, the scheme on the whole has shown that the breed has considerable potentialities of a " Dual purpose' breed. The work, however, has to be continued before definite conclusions can be drawn. One step in the right direction is that all experimental animals will now have a balanced ration and will therefore be free from the vagaries of rainfall in the area.

I am very grateful to the Pattagar for having shown me round and for his generous hospitality. I hope he will continue to take special interest in this unique undertaking.

P. N. NANDA
Animal Husbandry Commissioner.
Government of India.

Selectively reproduced from Pattabhiraman (1958)

APPENDIX – VII

WHORL MARKS OF CATTLE

TWISTS OR HAIR MARKS ON CATTLE.

TAMIL—SULI.

When a Hindu purchases cattle, the first thing he observes is (Suli) or twist. Those who have cattle with good marks will prosper whereas those with bad ones will not. Suli is observed chiefly by those who go in for a single animal for his house or those who want work animals for drives.

A twist, common in cattle, is the one situated in line with the umbilicus on the line from the head to the tail on the back of the animal. In some animals the twist is nearer the hump and in some nearer to the hip joint. Generally cattle have the ability to stir their coats behind the hump. If the twist is on this portion it is bad; but if it is a little away to the right or left of the ridge mark it is not considered bad.

If there are bad marks or twists on an animal, nobody will purchase it; therefore to hide these bad marks the sellers usually brand the skin over the marks.

LUCKY MARKS.

(1) *Thamani Suli* (தாமணிச் சுழி).—A ridge of hair along the middle line of the animal's back, about the centre or on either side of the neck—Thamani means a herd—indicates that the purchaser will acquire a large number of cattle.

(2) *Irattai Kavam* (இரட்டைக் கவம்).—Consists of two ridges of hair, one on each side of the brisket. A single hair mark on one side of the brisket (Othai-kavam ஒத்தைக்கவம்) is most unlucky, and forebodes the loss of all other cattle in the house, and also the death of the purchaser.

(3) *Bashikam Suli* (பாஷிகம் சுழி) is a crown on the forehead above the line of the eyes—Bhashikam is a wreath worn by bride and bridegroom during the marriage ceremony—or *Jodi Suli* (ஜோடிச் சுழி) : when the mark situated on the forehead is in a pair side by side. These indicate, if the purchaser be a bachelor or widower, he will soon marry. If the purchaser be a married man, he will either have the misfortune to lose his wife and marry again or the good fortune to obtain two wives.

(4) *Gopura Suli* (கோபுரச் சுழி).—A crown upon, in front of or immediately behind the hump, this is considered to be very lucky.

(5) *Nir Suli* (நீர் சுழி) is a crown situated on the middle line of the back just opposite to the opening of the urethra. Regarding this, the saying is (நீரூறினும் ஆகும், சுரூறினும் ஆகும்)—the family will either be reduced to ashes or swell like a river. This mark is thus of a doubtful significance. A purchaser rather than

risk the evil consequences, will avoid the purchase. The ryots say that if a little earth be taken and rubbed on this hair mark, the bullock will void urine.

(6) *Erupuran (ascending centipede)* (ஏறுபூரான்)—A ridge of hair on the hind quarters curving up to the back is a sign of coming prosperity. If the ridge curves downwards it is called Irangupuran (descending centipede) (இறங்குபூரான்) and indicates adversity to the purchaser.

(7) *Lakshmi Suli* (லக்ஷ்மிச் சுழி) is a hair mark situated on one side of the neck at some distance from the dewlap. Lakshmi is the Goddess of Fortune. This is considered to be the most lucky mark, but is rarely met with. A bullock with such a mark is highly esteemed, and fetches a large price.

(8) *Patti Suli* (பட்டிச் சுழி) is a twist on the hump and this is good. It indicates the animal will have a good number of its company in its shed.

(9) *Veebhuthi Suli* (வீபூதிச் சுழி)—Two twists between the eyes along the eye-line ; these are considered good.

(10) *Erunagam* (ஏறுநாகம்) is a single ascending twist on the outer side of the tail and is a good mark ; Erangunagam is a twist at the same place which is a descending one which is a bad mark.

Unlucky Marks.

(1) *Mukkan Suli or Agni Suli* (முக்கண் அல்லது அக்னிச் சுழி)—Three crowns on the forehead arranged in the form of a triangle is said to represent the three eyes of Siva of which one in the forehead will, if opened, burn up all things within the range of vision : this forebodes ruin to the purchaser.

(2) *Kudaimel-Kudai* (குடை மேல் குடை)—Two crowns one over the other on the forehead predict either prosperity or disaster. In the latter case it is called *Edi-mel Edi* (இடிமேல் இடி).

(3) *Othai Kavum* (ஒத்தைக் கவும்)—A single hair mark on one side of the brisket close to the middle line forebodes loss of all other cattle in the house, and the death of the purchaser.

(4) *Vilangu Suli—fetters* (விலங்குச் சுழி)—Hair marks on the fetlocks of either pair of legs indicate that the purchaser will soon be in jail.

(5) *Padai Suli* (படைச் சுழி)—Two ridges of hair on the back on either side of the middle line on the croup indicate that the purchaser will soon need a coffin.

(6) *Pendilandhan Su'i* (பெண்டிழந்தான் சுழி)—If the two ridges be still lower down above the anus and below the tail they are called Pendilandhan Suli and this denotes the purchaser will become a widower.

(7) *Irangupuran* (இறங்குபூரான்)—Descending centipede—A ridge of hair on the hind quarters curving downwards indicates adversity.

(8) *Nagapadam* (நாகபடம்)—A ridge of hair on the haunch spreading out at one end like the hood of a cobra. If the hood is upwards it is termed *Munnagam* (முந்நாகம்) and if downwards Pinnagam (பிந்நாகம்).

(9) *Thattu Suli* (தட்டுச் சுழி)—Obstacle—A crown situated on the back between the points of the hips indicates that any business undertaken by the purchaser will fail.

(10) *Thudappa Suli* (துடப்பச் சுழி)—A hair mark on the side of the tail near the root sometimes extending as ridge over the back.

(11) *Virikkattu or Puttani Suli* (விரிக்கட்டு அல்லது புட்டாணிச் சுழி) is a twist on the hip joint which is bad for the owner.

(12) *Elukattu padaikattu* (எழுகட்டு படைக்கட்டு)—This is a twist on the lips and is a bad mark.

(13) *Val Mudangi* (வால் முடங்கி) is a single twist at the bottom of the inner side of the tail and is bad for the other animals of the owner.

(14) *Erangunagam* (இறங்குநாகம்)—is a twist on the outer side of the tail and is a descending one which is a bad mark.

Other Superstitions.

(1) If a cow calves on a Sunday it is bad for the owner.

(2) If an animal is sold on a Wednesday it is bad for the other animals in the manger and therefore ryots will not sell animals on Wednesdays.

(3) If a ryot sells an animal, he will not part with the rope with which the animal was tied in his house. If he gives it away his wealth will decrease. Purchasers therefore bring their own ropes with them.

(4) A bullock whose tail has the root of the tuft of hair situated above the hock is said to have "Eruval" (ஏறுவால்) and to bring ill luck. A cow having Eruval is not objected to.

(5) A bullock having white hair, skin, horns and hoof is considered of weak constitution and not to be purchased.

(6) A black bullock is generally considered a jibber. If not a rogue, he is considered of great value according to the saying (கரிகால் மாடு கபடில்லாவிட்டால் ஒன்றரை கால் மாடு) a black bullock is but the fourth of a bull, but if he be guileless he is a bullock and a quarter.

(7) A bullock with numerous small spots over the body like a deer is considered very lucky provided these spots do not increase in number.

(8) Mattaikombu means horns bent backwards; this is a good sign in a cow. The saying is "மாடு வாங்கத் தெரியாதவன் மட்டக் கொம்பு மாடு வாங்கட்டும்"—let any man who does not know how to select a cow purchase one with horns curved backwards.

(9) Nerkombu is straight horns. Mun-kombu is horns pointed forwards and indicates spirit. Suruttaikombu is twisted horns and are considered good workers.

(10) *Kollikombu* (கொள்ளிக்கொம்பு)—Horns which are hollow and present white patches looking as if they were rotten are considered to be very unlucky.

(11) *Poongombu* (பூங்கொம்பு)—Horns with wide tops are also considered bad.

(12) If a cow at the time of purchase voids urine, it is considered a very good one, but if she passes dung it is considered bad. The reverse is the case with a bullock.

(13) A bullock which fails to cut the fourth pair of permanent incisors is called Arukatti-madu (ஆறுகட்டி மாடு) and is considered lucky (ஆறுகட்டி மாடு, ஆ[illegible]கட்டி வாழ்), that is, one who purchases a bullock with only six permanent incisors will become rich enough to keep an elephant.

(14) A bullock which cuts only seven permanent incisors is unlucky to the owner. The saying is that one who purchases such a bullock should have his coffin ready.

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