

## Sheep Genetic Resources of India

# MADRAS RED

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## PREFACE

Presently, mutton has become prime product from indigenous sheep as wool is losing economic importance because of availability of synthetic wool as well as low wool price in world market. Madras Red, a medium sized well-built, hairy type sheep, is one of the important meat breed of Southern India. Mutton from Madras Red is considered at par with chevon due to its top quality meat. The breed is highly suitable for farmers and entrepreneurs, who want to take advantages of growing domestic demand for fine textured, tender sheep meat with a pleasant meaty odour and flavor. Now, it is imperative to document this valuable germplasm for its wider publicity. This bulletin is a compilation of information available on Madras Red sheep and deals with its home tract, breeding practices, husbandry practices, growth performance, feedlot studies, genetic characterization, marketing prospects and development etc. We hope that this research bulletin will be useful to research scholars, extension workers and scientists working in Animal Science area.

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## 1. INTRODUCTION

Sheep rearing is an important component of rural economy, specifically in arid and semi-arid region of India. These region are characterized by sparse vegetation, marginal land holding and frequent droughts. Sheep are reared mainly by the poor people from the weeker section of society and is their main or subsidiary occupation for livelihood. It is the most appropriate livestock species on account of its sustenance on sparse grazing resources, adaptation to high ambient temperature and multi facet utility for meat, manure, wool, skin and milk. Sheep husbandry is a low-investment sustainable enterprise, yet contributing significantly to the income of sheep owners.

In recent past, mutton has gained importance in Indian economy whereas wool is loosing economic importance due to its low cost in international market and availability of synthetic wool after liberalization. The mutton/chevon from India has a preferential demand in domestic market (Kurup and Baliyan, 2012) as well as international market on account of its leanness and organic nature. One of the strategies to meet the surging internal and external demands for small ruminant meat is through their population expansion (Ranjhan, 2010). Presently, India is producing 238.80 million kg mutton annually, which is about 3% of the world's total mutton production. About 33.0% of the total sheep population is slaughtered annually to produce about 4.70% of the total red meat of the country. According to National Institute of Nutrition a balance human diet should contain 30 g/day, whereas availability of meat is 5 g/day per capita reflecting wide gap between availability of meat in the country. Further, it indicates future scope of growth in meat production to meet out the requirement.

Southern region of the country comprises of Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala states and other nearby Union Territories. Sheep rearing is important in all these states except Kerala. Most of the sheep breeds of this region are meat type as their wool is extremely coarse and hairy. Further, wool production is very low and has little market demand in view of prevailing climatic conditions and therefore fetches low market price. The predominant sheep breeds of this region are Deccani, Nellore, Bellary, Hassan, Mandya, Mecheri, Kilakarsal, Vembur, Coimbatore, Nilgiri, Ramnad white, Madras Red, Trichi Black and Kenguri of which Tamilnadu has eight recognized sheep breeds.

Madras Red is a renowned hairy mutton type sheep breed of Tamil Nadu and mainly found in Chennai, Thiruvallur and Kanchipuram districts. It is one of the popular sheep breed found in southern peninsular region of India. The animals of this breed are medium sized and well built and have some specific characteristics such as early maturing, fast growing, good mothering abilities, low fat meat and have comparatively better disease resistance. The sturdy legs make animals a good walker in hard terrains, and in rugged areas. It produces quality meat and is always in demand in the internal market. Madras Red can be proved as an important entrepreneur for farmers and business investors particularly for those who want to take advantages of growing domestic demand for finely textured, tender sheep-meat with a pleasant meaty odour and flavour. The skins are preferred in tanning industry and milk produced is just sufficient to maintain their neonates. It is able to adapt to a wide range of environment and suitable for southern tropical agro-climatic region with a comparative disease resistance.

## **2. NATURAL HABITAT, POPULATION AND DISTRIBUTION**

Madras Red sheep derived its name from native tract 'MADRAS' (presently known as Chennai) and body colour (Red). In the native tract it is also



known as “Kattupakkam Red” and is well recognized as important meat-type sheep breed of Southern India.

Breeding tract of Madras Red lies in the North-eastern agro-climatic zone of Tamil Nadu which includes Chennai, Thiruvallur, Kancheepuram, Vellore, Cuddalore, parts of Thiruvannamali and Villupuram districts (Figure 1). The tract lies between 8°5' and 13°2' of North latitude and 76.15° and 80.22° East longitude. The geographical area of the region is 31065 sq. km constituting around one fourth of the total area of Tamil Nadu state. Small number of Madras red sheep are also available in Puducherry. The topography is mainly plain-lands and has low scattered hills. The soil types are, in general, red non-calcareous, black, alluvial and ferruginous red loam. Black soil contains high amounts of iron, calcium and magnesium, is highly argillaceous comprising 30-50% clay and produces deep cracks in summer. The pastures consist of wild type grasses in abundance.

The climate is semi-arid tropical type with April-June as hot months and December-January as cold. The average temperature ranges from 20.4 to 37.6 °C with maximum and minimum temperature ranging from 28.2 to 38.9 °C and 19.5 to 24.8 °C, respectively.

The average relative humidity ranges from 58 to 84% and highest during the months of October-January (Annual report, 1994-95). The annual rainfall of the tract ranges from 800-1400 mm; total precipitation and distribution varies in different seasons and places within the tract.

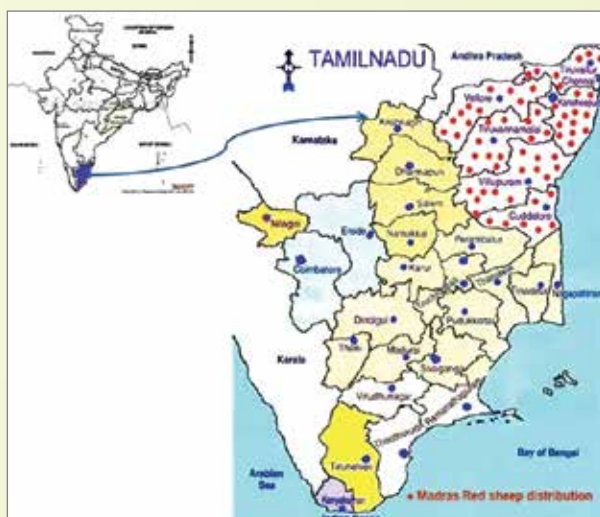


Figure 1. Distribution of Madras Red sheep

Present sheep population of Tamil Nadu is 7.99 million (Livestock Census, 2007) with a density 43 per km<sup>2</sup>. The state has registered an increase of 29.90% in sheep population during 2003-2007 (Livestock Census, 2003 & 2007). As per Livestock Census, present population of Madras Red sheep is 1.15 million (Livestock Census, 2007).



*Figure 2. Natural habitat*

### 3. HUSBANDRY PRACTICES

#### Socio economic condition of the sheep farmers

Most of the sheep farmers in the region were socially and economically disadvantaged and were landless. The Naiker, Pillai, Naidu, Yadva and SCs communities are rearing the sheep mainly. Average family size was 5.2 with almost equal number of males and females. Literacy rate was 35 and 37% in males and females, respectively. The age of the male and female shepherds ranged between 18-50 and 36-50 years respectively.



*Figure 3. Sheep farmer with flock*

Around 21% flocks are grazed by females (Anonymous 2007). In addition to the sheep the farmers also maintained other livestock species mainly cattle, buffaloes, goats, fowl and dogs. Eighty seven percent of the sheep farmers are also maintaining goat.

## Breeding and reproduction

Animals in most of the flocks in their native tract were purebred type. Rams were selected based on physical conformation, body size including height and weight, and libido. Age at first breeding was about 12 months in rams.



*Figure 4. Breeding ram*

Breeding males were

maintained for about four years in flock. Major breeding season is from July to September after the onset of Southwest monsoon and most of the animals were covered during this season. Lambing season starts from January and continue till March. This breeding season is more favourable



*Figure 5. Breeding ewe*

due to availability of greens and conducive climatic conditions. February-April is the minor breeding season, however less favourable due to limited availability of grass and good pastures in this season (Annual Report, 1994-95). Madras Red sheep are regular

lamb without any problem of repeat breeding except few instances. Lambing interval was about 12 months. The ewes were early maturing and fast growing with good mothering ability (Anonymous, 1999). Age at first lambing ranged from between 18 to 24 months. Twinning is rare. Abortion and still births were also rare in these animals. Old ewes are disposed off between 6-8 years of age (Anonymous, 2007).

Average age at first lambing was  $788.37 \pm 41.43$  days (Reddy and Krishnan, 1985). Under field conditions, the lambing ranged from 80 to 90%. Ewe's body weight at breeding ranged from 26.74 to 28.78 kg (Arora *et al.*, 2007, Sivakumar *et al.*, 2009, Balasubramanyam *et al.*, 2010). Studies under Network Project on sheep Improvement indicated that lambing percentage on the basis of ewes available was 90.34% (Report, 2001). Breeding rams and ewes are kept together in the flocks and natural service is practiced for mating of ewes.

### Feeding practices

Animals are maintained under extensive grazing system with about 8-10 grazing hours. The animals are watered twice a day. Seasonal tree lopping is a common practice. Major fodder trees and grasses for sheep feeding in area are- Kattuvagai



Figure 6. Sheep flock under grazing

(*Albizia Lebbek*), Banyan (*Ficus bengalensis*), Arasan (*Ficus religiosa*), Subabul (*Leucaena leucocephala*), Gliricidia (*Gliricidia maculata*), Poovarasu (*Thespesia populnea*), Kalyana murungai (*Erythrina indica*), Kodukapuli (*Inga*

*dulce*), *Cyperus* (*Cyperus L.*), *Eichnocloa* (*Eichnocloa L*) and Para grass. Dried groundnut haulms are also fed to the sheep in some of the area. Ganesakale and Rathnasabapathy (1974) reported 64.02% (from 9.45 kg to 15.50 kg) increase in 6 month body weight, when lambs were supplemented with concentrate as compared to feeding on grazing alone. The lambing percentage was significantly higher in concentrate supplemented ewes than those reared on grazing alone.

### Housing management

Most of the sheep farmers square their flocks in the agriculture fields for manuring purposes. Some of the farmers house their sheep at night only. The boundary/ partitions are made from dried thorny bushes. “All-open” housing is seen in Kancheepuram and Thiruvallur districts, while “half-open” housing made of palm tree leaves were also seen in few villages of adjacent areas (Balasubramanyam *et al.* 2012b).



*Figure 7. Housing management of Madras Red in native tract*

### Flock composition

Farmers maintain sufficient number of animals in flock. The flocks are of medium size and the number of animals varied from 20 to 50 in different villages. Average flock size was 46 comprising 28 ewes, 2 rams, 2 other adult males and 14 lambs. The flocks are stationary and do not migrate during any part of the year (Anonymous, 2007). Raman *et al.*, (2003)

reported average flock size of 85 sheep. The flock consists of mainly breedable females with 44 % breeding ewes and 29 % breedable replacement females. The breeding males are seen in limited numbers. Even for 100 breedable ewes only one ram is used (Balasubramanyan *et al.* 2012a). In some of the villages



*Figure 8. Sheep flock*

different flock owners share the same ram for breeding. The male lambs are disposed at about six month of age. All the young female lambs born are retained in flock. Acharya (1982) reported the average flock size of 83 animals ranging from 10 to 208, consisting 2 rams, 55 adult females and 26 young, on average.

### Disease prevalence

Madras Red being the native breed is well adapted to prevailing climatic conditions and as such there is no problem of its survival. Most prevalent diseases were Foot and Mouth Disease (FMD), foot rot and sheep pox. Most of the farmers vaccinated their sheep against FMD and sheep pox. Vaccination against viral diseases like Foot and Mouth Disease, Sheep Pox and against bacterial disease like anthrax, enterotoxaemia has been a routine practice in some of the institutional farms. Enteritis, pneumonia and hepatitis were reported to be major diseases responsible for mortality in Madras Red flocks (Kulkarni *et al.* (1997). The incidences of respiratory, skin/subcutaneous system diseases were relatively less in young and adult (Annual Report, 2000-2001).

Mortality ranged between 4-10 % (average: 6.0%) in adults, 7-13% (average: 10.1%) in young group and 8-18% (average: 11.9%) in lambs.

Acharya (1982) has reported 10.38, 2.69 and 0.62% mortality in age group of 0 to 4 months, 4 to 12 months and adults, respectively. Ganesakale and Raman (1994) reported 1.92% stillbirths and abortions. The disease incidence of alimentary system was higher when compared to general systemic disease, skin/subcutaneous and respiratory system infection (Arora *et al.* 2007). Roy *et al.* (2008) reported mortality of 24.28% in Madras Red as compared to 50% in Mecheri sheep during sheep pox outbreak at three sheep farms in Tamil Nadu.

Sheep were dewormed quarterly with fenbendazole and albendazole or morantel citrate and also with oxclozanide / triclabendazole or pyrantel pamoate annually against fluke and other worm infestation. Drenching and dipping as preventive measures and clinical treatment is also provided (Arora *et al.* 2007). It is recommended to treat the sheep showing diarrhea or nasal discharge on the same day and conduct periodical faecal examination and de-worming to avoid the increased worm infestation, otherwise which further leads to gastro intestinal complication (Kulkarni *et al.*,1997).

#### 4. BREED CHARACTERISTICS

The animals are medium sized, well built, hardy and strong with well proportioned frame. Chest is broad and deep with straight topline. Skin is fine and soft with light to dark red/brown/tan coat colour. Total 69.2% animals were red, 18.6% were medium tan and 12.2% were dark tan coloured. Some animals have white markings at the forehead, inner aspects of thigh and ventral abdomen (Annual report 1994-95). The body coat comprises thick hair with smaller length and doesn't require shearing (Anonymous 2007). Horns in rams are corrugated and twisted. Ewes are polled. Balasubramanyam *et al.*, (2012a) found 62% of the males and 4% of the female to be horned. Horn length ranged from 15 to 20 cm.

The ears are pendulous and 12-13 cm in length. The pendulous lobules (tassels/ wattles) hanging from the throat region are seen in both males and females. Some animals also have couple of lobules. The wattles are present in 73.2% in



**Figure 10. Adult male**



**Figure 9. Adult female**

females and 68.6% in males. Tail is short and thin. Udder is medium sized with well defined teats. Legs are light and long with clean bony limbs. The gait is quick; sheep are alert and active. Average adult body weight is  $31.8 \pm 1.05$  kg for rams and  $24.5 \pm 0.35$  kg for ewes (Anonymous 2007). The body measurements of Madras Red at different ages are given in Table 1 and 2.

**Table 1: Body measurements (cm) of Madras Red at different ages (based on dentition)**

Age	Sex	Height	Chest girth	Paunch girth	Length (Elbow -pin)
MT	M (778)	55.7	57.9	61.6	44.6
	F (1135)	57.6	59.4	64.3	45.7
2T	M (51)	71.2	77.3	87.0	56.2
	F (357)	67.0	72.6	79.4	53.1
4T	M (953)	72.2	79.6	81.7	55.9
	F (568)	67.8	74.5	78.8	53.4
6T	M (11)	71.3	80.2	86.3	56.5
	F (1243)	66.3	73.1	77.2	52.7
8T	M (3)	72.6	81.5	88.3	55.3
	F (969)	69.3	73.6	77.9	51.3

MT, 2T, 4T, 6T and 8T indicates age in terms of milk teeth, 2-teeth etc.; Figures in parentheses are number of observations.

**Source:** Status Paper (1995).



**Table 2: Body measurements (cm) of Madras Red at different age**

Traits	0-3 months		>6-12 months		Above 12 months	
	Male	Female	Male	Female	Male	Female
Length (Elbow-pin)	42.22±0.31	41.14±0.25	46.31±0.23	49.74±0.10	59.91±0.54	54.87±0.05
Height at withers	51.04±0.28	50.25±0.25	57.24±0.21	61.18±0.11	63.13±0.57	66.82±0.05
Chest girth	51.19±0.30	50.64±0.27	59.35±0.26	64.32±0.13	71.60±0.60	72.36±0.05
Paunch girth	54.06±0.37	53.49±0.32	63.11±0.31	68.49±0.15	78.11±0.60	77.82±0.06
Horn length	1.94±0.14	2.71±0.48	9.47 ± 0.84	5.65±0.39	30.00±1.50	7.39±0.69
Ear length	12.32±0.08	12.40±0.08	12.48±0.04	13.18±0.03	12.29±0.14	13.54±0.02
Tail length	7.79 ±0.08	7.76±0.08	7.99±0.04	8.69±0.03	7.48±0.14	9.32±0.03

Source: Balasubramanyam *et al.* (2012a)

## 5. GROWTH PERFORMANCE

Optimum live weight of animal at market age is an economically important characteristic for quality mutton production. The major income of sheep owners comes from sale of surplus animals. Therefore, growth potential of lambs plays major role in achieving the target weight. The average adult body weight as reported by Acharya (1982) is 35.5 kg in males and 23.2 kg in females. Bhat and Arora (2000) and Raman *et al* (2003) also reported 35 and 23 kg adult body weights for males and females of Madras Red sheep, respectively. However, Ganesakale and Ratnasabapathy (1973) reported it to be 42.63 kg in males and 24.08 kg in females. Average body weight at birth, 3, 6, 9 and 12 months of age reported in the field (farmers flocks) as well as in farm conditions are presented in Table 3 and 4, respectively. In farmers flocks birth weight ranged from 2.16 to 2.89 kg, weaning weight from 8.44 to 11.50 kg, 6 month body weight from 13.02 to 15.82 kg, 9 months from 16.22 to 19.39 kg and 12 month body weight ranged from 18.42 to 22.82 kg. In organized farms, the average body weights at different ages are in accordance with that reported for field flocks (Annual Report 2000-01, Sivakumar and Thiagarajan, 1999).

**Table 3: Body weight (kg) of Madras Red under field conditions**

S.N.	Items	At Birth	3 M	6 M	9 M	12 M	References
1	Range	2.16 to 2.82	8.44 to 9.50	13.02 to 14.66	16.22 to 18.48	19.04 to 21.65	Annual Report (2000-01)
2	Over all	2.60 ± 0.02	11.50 ± 0.12	15.82 ± 0.18	18.92 ± 0.34	22.95 ± 0.60	Raman <i>et al.</i> , (2003)
3	Range	2.27 ± 0.03 to 2.86 ± 0.012	9.12 ± 0.06 to 10.27 ± 0.14	13.96 ± 0.07 to 15.22 ± 0.14	17.03 ± 0.08 to 19.28 ± 0.21	19.43 ± 0.30 to 22.29 ± 0.24	Arora <i>et al.</i> , (2007)
4	Over all	2.74 ± 0.02	9.38 ± 0.01	14.79 ± 0.02	18.61 ± 0.02	20.75 ± 0.02	Devendran <i>et al.</i> , (2009)
5	Overall	2.68 ± 0.006 (2566)	9.64 ± 0.03 (2440)	15.02 ± 0.10 (1428)	17.80 ± 0.12 (972)	19.88 ± 1.14 (578)	Sivakumar <i>et al.</i> , (2009)
	Male	2.69 ± 0.009 (1261)	9.67 ± 0.041 (1230)	15.10 ± 0.08 (342)	17.98 ± 0.98 (342)	20.52 ± 1.16 (102)	
	Female	2.67 ± 0.009 (1305)	9.62 ± 0.042 (1210)	14.96 ± 0.09 (630)	17.69 ± 0.62 (630)	18.42 ± 1.04 (476)	
6	Overall	2.67 ± 0.006 (2937)	9.69 ± 0.028 (2889)	14.34 ± 0.035 (1557)	17.55 ± 0.055 (1000)	21.20 ± 0.080 (880)	Balasubramanyam <i>et al.</i> , (2010)
	Male	2.71 ± 0.009 (1470)	10.06 ± 0.041 (1452)	14.71 ± 0.054 (628)	17.13 ± 0.056 (652)	21.83 ± 0.160 (48)	
	Female	2.63 ± 0.009 (1467)	9.32 ± 0.040 (1437)	13.96 ± 0.04 (929)	17.96 ± 0.080 (348)	20.58 ± 0.058 (832)	
7	Over all	2.85	11.37	15.46	19.28	22.22	Anonymous (2011)
8	Overall	2.82 ± 0.004 (2446)	10.96 ± 0.023 (2420)	15.24 ± 0.022 (2403)	19.36 ± 0.070 (1307)	22.57 ± 0.131 (1279)	Balasubramanyum and Kumarasamy (2011)
	Male	2.89 ± 0.005 (1140)	11.02 ± 0.029 (1125)	15.30 ± 0.028 (1120)	19.39 ± 0.137 (25)	22.82 ± 0.26 (7)	
	Female	2.76 ± 0.005 (1306)	10.90 ± 0.028 (1295)	15.18 ± 0.028 (1283)	19.32 ± 0.026 (1282)	22.15 ± 0.027 (1272)	
9	Overall	2.76 ± 0.01 (5491)	9.90 ± 0.06	14.53 ± 0.05	18.16 ± 0.05	21.05 ± 0.09	Balasubramanyum <i>et al.</i> , (2012b)
	Male	2.81 ± 0.01 (1843)	9.97 ± 0.06	14.63 ± 0.05	18.30 ± 0.06	21.19 ± 0.10	
	Female	2.71 ± 0.01 (3648)	9.82 ± 0.06	14.43 ± 0.05	18.02 ± 0.05	20.90 ± 0.09	

M= Month

**Table 4: Body weight (kg) of Madras Red under farm conditions**

S.N.	Items	At Birth	3 M	6 M	12 M	References
1	Overall	2.01±0.02 (624)	9.78±0.15 (624)	12.44±0.16 (543)	18.03±0.24 (399)	Sivakumar and Thiagarajan (1999)
	Male	2.16±0.06 (291)	11.72±0.24 (291)	12.24±0.26 (233)	21.49±0.38 (174)	
	Female	1.89±0.03 (333)	8.10±0.03 (333)	11.09±0.11 (310)	15.35±0.17 (225)	
2	Overall	2.85±0.13 (1757)	9.55±0.23 (1754)	14.64±0.12 (1733)	20.60±0.12 (1676)	Annual Report (2000-01)
	Male	2.98±0.13 (797)	9.75±0.23 (797)	14.74±0.12 (788)	20.67±0.12 (736)	
	Female	2.73±0.93 (960)	9.36±0.23 (954)	14.54±0.12 (945)	20.53±0.12 (940)	

M= Month

## 6. FEEDLOT PERFORMANCE

Lambs' weight during postnatal period varied with age, nutritional level and management. In India, sheep are being reared under extensive grazing and zero input production system. Experiments under organized farm on Madras Red sheep were conducted to assess the growth performance under intensive feeding regimen (Khan *et al.*, 2002). Results showed that average weight of Madras Red ram lambs increased from initial weight of 9.3 to 17.7 kg (final weight), with feed conversion efficiency of 12.3% indicating the potentiality for mutton production. Feedlot performance of Madras Red lambs are depicted in Table 5.

**Table 5: Feedlot performance of Madras Red sheep**

S.N.	Parameter	Mean values
1.	Initial weight (kg)	9.3
2.	Final weight (kg)	17.7
3.	Average daily gain (gm)	87
4.	Feed efficiency (%)	12.3
5.	Hot carcass weight (kg)	8.2
6.	Dressing (%)	51.4

Source: Khan *et al.*, (2002)

Naidu and Pattabiraman (1998a) studied the effect of grazing and feedlot systems on body weight in Madras Red ram lambs. Concentrate @ 100 gm/lamb per day up to 5 months of age was offered and thereafter, the lambs were fed @ 200 gm/lamb per day up to 8 months of age as a supplementary ration. The ram lambs were weaned at 90 days of age and kept in separate wooden pen. They were fed *adlib* pellet feed comprising of 50 percent concentrate and 50 percent lucerne. The concentrate contained 50 parts maize, 20 parts GNC, 20 parts wheat bran and 2 parts mineral mixture including salt. The mean body weight of Madras Red ram lambs was increased from  $6.91 \pm 0.32$  kg at 3 months to  $17.83 \pm 0.50$  kg at eight months of age. The mid period (from 4 to 6 months) was noticed as the period of rapid growth of the lambs. The overall body weight of the lambs reared under feedlot system ( $13.40 \pm 0.16$  kg) was significantly higher than the lambs reared under grazing system ( $10.81 \pm 0.14$  kg).

Naidu and Pattabiraman (1998b) reported that the age at puberty was reduced by one month in Madras Red ram lambs reared under feedlot system (7 months) in comparison to those reared under grazing system (8 months). Further the body weight of ram lambs at puberty was more in feedlot system (19.94 kg) than those reared under grazing system (14.88 kg).

## 7. CARCASS CHARACTERISTICS

Madras Red is famous for production of quality meat in southern India and is well recognized for its mutton characteristics in home tract. The carcass traits of Madras Red sheep is given in Table 6. The dressing percent varied from 48.18 to 50.21% at different ages. However, Ganesakale and Rathnasabapathy (1974) reported the percentage of dressed carcass weight to live weight in grazing group and concentrate group to be

41.46 and 41.61%, respectively. The bone and meat ratio for above group was 1:2.49 and 1:3.41, respectively. The profit under two levels of feeding (grazing alone and grazing along with concentrate feeding) has been 1:2.16 for Madras Red sheep. Raman *et al.*, (2003) reported 49% dressing in Madras Red sheep.

**Table 6: Mean value of slaughter characters**

Age gp	Sex	Mean (kg)				Percentage	
		Live weight	Carcass weight	Skin weight	Blood weight	Dressing	Skin
Milk Teeth	Male (183)	17.00 ± 0.20	8.23 ± 0.11	1.81 ± 0.02	0.52 ± 0.03	48.25 ± 0.13	10.08 ± 0.13
	Female (33)	16.50 ± 0.56	8.11 ± 0.32	1.83 ± 0.05	0.45 ± 0.02	48.92 ± 0.55	11.30 ± 0.30
2 Teeth	Male (40)	20.94 ± 0.48	11.06 ± 0.25	2.24 ± 0.05	0.59 ± 0.01	48.18 ± 0.22	9.90 ± 0.25
	Female (38)	20.81 ± 0.37	10.04 ± 0.21	2.06 ± 0.06	0.53 ± 0.02	48.19 ± 0.37	9.91 ± 0.23
4 Teeth	Male (7)	27.91 ± 1.32	13.51 ± 0.60	2.60 ± 0.14	0.57 ± 0.03	48.47 ± 0.34	9.32 ± 0.29
	Female (61)	24.39 ± 0.45	12.07 ± 0.23	2.22 ± 0.04	0.57 ± 0.01	49.45 ± 0.22	9.23 ± 0.21
6 teeth	Female (23)	26.48 ± 0.89	13.04 ± 0.42	2.45 ± 0.08	0.61 ± 0.01	42.34 ± 0.36	9.48 ± 0.31
8 Teeth	Female (11)	28.89 ± 1.16	14.49 ± 0.55	2.58 ± 0.09	0.62 ± 0.02	50.21 ± 0.43	9.01 ± 0.33

Figures in parentheses are number of observations.

**Source:** Status Paper (1995).

## 8. SKIN CHARACTERISTICS

The skin of Madras Red are preferred among tannery due to better grains in fine sheep leather and have ample scope to be exploited in leather industry. Murlidharan (2002) categorized the skin thickness of Madras Red adult sheep in accordance to body weight of the animals as light

(up to 24.5 kg), medium (24.6 to 27.5 kg) and heavy (above 27.6 kg) types with corresponding thicknesses of  $2.36 \pm 0.06$ ,  $2.59 \pm 0.09$  and  $3.10 \pm 0.10$  mm, respectively. The significant ( $P < 0.01$ ) positive correlation was found between skin thickness and body weights in Madras Red sheep.

Similarly, Madras Red lambs were also categorized as light (0-11.5 kg), medium (11.6 to 12.5 kg) and heavy (12.6 kg and above). For these three categories the corresponding skin thickness was  $1.79 \pm 0.09$ ,  $1.83 \pm 0.28$  and  $1.86 \pm 0.08$  mm, respectively. The correlation coefficient of skin thickness with body weight was also found significant ( $P < 0.01$ ; Murlidharan, 2002). Skin thickness and weight increased with age. Ahmad *et al.*, (2011) reported that the skin was the thickest on the neck dorsal region and thinnest on the thorax ventral region, in all the age groups studied. The epidermis on the dorsal regions was found to be slightly thicker than the lateral and ventral regions of neck, thorax and loin.

## 9. GENETIC PARAMETERS

Knowledge of precise estimates of heritability and genetic correlations among economic traits is highly important, which helps in predicting the genetic improvement in selection experiments. The genetic parameters play an important role in deciding the appropriate selection strategies and breeding plans. These parameters should periodically be assessed for a particular flock. The estimates of heritability genetic and phenotypic correlations among economic traits in Madras Red as reported by Balasubramnyam *et al.*, (2012b) are given in Table 7. Moderate to high estimates of heritability for body weights at 3, 6, 9 and 12 months of age indicated the scope for improvement of these traits through selection. Devendran *et al.*, (2010) reported heritability estimate for growth efficiency as low (0.08) during 0–3 months and moderate to high

(0.14–0.31) from 3–6, 6–9 and 9–12 months of age, which suggested that selective breeding could improve the growth efficiency.

Balasubramnyam *et al.*, (2012b) reported positive and significant phenotypic trend in body weight at all stages. The genetic trend was negative in body weight at birth and 6 months of age. This suggested that selection criterion adopted was not effective for genetic gain in these traits.

**Table 7. Estimates of heritability (diagonal), phenotypic (below diagonal) and genetic (above diagonal) correlations among growth traits**

Traits	Birth wt	3 M Bwt	6 M Bwt	9 M Bwt	12 M Bwt
Birth wt	0.087 ±0.02	0.624±0.10	0.236±0.125	0.338±0.14	0.286±0.14
3 M wt	0.355±0.03	0.405±0.06	0.592±0.08	0.411±0.10	0.637±0.07
6 M wt	0.311±0.03	0.422±0.01	0.258±0.04	0.540±0.09	0.675±0.07
9 M wt	0.296±0.04	0.376±0.02	0.694±10.02	0.300±0.05	0.666±0.07
12 M wt	0.193±0.05	0.508±0.02	0.4587±0.02	0.700±0.01	0.665±0.09

M= month; Bwt= Body weight

## 10. GENETIC CHARACTERIZATION

Genetic characterization of Madras Red sheep was done by various workers. Prema and co-workers (2008) characterized Madras Red by using 17 ovine-specific microsatellite markers. The polymorphism information content (PIC) and expected heterozygosity were 0.6667 and 0.7168, respectively and overall  $F_{IS}$  value was 0.0213. Study revealed the deficit of heterozygosity in Madras Red population.

Selvam *et al.*, (2009) used 10 ovine-specific micro satellite markers for genetic characterization of Madras Red sheep. Average polymorphism information content value was 0.809. The observed and expected heterozygosities were 0.972 and 0.785, respectively. High heterozygosity value indicated the higher amount of genetic variability of the population.

Rao (2012) studied the genetic diversity in Madras Red sheep (50 animals) by using 26 fluorescent tagged ovine-specific micro satellite markers recommended by FAO. A total of 176 alleles were observed in the sampled population for all 26 marker loci. The number of alleles at each locus varied from a minimum of two to a maximum of twelve with a mean of 6.7692 alleles across all loci (Table 8). The most frequent number of alleles was seven. Of the 26 microsatellite loci studied, the effective number of alleles ranged from 1.0631 (CSSM47) to 5.7735 (OMHC1), the mean number of effective alleles was 3.3322 across all loci. The mean PIC value for all the 26 loci was found to be 0.6075. Half of the loci under investigation (13 out of 26) showed significant Chi-square values, suggesting departure from Hardy-Weinberg Equilibrium proportions. The mean observed heterozygosity ( $H_o$ ) value was 0.5581, which indicated the heterogeneous nature of the population distributed in the breeding tract. The expected ( $H_e$ ) values ranged from 0.0594 (CSSM47) to 0.8268 (BM1314) with a mean value of 0.6403. The  $F_{IS}$  values were negative for thirteen loci indicating an absence of inbreeding in those loci, while the remaining loci revealed  $F_{IS}$  values ranging from 0.0857 (INRA63) to 0.9512 (OarCP34). The mean  $F_{IS}$  value observed was 0.1493. Mode shift analysis excluded Madras Red population from a genetic bottleneck in recent past.



**Table 8. Genetic variability indices across 26 microsatellite markers in Madras Red sheep**

Locus	Number of alleles		Heterozygosity		Inbreeding estimate ( $F_{is}$ )
	Observed ( $N_a$ )	Effective ( $N_e$ )	Observed ( $H_o$ )	Expected ( $H_e$ )	
BM757	6	2.3424	0.4286	0.5731	0.2522
BM8125	5	1.9818	0.5600	0.4954	-0.1304
BM1314	7	5.5494	0.4200	0.8198	0.4877
BM6526	8	3.5039	0.6200	0.7146	0.1324
OarFCB128	9	3.1211	0.7200	0.6796	-0.0594
TGLA377	6	2.1043	0.2424	0.5248	0.5381
OarCP34	5	2.7788	0.0312	0.6401	0.9512
CSSM47	2	1.0631	0.0612	0.0594	-0.0316
OarFCB48	9	5.6883	0.9000	0.8242	-0.0920
OarHH41	6	1.7618	0.2400	0.4324	0.4450
BM827	4	3.2337	0.8367	0.6908	-0.2113
OarVH72	7	2.8402	0.7209	0.6479	-0.1127
BM6506	6	1.5874	0.1739	0.3700	0.5300
OarHH47	8	3.2936	0.3673	0.6964	0.4725
OarHH64	4	2.3364	0.0400	0.5720	0.9301
OMHC1	7	5.7735	0.9990	0.8268	-0.2095
JMP8	4	2.042	0.2558	0.5103	0.4987
JMP29	7	5.01	0.9200	0.8004	-0.1494
OarCP20	6	2.2013	0.6809	0.5457	-0.2476
INRA63	9	3.500	0.6531	0.7143	0.0857
OarCP49	12	3.655	0.8400	0.7264	-0.1564
CSSM31	7	4.5036	0.8936	0.7780	-0.1487
HSC	8	5.3079	0.6800	0.8116	0.1621
MAF214	10	3.0358	0.7600	0.6706	-0.1333
OarHH35	7	4.2036	0.8529	0.7621	-0.1192
CSRD247	7	4.2197	0.6122	0.7630	0.1976
Mean	6.7692±0.4162	3.3322±0.2655	0.5581±0.0587	0.6403±0.034	0.1493±0.0692

(Source : Rao, 2012)

## 11. BIOCHEMICAL TRAITS

### Haemoglobin

Haemoglobin A and B are genetically determined by two co-dominant alleles each responsible for formation of one kind of haemoglobin. Rathnasabapathy *et al.* (1972) reported frequency of Hb<sup>B</sup> as 0.995 (Table 9) in Madras Red sheep and is perhaps, the highest frequency reported so far among Indian breeds. It is likely that the breed may have originated from a small nucleus, which had a preponderance of the Hb<sup>B</sup> phenotype, or the number in the flock had been small and “Genetic drift” could have brought to the rarity of the allele. Selection for mutton could have resulted in increasing the frequency of the ‘B’ allele.

**Table 9: Distribution of haemoglobin phenotypes in Madras Red**

Number	Haemoglobin Phenotypes			Gene frequency		
	HbAA	HbAB	HbBB	Hb <sup>A</sup>	Hb <sup>B</sup>	
102	Number	0	1	101	0.005	0.995
	Percentage	0	0.98	99.02		

Source: Rathnasabapathy *et al.*, (1972).

### Blood potassium

Blood potassium concentration in Madras Red was studied by Reddy and Krishnan (1985a). The percentage of low (LK) and high (HK) potassium concentration was 59.78 and 40.22, respectively. So, in general the HK types were lesser than LK, and the inheritance data confirmed that the potassium types are controlled by a pair of alleles at single locus with K<sup>L</sup> allele being dominant over K<sup>H</sup> allele. Association of potassium types with reproduction traits (Reddy and Krishnan 1985b) and with body weights (Reddy and Krishnan, 1988) revealed that potassium types did not show any influence over these traits and no specific trends in correlation between potassium concentration and within *K* types and reproduction traits/body weights, were present.

## Serum esterase

Based on the staining intensity, the variants were classified into EsA<sup>+</sup>, EsA<sup>-</sup> and a phenotype having intermediate activity. Inheritance pattern of EsA is controlled by a pair of autosomal co-dominant alleles. The genotypes were assumed to be EsA<sup>+</sup>/EsA<sup>+</sup>, EsA<sup>-</sup>/EsA<sup>-</sup> and EsA<sup>+</sup>/EsA<sup>-</sup>, respectively. Sivaselvam and Krishnan (1985b) observed the gene frequencies of EsA<sup>+</sup> and EsA<sup>-</sup> as 0.4281 and 0.5719. The association between the EsA types and production traits viz. body weights at birth, weaning, 6 and 12-month were studied by Sivaselvan and Krishnan (1985a). The EsA<sup>+</sup>/EsA<sup>+</sup> genotypes were found to be better associated with higher production, in terms of weight gained than EsA<sup>-</sup>/EsA<sup>-</sup> and heterozygotes. Hence, selection for EsA<sup>+</sup> genotype might helpful in improving growth rate in Madras Red sheep.

## Total protein

Prabhakaran *et al.* (1994) reported that lambs at birth possess lower total serum protein compared to lambs those have ingested colostrum, and the total protein concentration increased steadily from 3 months to 2 yrs to reach a maximum level of 6.03±0.48 g/dl. After two years of age the protein level showed a decreasing trend (Table 10).

**Table 10: Total protein, albumin and globulin (g/dl) in Madras Red**

Group No.	Age	No. of Animals	Total Proteins	Albumin	Globulin
1.	At birth	6	3.13±0.23	2.19±0.20	0.97±0.06
2.	24 hours	8	6.77±0.27	2.54±0.17	4.30±0.32
3.	48 hours	8	6.41±0.27	2.30±0.07	3.11±0.21
4.	0-3 months	12	5.66±0.24	2.96±0.15	2.70±0.23
5.	3-6 months	18	5.04±0.23	2.95±0.15	2.00±0.14
6.	6-9 months	18	5.49±0.16	3.07±0.09	2.48±0.16
7.	9-12 months	18	5.93±0.59	2.65±0.19	3.29±0.40
8.	1-2 years	24	6.03±0.48	2.41±0.17	4.62±0.40
9.	2-3 years	12	5.38±0.63	2.19±0.22	3.20±0.42
10.	3 years	11	5.05±0.23	2.26±0.06	2.73±0.20

Source: Prabhakaran *et al.*, (1994)

## 12. MARKETING

Effective marketing of live animals and their produce is important determinant for economic gains. There is a huge demand of Madras Red germplasm in its native tract. Mutton of Madras Red is preferred in the local meat industry due to quality meat which is considered at par with chevon. Madras Red meat is characteristically fine textured and tender with a pleasant odour and flavour. The milk produced by ewes is just sufficient to maintain their lambs. The dung has a good value for agricultural purpose (Balasubramanyam *et al.*, 2012a). Skins are preferred in tannery due to better grains.

Sivakumar and Thiagarajan (1999) compared the meat producing efficiency and economics among sheep (Madras Red), goat (Tellichery), pigs (Large White Yorkshire), calves (Jersey Crossbred) and rabbits (New Zealand White). They reported that mean live weights obtained at 18<sup>th</sup> fortnight of age in sheep, goat and pigs were 17.50, 14.20 and 65.30 kg respectively, and 105.32 kg at 24<sup>th</sup> fortnight in calf and 1.60 kg at 10<sup>th</sup> fortnight in rabbits. The total cost of production for one cattle unit of sheep, goat, pig, calf and rabbit were ₹ 3666/-, 3719/-, 7730/-, 4387/- and 4134/- respectively at the age of 270, 270, 270, 365 and 140 days. One sheep or goat being equated to 0.1 cattle unit, pig 0.2 cattle unit, calf 0.6 cattle unit and rabbit 0.01 cattle unit. The cost per kg live weight gain was ₹ 21.07 in sheep, ₹ 26.18 in goats, ₹ 23.67 in pigs, ₹ 24.99 in calves and ₹ 25.84 in rabbits. The calculated net returns per cattle unit of sheep, goat, pig, calf and rabbit were rupee 7424/-, 5453/-, 1515/-, 1454/- and 1447/- for 270, 270, 270, 365 and 140 days of maintenance, respectively. With species-specific dressing percentage, the cost per kg of meat production was maximum in goats (₹ 52/-) and in rabbits, sheep, calves and pigs the respective figures were rupee 43/-, 42/-, 41/- and 32/-. The study indicated that under the price structure existing at Chennai, the maximum net profit was from small ruminants enterprises mainly due to relatively high market price of mutton and chevon.

### 13. RESEARCH AND DEVELOPMENT

Madras Red sheep is one of the important meat breeds of Tamil Nadu and known for its quality meat and skin/ leather. It is well adapted to native agro-climatic conditions. It has better feed conversion efficiency and preferred over other breeds by local sheep keepers due to their high dressing percentage. AICRP on sheep breeding for mutton was started in 1971 under which experiments were conducted to improve Madras Red sheep by crossing it with Dorset rams (Report AICRP, 1993). Network Project on sheep improvement was initiated in 1990-91 to undertake survey, evaluation and improvement of indigenous sheep breeds. Under the project a field unit on Madras Red was initiated at Post Graduate Research Institute in Animal Sciences, Kattupakkam (Tamil Nadu Veterinary and Animal Sciences University). Ram lambs are initially identified in the farmers' flocks at 3 month of age and superior male lambs are selected on the basis of six-month body weight. Selected ram lambs from improver flocks are supplied for breeding to base flocks. In Chengalpattu district 4 centres each having a population of 1500 sheep was identified for improvement of Madras Red sheep (Anonymous, 2011).

Income from Madras Red sheep is a major source of livelihood for sheep farmers of its native tract due to increasing demand of mutton and low initial investments. Non-availability of quality fodder is major constraint in natural habitat of Madras Red. There is need to strengthen the ram rearing centers at specific locations in the native tract, so that maximum coverage could be provided to farmers flocks. Farmers need to be upraised about the importance of Madras Red sheep, advantages of genetic variability in the flocks, importance of feeding quality fodder/pastures and advantages of avoiding inbreeding. Preventive health measures in the farmers' flocks also need to be intensified for better sheep rearing in the region.

## Breed Descriptor of Madras Red Sheep

### National Bureau of Animal Genetic Resources

Karnal-132001 (Haryana)

Accession No. **INDIA\_SHEEP\_1800\_MADRASRED\_14025**

#### I. GENERAL DESCRIPTION

1.	Breed name	<b>Madras Red</b>	
2.	Synonyms	Chennai Sigappu	
3.	Background for such a name / origin	The native tract for Madras Red sheep is the districts adjacent to Madras and the skin colour is red. So the name originated as Madras Red	
4.	Strains (or within breed types)	Kattupakkam Red	
5.	Native tract of distribution	<u>State</u>	<u>District</u>
		Tamil Nadu	Chennai, Kancheepuram, Villupuram, Tiruvallur and parts of Cuddalore and Thiruvannamalai districts
6.	Estimated population		
	a. Year of estimation	2007	
	b. Population	11,49,817	
	c. Source / Reference	18 <sup>th</sup> Livestock and Poultry Census, Department of Animal Husbandry, Dairying & Fisheries	
7.	a. Communities responsible for developing the breed	Naicker and Pillai are the two communities responsible for the development of the breed in the native tract of Kancheepuram and Thiruvallur districts	
	b. Description of community	The Pillai community consist of traditional	
	(Farmers/nomads/isolated/tribals)	farmers doing sheep farming generation after generation. Most of them own medium sized flocks and do agriculture and sheep rearing. Both the communities belong to most-backward classes. Very few sheep farmers belong to scheduled caste.	
8.	Flock size	20-50	
	Composition (%)		
	Ewes	76	

	Rams	2
	Lambs	22
9.	Utility of the breed	Meat
10.	Any other information	The sheep farming forms a major source of livelihood for the farmers of this area because of the increased demand for meat and low initial investments when compared to large animals. Even though, the Madras Red sheep are generally maintained on grazing alone, their meat yield is good as compared to that of other sheep breeds of the country

## II. PHYSICAL CHARACTERS

1.	Colour (Distinctive colour markings, if an)	Red. Intensity varies from tan to dark brown  Some have white markings at the forehead, inner aspect of thigh and lower abdomen
2.	Head profile (straight/slightly convex/ convex)	Straight (97.2%) and slightly convex (2.8%)
3.	Ears (erect/pendulous/horizontal)	Pendulous  Ear length : 12-13 cm
4.	Wattles (present/absent)	Present in both male and females
5.	Horns	
	a. Number	Two
	b. Colour	Grey
	c. Shape	Curved
	d. Orientation	Inward and outwards
	e. Size (small<15/medium 15-25 / large >25 cm)	Rams - Medium (15-25 cm) Ewes - Small (below 15 cm)
6.	Coat type (hair/wool)	Hairy type and never shorn
7.	Beard (present/absent)	Absent
8.	Tail	
	a. Type	Medium
	b. Length (short/medium/long)	Medium - 7-9 cm

### III. PERFORMANCE

#### 1. Body weight (kg)

Weight at	Male		Female	
	Average	N	Average	N
Birth	2.86 ± 0.006	1518	2.85 ± 0.005	1550
Weaning/ 3 months	11.38 ± 0.13	1469	11.36 ± 0.11	1485
6 months	15.47 ± 0.15	1199	15.45 ± 0.14	1197
1 year	23.56 ± 0.08	432	22.33 ± 0.15	976
Adult weight	26.33 ± 0.39	361	23.23 ± 0.04	7510

#### 2. Body measurements (cm)

Trait	Average	
	Male (N = 361)	Female (N = 7510)
Chest-girth	71.60 ± 0.60	72.36 ± 0.05
Body length	78.11 ± 0.60	77.82 ± 0.06
Height at withers	63.13 ± 0.57	66.82 ± 0.05

#### 3. Carcass characters

Trait	Male			Female		
	Average	Range	N	Average	Range	N
Age at slaughter(days)	180	170-190	183	180	170-190	33
Weight at slaughter (kg)	17.04±0.21	14.3-21.5		16.50±0.36	12.9-19.4	
Carcass weight (kg)	8.23±0.11	6.8-11.0		8.11±0.32	6.1-9.8	
Dressing %	48.25±0.13	44.6-52.3		48.92±0.55	44.5-53.3	

#### 4. Dairy performance: Nil

#### 5. Reproduction

Trait	Average	Range	N
Age at first mating in females (months)	13	11-15	1202
Age at first lambing (months)	18	16-21	1182
Lambing interval (days)	243.2	213-274	1441
Gestation length (days)	149	145-154	1235
Litter size	1	-	1202
Lifetime lamb production	5	4-6	1230
Lambing rate (%)	84.56	82-88	3628



6. Wool production (true wool/heterotypes/hair/kemps): Hairy type

7. Pelt production: Nil

**Source:**

Acharya R M .1982. Sheep and goat breeds of India. Animal Production and Health Paper. No.30. FAO, Rome.

Balasubramanyam D, Jaishankar S and Sivaselvam S.N. 2010. Performance of Madras red sheep under farmer's flocks, *The Indian Journal Small Ruminants* **16** (2): 217-220.

Balasubramanyam D and Kumarasamy P .2011. Performance of Madras Red sheep in Kancheepuram District., *Indian Journal of Fundamental and Applied Life Sciences*, **1**(2): 133-137. An Online International Journal Available at <http://www.cibtech.org/jls.htm>,

Sivakumar T, Balasubramanyam D, Jawahar K, Thilak Pon, Gopi H and Jaishankar S .2009. Growth and reproductive performance of Madras Red sheep under field conditions, *The Indian Journal of Small Ruminants*, **15**(2): 248-252.

[http://dahd.nic.in/LStockReport/AllIndia/PDF/TABLE5D\\_NM\\_00.pdf](http://dahd.nic.in/LStockReport/AllIndia/PDF/TABLE5D_NM_00.pdf)

## REFERENCES

- Acharya R M. 1982. Sheep and goat breeds of India. Animal Production and Health Paper, 30 FAO, Rome, Italy.
- Ahmad M S, Sathyamoorthy O R, Geetha R and Balachandran. 2011. Cmicrometrical studies on the skin of madras red sheep (*Ovis aries*) in different age groups, *Tamilnadu J. Veterinary & Animal Sciences* **7** (1): 23-28.
- Annual Report. 1994-95. "Network Project on Sheep Improvement" Livestock Research Station TANVAS University, Kattupakkam-602 303.
- Annual Report. 1997-98. Network Project on Sheep Improvement. Livestock Research Station Kattupakkam-603 203 (TANVAS, University).
- Annual Report. 1998-99. Network Project on Sheep Improvement. Livestock Research Station Kattupakkam-603 203 (TANVAS, University).
- Annual Report. 2000-2001. Network Project on Sheep Improvement (Madras Red Unit), Livestock Research Station, TANVAS, University, Kattupakkam-603 203.
- Anonymous. 1999. Kattupakkam Red, sheep breed for meat, ICAR News, Monthly Bulletin of ICAR, New Delhi. January-March, 1999.pp17.
- Anonymous. 2007. Annual report 2006-2007. NBAGR, Karnal, Haryana.
- Anonymous.2011.[http://www.cswri.res.in/networkproject\\_on\\_sheep\\_improvement.asp](http://www.cswri.res.in/networkproject_on_sheep_improvement.asp)
- Arora C L and Garg R C. 1998. "Sheep Production and Breeding". International Books distribution co., Lucknow (UP).
- Atrashi F. 1979. Phenotypic and genetic association between production/ reproduction traits and blood biochemical polymorphic characters in Finn sheep. Thesis submitted to the University of Helsinki, Helsinki, on 1 June 1979.

- Balasubramanyam D and Kumarasamy P. 2011. Performance of Madras Red Sheep in Kancheepuram District, *Indian Journal of Fundamental and Applied Life Sciences*, **1**(2): 133-137. An Online International Journal Available at <http://www.cibtech.org/jls.htm>.
- Balasubramanyam D, Raja T V, Jawahar, K T P, Jaishankar S, Kumarasamy P and Sivaselvam S N. 2012a. Characterization of Madras Red sheep in their breeding tract, *Animal Genetic Resources*, **50**: 37-42.
- Balasubramanyam D, Raja T V, Kumarasamy P and Sivaselvam S N. 2012b. Estimation of genetic parameters and trends for body weight traits in Madras Red sheep, *The Indian Journal of Small Ruminants*, **18**(2): 173-179.
- Balasubramanyam D, Jaishankar S and Sivaselvam S N. 2010. Performance of madras red sheep under farmer's flocks, *The Indian Journal of Small Ruminants*, **16**(2): 217-220.
- Bhaskaran B and Krishnamurthy U S. 1979. Genetics of erythrocyte glutathione in Mandya and their crossbred sheep. *Cheiron*, **8**(2): 125-129.
- Bhat P N and Arora C L. 2000. Sheep Production, Studium Press (India) Pvt. Ltd. New Delhi 110002.
- Delgado C, Rosaegrant M, Steinfeld H, Ehui S and Courbois C. 1999. The new food revolution; International food policy research discussion paper EPTD 28, Washington DC.
- Devendran P, Cauveri D and Gajendran , K. 2009. Growth rate of madras red sheep in farmers' flocks, *Indian J. Anim. Res.*, **43** (1): 53-55.
- Devendran P, Cauveri D, Murali N, Ravimurugan T and Gajendran K. 2010. Growth efficiency of Madras red sheep under farmer's flocks, *The Indian Journal of Small Ruminants*, **16** (2): 210-212.
- Dhanammal C, Thangaraju P, Edwin M J and Nainar A M. 1999. NOR bonding in Madras Red sheep, *Indian Journal of Animal Sciences* **69**(2): 121-123.

- Final Report. 1993. Project Coordinator, sheep Breeding (AICRP), CSWRI, Avikanagar, 304 501. India.
- Ganesakale D. 1975. Effect of season of mating on the economic traits in sheep, *Cheiron* **4**(1): 40-44.
- Ganesakale D and Raman K S. 1994. Sex ratio, twinning, still births and abortions in Madras Red and Mandya breeds of sheep, *Indian Veterinary Journal* **71**(12): 1195-1197.
- Ganesakale D and Rathnasabapathy V. 1973. Sheep Breeds of Tamil Nadu, *Cheiron* **2**(2): 146-155.
- Ganesakale D and Rathnasabapathy V. 1974. Effect of two levels of feeding on the performance of Madras Red and Mandya Breeds of sheep, *Cheiron* **3**(2):141-147.
- Kannaiyan V R, Shanmugasundaram S, Thaiagarajan M and Michael R D. 1979. The fibre characteristics of Mandya, Madras red and crossbred sheep, *Cheiron* **8**(4): 247-251.
- Khan B U, Arora A L and Sharma R C. 2002. Enhancing Productivity of sheep: Technology Dimensions. In: Technology options for sustainable livestock production in India, Proceeding of the workshop on, Documentation, Adoption and impact of livestock technologies in India, from 18-19 January 2001, at ICRISAT, Patancheru-502324, Andhra Pradesh., pp:113-124.
- Kulkarni V V, Gajendra K, Thomas V, Kumar P and Meenakshisundaram A. 1997. Survey on causes of mortality in Madras Red sheep and Tellicherry goats under farm conditions, *Cheiron* **26**(5 & 6): 113 - 116.
- Kurup S A and Baliyan K. 2012. Production and export of meat of small ruminants in India: an overview, *The Indian Journal of small ruminants* **18**(2): 163-172.

- Litt M and Luty J A. 1989. A hyper variable microsatellite revealed by *in vitro* amplification of a dinucleotide repeat within the cardiac muscle actin gene. *American Journal of Human Genetics* **44**: 397-401.
- Murlidharan M R. 2002. Factors influencing skin thickness in sheep, *Indian Veterinary Journal* **79**(3): 258-261.
- Naidu K, Venugopal and Pattabiraman S R. 1998a. Effect of grazing and feedlot systems on body weight in grazing Madras Red ram lambs, *Cheiron* **27**(3 & 4): 75-76.
- Naidu K, Venugopal and Pattabiraman S R. 1998b. Effect of grazing and feedlot systems on the attainment of puberty in Madras Red ram lambs, *Indian Veterinary Journal* **75**(11): 990-992.
- Panneerselvam S and Krishnan A R. 1987. Serum alkaline phosphatase polymorphism in madras Red and Mandya sheep, *Cheiron* **16**(2): 60-64.
- Panneerselvam S, Krishnan A R and Narahari D. 1988. The influence of age, sex and breed on serum alkaline phosphatase levels in sheep, *Cheiron* **17**(4): 161-163.
- Prabhakaran S K and Rao R G. 1994. Total proteins, Albumin, Globulin and A/G ratio in Madras Red sheep, *Cheiron* **23**(2): 62 - 65.
- Prema S, Sivaselvam S N and Karthickeyan S M K. 2008. A note on genetic analysis in Madras Red sheep *Ovis aries* of India using microsatellite markers, *Livestock Research for Rural Development* **20**:181-85. <http://www.lrrd.org/lrrd20/11/prem20181.htm>.
- Raman K S, Sundararaman M N, Haribhaskar S and Ganesakale D. 2003. Bometrics and breed characteristics of *Madras red* sheep, *The Indian Journal of Small Ruminants* **9**(1): 6-9.
- Raman K S, Doraisamy K A, Kathaperumal V and Jayarajan S. 1993a. Dentition-normal tear in Madras Red sheep, *Indian Veterinary Journal* **70**(7): 669-670.

- Raman K S, Kathaperumal V, Doraisamy K A and Jayarajan S. 1993b. Ageing in Madras Red lambs, *Indian Veterinary Journal* **70**(8): 763-765.
- Ranjhan S K. 2010. India's meat industry: Perspectives, Food and Agriculture Organization.
- Rao P H R. 2012. Molecular Characterization of Madras Red Sheep. M.V.Sc. Thesis, Submitted to Tamil Nadu Veterinary and Animal Sciences University, Chennai, Tamilnadu.
- Rathnasabapathy V, Krishnamurthy U S, Kothaandopani R and Ananthakrishnan R . 1972. Haemoglobin and Transferrin polymorphism in Madras Red Breed of sheep, *Cheiron* **1**(1): 71-74.
- Reddy V R C and Krishnan A R. 1985a. Blood-potassium polymorphism in sheep, *Cheiron* **14**(3): 119-124.
- Reddy V R C and Krishnan A R. 1985c. Relationship of Erythrocyte Reduced Glutathione level with growth traits in sheep, *Cheiron* **14**(5): 259-265.
- Reddy V R C and Krishnan A R. 1988. Blood potassium types and their relationship with body weights in sheep, *Cheiron* **17**(3): 114-119.
- Reddy V R C and Krishnan A R. 1986. Genetics of erythrocyte reduced glutathione in sheep, *Indian Journal of Animal Sciences* **56**(4): 434-439.
- Reddy V R C and Krishnan A R. 1987. Influence of erythrocyte glutathione (GSH) and blood potassium types of ewes on the their lamb mortality, *Indian Journal of Animal Sciences* **57**(16): 596-597.
- Reddy V R C and Krishnan A R. 1985. Blood Potassium types and their relationship with certain reproduction traits in sheep, *Cheiron* **14**(4): 188-194.
- Report AICRP. 1993. Project Coordinator, Sheep Breeding (AICRP), CSWRI, Avikanagar, India.
- Report. 2001. Project Coordinators Report on Network Project on Sheep Improvement, CSWRI, Avikanagar 304 501. India.

- Roy P, Purushothaman V, Sreekumar C, Tamizharasan S, Chandramohan A. 2008. Sheep pox disease outbreaks in Madras Red and Mechery breeds of indigenous sheep in Tamilnadu, *Research in Veterinary Science* **85**(3):617-21.
- Sambrook J, Fritsh E F and Maniatis T. 1989. *Molecular cloning: A laboratory manual*. Cold Spring harbor laboratory press, Cold Spring, N.Y.
- Selvam R, Rahumathulla P S, Sivaselvam S N, Karthickeyan S M K and Rajendran R. 2009. Molecular genetic characterization of Madras Red sheep in Tamil Nadu, India using microsatellite markers, *Livestock Research for Rural Development* 21, Article #50. <http://www.lrrd.org/lrrd21/4/selv21050.htm>.
- Selvaraj V, Kumar T. Ramesh, Nathan R, Sen T, Meenakshisundaram S and Gajendran K. 2002. Prediction of body weight from body measurements in Madras Red sheep, *Indian Journal of Animal Sciences* **72**(2): 180-181.
- Sivakumar T and Thiagrajan M. 1999a. Growth rate and growth prediction in Madras Red lambs and Tellichery kids, *Cheiron* **28**(5):140-147.
- Sivakumar T and Thigarajan M. 1999b. Comparative performance of madras red sheep, Tellicherry goats, large white Yorkshire pigs, Jersey crossbred calves and New Zealand White rabbits, *Cheiron* **28**(6): 209-216.
- Sivakumar T, Balasubramanyam D, Thilak K, Jawahar P, Gopi H and Jaishankar S. 2009. Growth and reproductive performance of madras red sheep under field conditions, *Indian Journal of Small Ruminants* **15**(2): 248-252
- Sivaselvam S N and Krishnan A R. 1985a. Serum esterase polymorphism and production traits in Madras Red sheep, *Cheiron* **14**(2): 53-56.
- Sivaselvam, S N and Krishnan A R. 1985b. Genetic polymorphism of serum esterase in Madras Red sheep, *Cheiron* **14**(4): 195-199.
- Sridar C S, Shanmugasundaram S, Syamasundaram S and Thiagrajan M. 1985. The effect of season of mating on birth, weaning and yearling weights of lambs of some native breeds of sheep in Tamil Nadu, *Cheiron* **14**(3): 125-128.

Status Paper 1995. Network project on Sheep Improvement. Project Coordinator (Sheep breeding). CSWRI, Avikanagar-304 501 (Rajasthan) India.

Subramanian R, Kanakaraj P and Ganesakale D .1981. Hematological sex-determination in sheep, *Cheiron* **10**(1): 45-47.

Thiagarajan R and Rao R. Govinda .1993. Interrelationship of 2 3-Diphosphoglycerate, glutathione and Haemoglobin types in Madras Red sheep, *Indian Veterinary Journal* **70**(7): 653-656.

Yeh F C, Boyle T, Rongcai Y, Ye Z and Xian J M .1999. POPGENE version 1.31. A Microsoft window based freeware for population genetic analysis. University of Alberta, Edmonton.

