

Current status of sheep farming in India

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Abstract

Sheep, with multi-facet utility (for meat, wool, skin, dung, and to some extent milk) plays a significant part in the Indian agricultural economy. India is having the second greatest number of sheep & goat in the world after China and has indigenous breeds with good productivity. Sheep are better adapted to India's arid and semi-arid tropical zones with marginal and sub-marginal lands. Sheep are possibly the most ideal small ruminants to exploit the scant vegetation available in dryland environments through rangeland management and reseeded pastures. The sheep farming sector in India needs marketing infrastructure facilities for value addition such as meat processing, warehousing, cold storage, and refrigerated trucks and there is a notable shortage of public-private partnerships. However, being advanced in veterinary infrastructure at ground level, and the expanding demand for sheep-sourced products generates an untapped opportunity for the export & value-added products. The current paradigm change in government policies is enabling farmers to move to scientific sheep farming which can assist and boost the productivity and farmer's revenue in India.

Keywords: Indigenous breeds; Indian farmers; Genetic resources; Scientific sheep farming

Introduction

Small ruminants (sheep and goats) play a significant role in the socio-economic and cultural livelihood of the rural folk in India. It provides livelihood to two-thirds of the rural community. The rural population constitutes 72.22% out of which the majority are dependent directly or indirectly on agriculture and livestock-related occupations. According to the 20th livestock census (2019), species-wise out of total livestock available in the country, around 36.04% are cattle, 27.74% are goat, 20.74% are buffaloes, 13.83% are sheep and 1.69% are pigs. All other species of livestock are less than 0.23% of the total livestock. The small ruminants suites the need for the small landholder and village system due to low initial investment, ease of rearing, and high feed conversion efficiency. Besides this, they are very well adapted to the harsh climate, long migration, resistance to tropical diseases, poor nutrition, and shortage of drinking water and water quality.

Sheep with multi-facet utility (for meat, wool, skin, manure, and to some extent milk) play a vital role in the Indian agrarian economy. They are better adapted to arid and semi-arid tropics with marginal and sub-marginal lands. They are perhaps the most suitable small ruminants to utilize the sparse vegetation available in dryland areas through rangeland management and reseeded pastures (Adegbeye et al., 2020). Sheep farming is important source of livelihood in various parts of underdeveloped or developing world viz. steppe (Inal et al., 2021), Chiapas, Mexico (Rebello-Morales et al., 2021), North Caucasus (Gogav et al., 2021) and Algeria (Merrouchi et al., 2021). According to the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) (2019) database of the United Nations Food and Agriculture Organization, the top three countries by the number of heads of sheep were: Mainland China (163.48 million heads), India (74.26 million) and Australia (65.75 million). India ranks second in sheep population and accounts for more than 4.03% of the world population (FAOSTAT, 2019) with 74.26 million sheep to its record.

In India from post-independence 1951 (39.10 million) till the 2019 livestock census (74.26 million) the sheep population increased by 89 %. Sheep husbandry or sheep farming is the backbone of the rural economy in India. Indigenous sheep contribute greatly to the agrarian economy, especially in areas where crop and dairy farming are not economical and play an important role in the livelihood of a large proportion of small and marginal farmers and landless laborers. Sheep were developed following domestication and natural and human selection over the past 12,000 years. They provide a dependable source of income to the animal owners. According to the FAO World Watch List (2000), there are 60 breeds of sheep in India. This list includes both well recognized and lesser-known breeds along with some wild species and according to the National Bureau of Animal Genetic Resources NBAGR (2021), details of 44 distinguished sheep breeds are available. These sheep breeds are well adapted to specific agro-climatic regions of the country. The current number of breeds of sheep is likely an underestimation as a large proportion of indigenous livestock populations in developing countries including India, are yet to be described at phenotypic and genetic levels. Genetic diversity signifies a unique resource to respond to the present and future needs of sheep production and human needs.

Importance of livestock sector with special reference to sheep

Sheep Husbandry or sheep farming contributes significantly not only to numbers but also to sustainable livelihood options in the country. It has been observed in recent days that the sheep population has increased in the areas of Telangana, Andhra Pradesh, and Karnataka (Table 1), where farmer suicides due to crop failure were more. Sheep are the lifeline in areas where crop failure is commonplace and the rural population, NGOs, and also government is realizing the importance of this species in sustaining their livelihood. According to the 20th livestock census by India's Department of Animal husbandry and Dairying (DAHD) (2019), Telangana ranks first in sheep population with nearly 25.72% sheep population followed by Andhra Pradesh (23.70%) and Karnataka (14.95%). Large ruminants are specifically reared for milk production in our country and therefore they are out of production for a significant part of their life. However, sheep are such an animal that is a true sense act as a security option and remain always ready for cash option with the farmer. Utilizing sheep husbandry as a livelihood security option in arid and semi-arid regions of India can be tried to minimize dependency on rain-fed crops.

Sheep genetic resources

India is one of the few countries in the world, which has contributed richly to the international livestock gene pool and improvement of animal production in the world. Sheep biodiversity in India is characterized by a high degree of endemism and variations in agro-climatic conditions of the different regions have led to the development of various breeds/strains that are well adapted to a specific set of environmental conditions. These breeds have generally been named after their place of origin and some based on their prominent characteristics. A few breeds have evolved from the base populations created by crossing native and fine wool exotic breeds.

Acharya (1982) described the Indian breeds of sheep based on published literature and also on his surveys. Further, not much information is usually available on their genetic characteristics and phylogenetic diversity - the first guidance in making conservation decisions in ovines. The Indian Council of Agricultural Research (ICAR), India has established NBAGR at Karnal to take up description, evaluation, and conservation of the livestock genetic resources and suggest strategies for their long-term conservation. Efforts are being made at NBAGR Karnal to determine the latest status by compiling information on characteristics of indigenous breeds of sheep through surveys on native tracts. Additional activities on molecular characterization of indigenous sheep breeds are also well underway at NBAGR (Arora and Bhatia, 2004; Sodhi et al., 2003) because of worldwide recognition of the need for analysis of genetic structure and relationships of sheep populations/breeds to conserve ovine diversity (Arranz et al., 1998, Arranz et al., 2001; Saitbekova et al., 2001; Sun et al., 2004).

According to the NBAGR (2021), the details of sheep breeds are classified based on agro-ecological regions viz. a) North temperate region, b) North Western arid and semi-arid region, c) Southern peninsular region, and d) Eastern region is depicted below (Table 2a and 2b). In our country, a sizable population of sheep is non-descript due to indiscriminate breeding and intermixing of breeds.

Fig. 1 shows the percentage distribution of various indigenous breeds of the sheep population. It is observed that among the indigenous breeds, the Nellore breed contributes the highest in the category with 19.17% following which the breeds namely Deccani, Marwari, Bellari, Jaisalmeri, and Mecheri contribute a major share as shown in the following diagram. There are 27 indigenous breeds whose contribution is less than 1% share of total indigenous sheep.

Table 1- Leading states in sheep population (20th livestock census 2019)

State	Population (In million)		% share	% change over 19 th census
	2012	2019		
Telangana	12.8	19.1	25.72	48.51
Andhra Pradesh	13.6	17.6	23.70	30.00
Karnataka	9.6	11.1	14.95	15.31
Rajasthan	9.1	7.9	10.64	-12.95
Tamil Nadu	4.8	4.5	6.06	-5.98
Jammu & Kashmir	3.4	3.2	4.31	-4.19
Maharashtra	2.6	2.7	3.64	3.87
Gujarat	1.7	1.8	2.42	4.66
Odisha	1.6	1.3	1.75	-19.10
Uttar Pradesh	1.4	1.0	1.35	-27.25
India Total	65.07	74.26	100	--

1. About 70% of sheep are found in southern states (mutton and hair wool).
2. About 15% of sheep are found in Rajasthan, Gujarat and Uttar Pradesh states (carpet wool and mutton).
3. About 6% of sheep are found in Jammu & Kashmir, Uttarakhand and Himachal Pradesh (fine wool and mutton).

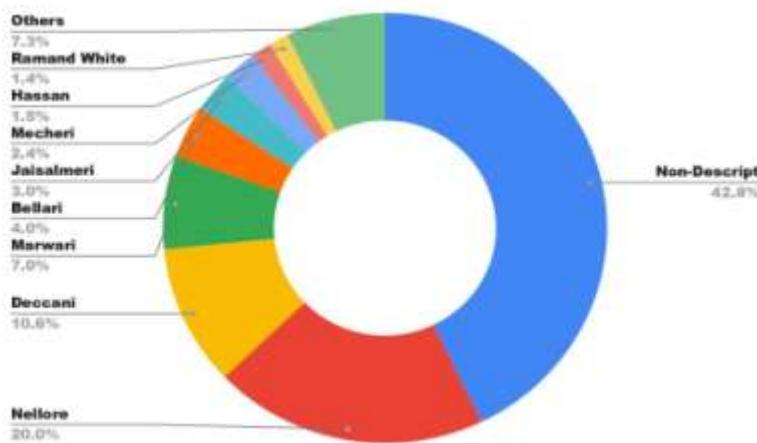


Fig. 1: Percentage share of indigenous sheep including non-descript population

Source: DAHDF, Based on breed survey (2013)

Table 2a- Breeds of sheep in northern temperate and north western arid and semi-arid regions in India

Breed	Location	Major utility
Northern temperate region		
Bhakarwal	J & K, migratory flock	Carpet wool
Changthangi	Changthang region of Ladakh	Carpet wool
Gaddi	Kulu, Kangra&Chamba districts of H.P.	Carpet wool
Gurez	Gurez tehsil in northern Kashmir	Carpet wool
Karnah	Karnah in north Kashmir	Apparel wool
Kashmir Merino*	Merino Kashmir valley	Apparel wool
Poonchi	Poonch&Rajouri districts of J&K	Carpet wool
Rampur Bushair	Rampur Bushair, Simla, Kinnaur, Nahan, Bilaspur&Lahaul Spiti districts of H.P.	Carpet wool
North western arid and semi-arid region		
Chokla	Nagaur, Sikar, Churu and Jhunjhunu districts of Rajasthan	Carpet wool
Jaisalmeri	Jaisalmer, Barmer& Jodhpur districts of Rajasthan	Mutton& carpet wool
Jalauni	Jalaun, Jhansi & Lalitpur districts of U.P.	Mutton t & carpet wool
Kheri*	Merta, Nagaur, Jodhpur, Sawai Madhopur, Tonk districts of Rajasthan	Mutton& carpet wool
Magra	Bikaner, Nagaur, Jaisalmer and Churu districts of Rajasthan	Carpet wool
Malpura	Jaipur, Tonk, Ajmer, Bhilwara, Bundi&Sawai Madhopur districts of Rajasthan	Mutton& carpet wool
Marwari	Jodhpur, Jalore, Nagaur, Pali and Barmer, Ajmer and Udaipur districts of Rajasthan and Jeoria region of Gujarat	Mutton& carpet wool
Munjal*	Hissar , Ambala and Karnal districts of Haryana, Patiala and Bhatinda districts of Punjab	Mutton& carpet wool
Muzzafarnagri	Muzzafarnagar, Bulandshahar, Saharanpur, Meerut & Bijnor districts of U.P. and Dehradun district of Uttarakhand	Mutton& carpet wool
Nali	Ganganagar, Churu And Jhunjhunu district of Rajasthan	Carpet wool
Patanwadi	Saurashtra, Kutch, Patan, Kadi, Kalol, Sidhpur and Mehsana districts of Gujarat	Carpet wool
Pugal	Bikaner & Jaisalmer districts of Rajasthan	Mutton& carpet wool
Sonadi	Udaipur, Dungarpur&Chittorgarh districts of Rajasthan	Mutton& carpet wool
Panchali	Panchal area of Gujarat	Milk & meat
Kajali	Sangrur, Barnala, Ludhiana, Moga and adjoining districts in Punjab	Mutton

Table 2b- Breeds of sheep in southern peninsular and eastern regions in India

Breed	Location	Major utility
Southern peninsular region		
Bellary	Bellary, Davangere, Haveri and Chitradurga districts of Karnataka	Mutton& carpet wool
Coimbatore	Coimbatore &Dindigul districts of Tamil Nadu	Mutton& carpet wool
Deccani	Semi arid areas of Maharashtra, Andhra Pradesh and Karnataka	Mutton
Hassan	Hassan district of Karnataka	Mutton
Kenguri	Raichur district of Karnataka	Mutton
Kilakarsal	Virudunagar&Ramnathpuram districts of Tamil Nadu	Mutton
Madras red	Chingalpet& Madras districts of Tamil Nadu	Mutton
Mandy	Mandy and bordering Mysore districts of Karnataka	Mutton
Mecheri	Salem, Erode & Namakkal districts of Tamil Nadu	Mutton
Nellore	Nellore, Prakashan, Ongole districts of A.P.	Mutton
Nilgiri	Nilgiri hills of Tamil Nadu	Apparel wool
Ramnad white	Ramnathpuram&Virdunagar districts of Tamil Nadu	Mutton
Tiruchi black	Tiruchy, Perambalur, Tiruvannamalai, Salem & Dharampuri districts of Tamil Nadu	Mutton
Vembur	Tuticorin&Virudunagar districts of Tamil Nadu	Mutton
Katchaikatty Black	Vedipatti taluka of Madurai district of Tamil Nadu	Mutton
Chevaadu	Tirunelveli and Thoothukudi districts of Tamil Nadu	Mutton
Eastern region		
Balangir	Balangir, Sambalpur and Sundargarh districts of Orissa	Mutton& carpet wool
Bonpala	Southern part of Sikkim	Mutton& carpet wool
Chottanagpuri	Chottanagpur, Ranchi, Palamau, Hazaribagh, Singhbhum & Dhanbad districts of Jharkhand	Mutton& carpet wool
Ganjam	Koraput, Phulbani and part of Puri districts of Orissa	Mutton& carpet wool
Shahbadi	Shahabad, Patna & Gaya districts of Bihar	Mutton
Tibetan	Sikkim and Kameng districts of Arunachal Pradesh	Carpet wool
Garole	Sundarban region of West Bengal	Mutton&Prolificacy
Kendrapara	Kendrapara, Puri, Jagatsinghpur and Cuttack districts of Orissa	Mutton&Prolificacy

* Breeds not included in the list recognized at the National level. **Source:** NBAGR and Bhatia and Arora (2005).

Sheep breeding strategies in India: Lessons from the past and a way ahead

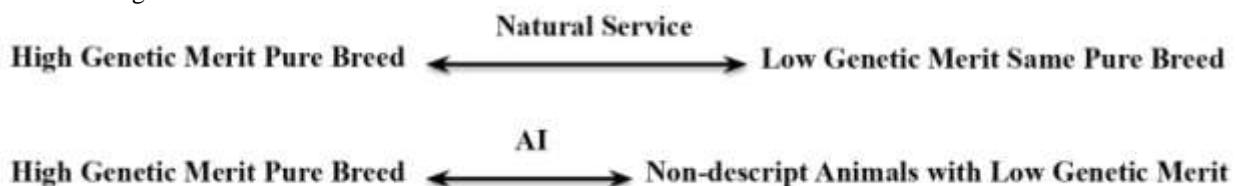
The focus of sheep development in past was essentially on the improvement of quality and quantity of wool by using different types of exotic fine wool breeds. Several strains were developed through crossbreeding of native breeds with exotics (Task Force Reprt 1996; Singh et al., 2005). Developed genotypes demonstrated their production potential in terms of body weight, wool quantity, and quality under experimental farm management conditions but these could not outdo the natives in field conditions barring a few genotypes due to non-availability of the required plane of nutrition and climatic conditions. Presently mutton has almost outperformed the wool in terms of income to the farmers. In addition to the Network Project on Sheep Improvement (NWPSI) and Mega Sheep Seed Project (MSSP) programs of ICAR, the genetic improvement of indigenous breeds of sheep in their home tracts at present is being mostly done through state governments. State-wise sheep breeding policies were first proposed in 1970 by the Ad-hoc Committee on sheep breeding policy set up by the Government of India. Agriculture is a state subject hence; sheep breeding policies are to be enunciated by the State Government. Well defined sheep breeding policy in a large number of states is still awaited.

There are several methods of genetic improvement of Indian sheep, which include the 4 step action plan with a focus on separately identified breeds for meat and wool production. The 4 steps are:

- 1) Breed improvement of the identified breeds of sheep from amongst the same breed but higher comparative genetic merit animal (example -Deccani sheep for the higher weight of meat per animal by selective breeding from amongst the same species better genotypes/phenotypes) – that is pure line high genetic merit breeding.
- 2) Breed improvement of identified breeds of lesser genetic merit (for example selective breeding of lesser breed, Chotanagpuri with Deccani sheep) - that is hybrid high genetic merit breeding.
- 3) Breed improvement of much lower yield but high population non-descript breed which is typically lesser in genetic merit than the least merit identified breed itself - that is hybrid of low genetic merit non-descript breed with the high genetic identified breed.
- 4) Breed improvement through a hybrid of high genetic merit exotic germplasm of suitable genetic traits for higher meat and wool production.

The following methodology shall be adopted for this,

- i. Genetic improvement of identified indigenous descript breeds of sheep through selective breeding for better yielding breed stock for meat, milk, and wool.
- ii. Genetic improvement of non-descript breeds of sheep by germplasm from existing improved descript indigenous breeds.



Synthetic breeds/strains developed

Table 3 summarizes breeds/strains developed in this category as a result of attempts made for the upgradation of indigenous animals with exotic breeds for improving wool production, wool quality, and mutton in sheep species. Imported breeds used for crossing were (i) Australian/ Russian Merino and Rambouillet for improvement in wool (ii) Suffolk and Dorset for improvement in meat quality and feed efficiency and (iii) Karakul for pelt production. The flocks of these synthetic breeds have been developed in some pockets/government establishments and are being maintained at government-organized farms. Kashmir Merino was, however, evolved in Jammu and Kashmir under field conditions. Most of these breeds/strains have not done well with the farmers because of a lack of input, poor health, management, and expertise available under field conditions (Bhatia and Arora, 2005).

Least discussed breeds

Kajali sheep

Kajali sheep is the large-sized animals with well-built bodies distributed in Sangrur, Barnala, Ludhiana, Moga and adjoining districts in Punjab. Kajali sheep has two types /color variants: Black (Kali) and White (Chitti) Kajali. Black Kajali has a complete black or black-brown or brown body. White Kajalihavea completely white coat with a black or dark brown circle/patch around the eyes, and on the face and ears (Fig. 2). These sheep have a Roman nose, long and pendulous ears, and long tail touching the ground (about 55 cm). Primarily reared for mutton

production. Average adult weight is about 57 kg in males and 43 kg in females. It produces white or black/brown coloured coarse wool (0.8-1 kg). Population size is approximately 6000-8000.



Fig. 2: Kajali female sheep breed.
Source: nbagr.icar.gov.in



Fig. 3: Dumba (Fat tail) sheep at ICAR-CSWRI, Avikanagar Source: ICAR-CSWRI, Avikanagar



Fig. 4: Avishaan sheep at ICAR-CSWRI, Avikanagar
Source: ICAR-CSWRI, Avikanagar



Fig. 5: Sheep with its multi-facet utility



Fig. 6: Garole ewe with triplets lamb at ICAR-CSWRI, Avikanagar Source:cswri.res.in/breed_profiles.asp

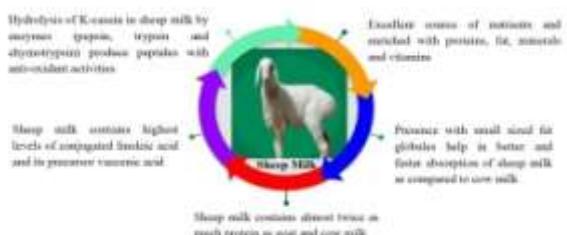


Fig. 7: Benefits of sheep milk

Dumba (Fait tail) sheep

Sheep are classified according to their utility, i.e. wool, meat, milk, pelt, etc. Fat-tailed sheep are classified as short fat-tailed, long fat-tailed, and fat-rumped. Fat-tailed sheep constitute 25% of the World's sheep population (Davidson, 1999). Fat-tailed or fat-rumped sheep are so named because they store a large amount of fat in their tail rump region. Fat-tailed sheep breeds are known to deposit up to 20% of their carcass weight as tail fat (Yousefiet al., 2012). In evolutionary terms, fat-tail is developed for storing nutrients when food is plentiful and utilized as metabolic energy at the time of food scarcity, particularly during harsh seasonal fluctuations and migration (Atti and Mahouachi, 2011). Fat-tailed sheep are widely found in Iran, Israel, Jordan, Syria, Turkey, Indonesia, Lebanon,

Ethiopia, South Africa, Zimbabwe, China, Afghanistan, Pakistan etc. (Pourlis, 2011). More than 96% of Iranian sheep are fat-tailed and the remaining 4% are thin-tailed and semi-fat-tailed (Kiyanzad, 2005).

In our country, a few fat-tailed sheep of unknown breeds are found in urban - and peri-urban areas of Rajasthan, Jammu & Kashmir and Uttar Pradesh etc. Most of them are raised on stall feeding for meat production. These animals are - sold in the market on the occasion of festivals. Fat-tailed Awassi and Karakul sheep are famous for milk and pelt production. At ICAR-Central Sheep and Wool Research Institute, Avikanagar (Rajasthan) a few studies on Awassi and Karakul sheep were initiated earlier, but later on, terminated. The present fat-tailed sheep found in the country is completely different from Awassi and Karakul breeds and are reared for producing meat. Locally, these sheep are named Dumba. Fat-tailed sheep concerning native breeds in the country are large in body size and weight, attained body weights of 33 kg at 3 months, 50 kg at 6 months, and 90 kg at 12 months of age. They produce 70 liters of milk in a lactation period of 90 days with a daily milk yield of 780 g (Anon, 2017). They are also well-adapted to hot and dry topographies of the country and fetches high prices (>Rs. 1.00 lakh for a male adult) in the market.

Because of the ever-increasing demand for meat, a large body size with rapid growth efficiency is the current need for sheep farming in the country. The production of Dumba (Fat tail) sheep seems to be one of the options for enhancing meat production and bridging the gap between demand and availability of meat in the country (Mohapatra and Shinde, 2018). Fat-tailed sheep of no specific breeds are found in some parts of India like Agra, Jaipur, Ajmer, Muzaffarnagar, Delhi etc. Entrepreneurs in urban or peri-urban areas maintained a few numbers of fat-tailed sheep on stall-feeding and sold them at very high price on the occasion of Eid festival. A small flock of fattaile sheep is being maintained at ICAR-CSWRI, Avikanagar and preliminary studies have been initiated on growth, production, reproduction and wool production (Anon, 2017). The growth performance of Dumba and its crosses is given below in the (Table 4). The faster growth of these animals as indicated by higher body weights at different age shows the potential of Dumba sheep in enhancing the mutton production (Fig. 3).

Avishaan

ICAR-Central Sheep & Wool Research Institute, Avikanagar released a high performing prolific three breed cross developed by it on 04.01.2016 on the occasion of Institute foundation day for testing in the farmer's field. The prolific cross is a composite cross having 12.5% Garole, 37.5% Malpura and 50% Patanwadi blood (Fig. 4). The average growth performance of Avishaan in farm condition is 3.30 kg at birth, 16.80 kg at 3 month, 25.90 kg at 6 month and 34.70 kg at 12 month age. Avishaan excelled by about 30% over native Malpura sheep in terms of Ewe Productivity Efficiency (EPE) at six month of age. In the current female population 47% females produced 2 lambs and 2% produced 3 lambs in a lambing leading to overall 49% prolificacy. With an enhanced growth, farmers can get 1.5 times income from rearing of Avishaan without extra investments. Boon for sheep rearing for more lambs, more milk, more live weight and more adaptability. The enhanced milk production will lead to sustenance of more lambs, fulfillment of domestic requirement, thus adding up to the nutritional security of the sheep farmers. The prolificacy of prolific three breed cross 'AVISHAAN' is presented in (Table 5).

Breeds exhibiting unique characteristics

All the indigenous sheep breeds are known for adaptability under varied climate conditions, which is obvious from their long struggle against the natural forces. Some of the unique features have been identified in few indigenous breeds, which are summarized in (Table 6).

Sheep migratory patterns and production systems in India

Sheep migratory patterns

In spite of a number of sheep development activities in operation in different states of the country, sheep rearing still continues to be a nomadic/backward proposition and thus mostly concerned to poor and landless people. For scanty suitable grazing lands in most of the states, the shepherds keep on migrating their flocks over extensive areas within or even in the neighboring states. Sheep rearing is thus practiced in a diversified form depending upon the region and the location. In Rajasthan, around 5 lakh sheep are in permanent migration where the flocks do not return to their home tract at any time of the year. The shepherds, however, keep on relieving one another and return home in turn. These sheep are mainly grazed in MP, UP, Punjab, Haryana and parts of Rajasthan. Generally there are two types of migratory flocks:-

Table 3- Synthetic (crossbred) breeds/strains of sheep in India

New breed/strain	Location	Parent Breeds		Level of exotic inheritance %
		Indian	Exotic	
Hissardale	Govt livestock farm, Hissar	Bikaneri (Magra)	Merino	75
Bharat Merino	CSWRI, Avikanagar	Chokla, Nali	Rambouillet, Merino	75
Avivastra	CSWRI, Avikanagar	Chokla, Nali	Rambouillet, Merino	50
Avikalin	CSWRI, Avikanagar	Malpura	Rambouillet	50
Avimanns	CSWRI, Avikanagar	Malpura, Sonadi	Dorset, Suffolk	50
Nilgiri Synthetic (Sandyno)	SRRS, TANUVASU, Sandynallah	Nilgiri	Merino	62.5/75
Patanwadi synthetic	GAU, Dantiwada	Patanwadi	Rambouillet, Merino	50
Indian Karakul	CSWRI, ARC, Bikaner	Marwari, Malpura, Sonadi	Karakul	75
Kashmir Merino	J & K State	Gaddi, Bhakarwal	Delaine Merino, Rambouillet, Soviet Merino	50-75

Source: Bhatia and Arora (2005).

Table 4- Body weight (kg) of Dumba sheep in India

	Male	Female	Pooled	Maximum
Dumba				
Birth	4.16	3.58	3.87	5.6
3 month	30.28	31.18	30.73	39.5
6 month	43.55	44.56	44.06	51.7
9 month	64.6	56.55	60.58	81.6
12 month	81.6	66.25	73.93	90.2
Dumba crosses				
Birth	3.65	3.42	3.53	5.3
3 month	19.93	18.45	19.19	29.2
6 month	31.79	27.24	29.51	46.7
9 month	50.75	30.28	40.51	58.8
12 month	72.0	34.22	53.11	72.0

Source: ICAR-CSWRI, Avikanagar

Table 5-Prolificacy of prolific three breed cross Avishaan sheep

Prolificacy	74.0%
Litter size	1.82
Tupping	99.3%
Lambing (ewe available)	98.5%
Birth weight	3.3 kg
Weaning weight	16.9 kg
EPE at weaning	26.0 kg
Adult survivability	98.6%
Lamb survivability	94.0%

Source: ICAR-CSWRI, Avikanagar.

Table 6- Some unique sheep breeds of India

Breed	Unique characteristics
Changthangi	Fiber fineness
Chokla	Fine carpet quality fleece
Magra	Lustrous carpet quality fleece
Mecheri Chennai Red	High-quality skin and mutton
Mandyā	Excellent meaty conformation, high quality, and meat palatability
Nellore	Tallest sheep breed of India
Garole	High fecundity- twins and triplets common. Survival under saline conditions
Marwari, Deccani, Jaisalmeri	Hardy and capable of walking long distances during migration

Source: Bhatia and Arora (2005).

- (i) Truly nomadic flocks with no fixed centers but following seasonal migratory routes to grazing areas, they are largely governed by the availability of foraging and drinking water resources.
- (ii) Flocks on the fallow land, but following definite migratory routes to the season pastures and returning to their permanent abodes during other seasons.

Production systems

Sheep in India are mostly maintained on natural vegetation, common grazing lands, wastelands, uncultivated (fallow) lands, stubbles of cultivated crops, and top feeds (tree toppings). Few farmers rear the sheep even on grain, cultivated fodder and crop residue. In developing countries such as India, the farming system could be categorized as intensive, semi-intensive, and extensive systems (Karthik et al., 2021). In intensive farming, the animals are fed in confinement with no access to graze. The system involves high cash inputs. The animals are fed cultivated green fodder and concentrated feed, which allows for greater management of the animals. As India's population grows, so does the need for mutton. To meet this demand, the intensive farming method must be implemented in India in order to improve the quality of sheep's meat (Kulkarni et al., 2008). Ewe lambs' body weight and average daily increase were greater in intensive systems than in semi-intensive and extended systems of raising in Indian environmental disputes. The ewe lambs in the intensive system reached puberty and first service at a younger age than in the other two ways of raising (Rangamma et al., 2022). Compared to semi-intensive and extensive farming, the gross and net income of sheep were greater in the intense system because of larger weight growth (Karthik et al., 2021). With intensive rearing, the sheep's feed conversion efficiency was greater than that of the semi-intensive and extended systems of rearing, respectively (Kochewad et al., 2017).

In extensive and semi-intensive farming system, the sheep flocks are let loose for a grazing period of 4–8 hours. This practice helps in increasing the fertility of land via the return of dung and urine, control of waste herbage growth, reduced fertilizer usage, easier crop management, increased crop yields, and greater economic returns. Extensive system or pastoralism involves low carrying capacity in situations where land is marginal and plentiful, which is characterized by low rainfall and grazing. Extensive farming is a way of life in several geographies, including Australia, Africa, India, Eurasian steppes, Tibetan plateau, and many third world countries (Mbow et al., 2019). Most of the time, no welldefined pasturelands are available for sheep and they mainly depend on waste lands, which are otherwise not suitable for crop production. Generally in India five types of sheep production systems are used described in (Table 7).

Table 7- Sheep production systems in India

Extensive	More than 90% of landless, small and marginal sheep farmers rear sheep under extensive system on common property resource. Declining in areas and biomass yield of CPRs are affecting the production (Zero input).
Semi-intensive	Sheep graze in grazing lands nearby to their villages and supplemented green and dry and concentrate at stall after returning from grazing.
Intensive	Sheep stall fed on roughage and concentrate for commercial production. This system is prevalent in urban and peri-urban areas.
Nomadic	Small, marginal and landless farmers practice migration during scarcity period to protect their sheep from feed and water scarcity in arid regions of Rajasthan and Gujarat. More than 70% of sheep in Himachal Pradesh and Jammu and Kashmir reared sheep up hill migration.
Tethering	It is a sedentary system and common in the sub-humid and humid regions because of intensive cropping. This system is suitable for grazing of 4-5 sheep/goat at a time.

Sheep production practices in India

Meat (Mutton) production

By the year 2050, the agriculture sector has the challenge to increase production by over 60% to feed the world (Food and Agriculture Organization of the United Nations (FAO), 2012). In this scenario, meat consumption, as a strategic source of protein in the human diet, is expected to grow substantially. The projected demand shows that the leading position will be taken by poultry and pig meats, followed by bovine and sheep meats, respectively.

In India, most sheep and lambs are indigenous dual-purpose animals kept primarily for the production of lambs for meat or dual-purpose breeds kept for both meat and wool production. Sheep with its multi-facet utility for wool, meat, milk, skins, and manure may be called a "FIVE STAR" animal (Fig. 5). Meat production is also a significant profit center in sheep rearing. Meat sheep producers sell either slaughter lambs or feeder lambs. Slaughter lambs are usually purchased for immediate slaughter. In the present conditions, the average slaughter weight for a lamb is 20-35 kg and the Dressing percentage is 40-50%. The average meat yield of Indian sheep (12 kg/animal) is lower than the world average of 15.6 kg (Reddy et al., 2018). It is mostly due to a lack of knowledge

among traditional shepherds about the importance of a balanced diet for optimal development rates, as well as a lack of genetic improvement in sheep. Increasingly, there is a market for slaughter lambs of any weight. Feeder lambs are lambs that are usually fed to heavier weights before being harvested. Feeder lambs vary in weight, usually from 40-50 kg. These are mainly meat breeds or selected cross-bred animals. However, in India, the 14 availability of feeder lambs/meat breeds are very less despite increased demand and profit.

By the year 2019, India produced 27.63 tonnes meat ofin the world according to the Food and Agriculture Organization of the United Nations (FAO, 2019). According to the Basic Animal Husbandry Statistics (2020), India's mutton output was 8.36 percent of the country's total meat production (Table 8). In 2021, India would eat over 728 million metric tons of sheep meat, which is a significant amount. The total number of metric tons of sheep meat produced from 2013 to 2020 was 726.76 million metric tons, an increase above the previous year's total of 717.47 million metric tons. Bakrid and Eid, the finale of Ramzan, saw a spike in the consumption of sheep meat, especially lamb. The country is the largest exporter of sheep and goat meat to the world. The country has exported 7,050.55 MT of sheep and goat meat to the world for the worth of Rs. 329.96 Crores/ 44.57 USD Millions and have the major export destinations to 75.16% UArab Emts, 10.62% Qatar, 5.54% Kuwait, 2.91% Suadi Arab, and 2.69% Oman according to Agricultural and Processed Food Products Export Development Authority (APEDA, 2021).

Prolific sheep: A hope for the future sheep industry in India

Considering the importance of multiple births in sheep breeding in special reference to mutton production, Garole, a small sized (Micro-sheep) indigenous prolific breed of sheep reared for meat and mostly known for high reproductive (Multiple births, Fig. 6) performance is found in hot, humid, swampy Ganges delta or Sunderban area of West Bengal (Table 9). It was introduced at CSWRI, Avikanagarin 1997 for improving the reproductive efficiency of Malpura sheep. The results indicated that the twining percent in Garole × Malpura (GM) half-breed ewes was 52.24 % and lamb born, as triplets were 7.46%. The average number of lambs born per ewe lambed was 1.64 in GM and 1.08 in Malpura sheep (Kumar et al., 2006; Mishra et al., 2007). Lambing rate in GM was 118.6% as compared to 89.47% in Malpura ewes (Sharma et al., 2004). It was observed that the body weight at different ages of GM half-bred was on lower side compared to contemporary Malpura lambs. This was however the first report that also signified the importance of enhancing Malpura inheritance to 75% for better live weight gain and mothering ability in prolific crosses. The overall percent gain in prolificacy in GM was 52.38%, which increased to 75.73% in third parity (Mishra et al., 2007). A similar study was also carried out at Nimbkar Agricultural Research Institute (NARI) Phaltan (Maharashtra) using Deccani and Bellary breed (Nimbkar et al., 2000).

Table 8- Contribution of major states in mutton production

States /UTs	Mutton ('000 tonnes)	% share
Telangana	236.59	34.90
Andhra Pradesh	161.55	23.83
Tamil Nadu	60.64	8.94
Rajasthan	51.47	7.59
Karnataka	47.42	6.99
Jammu & Kashmir	21.37	3.15
West Bengal	20.56	3.03
Uttar Pradesh	18.78	2.77
Orissa	17.55	2.59
Maharashtra	12.73	1.88
Haryana	12.52	1.85
Other states	16.81	2.48
India Total	677.99	100.00

Source: Basic Animal Husbandry Statistics (2020).

Table 9-Reproductive performance of Garole ewes

Age at puberty	226.70 days
Weight at puberty	9.06 kg
Age of first conception	252.67 days
Weight of first conception	9.85 kg
Lambing interval	205.53 days
Lambing rate	173.56/100 ewes
Lambing births	Single (41.63%), Twins (43.35%), Triplets (14.81%)

Source: Arora et al. (2005).

Interventions in genetic improvement for enhancing mutton production

The GM (GaroleMalpura) carrying the FecB gene was backcrossed with Malpura ewes to generate the GM x Malpura (GMM). The growth performance of backcrossed progenies was compared to that of current Malpura and GM lambs. At birth, weaning, and six months of age, GMM lambs gained 53.76, 49.13, and 33.52 percent more body weight than GM half-breeds, respectively (Naqvi et al., 2014). While GMM sheep were a viable alternative to Malpura, it was thought that the milk output should be raised to reduce lamb losses and accelerate the growth rate of lambs owing to repeated birth. Thus, Patanwadi sheep inheritance was introduced to increase the milk supply of dams in prolific sheep. Lambs born from GMM-Patanwadi crosses (GMM as father and Patanwadi as a dam breed) exhibited a greater body weight, survival, and FecB inheritance than Malpura sheep. At birth, 3, 6, and 12 months, the average body weight of GMM x Patanwadi crosses was 3.34, 20.34, 30.15, and 41.00 kg, respectively (Arora et al., 2010). Current data indicate that the three breed crosses with increased body weights have a 33 percent prolificacy rate, igniting a new era of successful sheep farming. Additionally, using marker-assisted selection for FecB in the breeding program at CSWRI, three breed crosses with faster increase and total live weight are being developed on a bigger scale.

Since independence, ICAR has started several sheep crossbreeding programs to address the rising demand for animal products (Mishra et al., 2017). For each state, an agroclimatic and breed-specific cross-breeding policy is in place. Random crossbreeding of nondescript animals with foreign germplasm increased productivity and reproductive potential, but it diluted the local breeds of valuable livestock that were formerly isolated in their natural breeding area. Due to the success of this approach, several new animal breeds have been created. Romeny Marsh crossbreeding with indigenous sheep was carried out in both plains and hills in the early twentieth century. Regional sheep development research programs were initiated by the Indian Council of Agricultural Research (ICAR), which now encompasses nearly all of India's major sheep-rearing states. An Indo-Australian (now Central) Sheep Breeding Farm was established in Hissar with the Corriedale breed to produce and distribute Corriedale stud rams to other states for crossbreeding to boost wool and mutton output under the Fourth Plan. Corriedale was eventually replaced by Rambouillet because of its poor reproductive and survival results. At GLF Hissar, the crossbreeding of Bikaneri ewes with Australian Merino rams resulted in the creation of a new breed called 'Hissardale'. Similarly, the 'Kashmiri Merino' breed was formed by the crossing of Gaddi, Bhakrawal, and Poonchi ewes with Merino and Rambouillet rams. At Avikanagar, indigenous Indian breeds (Chokla, Nali, Malpura, and Sonadi) were crossed with Karakul to improve pelt output in India. It was discovered via these crossbreed tests that mixing coarse carpet Indian breeds with Karakul had a high potential for pelt output. Additionally, crossbreds are less able to adapt to hard climates, are more sensitive to tropical illnesses, and require regular input of sound management practices, in comparison to our indigenous livestock genetic resources, which greatly outperform them in these areas. Thus, even if crossbreeding was initially successful, it is vital to conduct large-scale evaluations of crossbred animals (Mishra et al., 2017).

Improving reproductive efficiency to increase mutton production

For mutton production, animals with a higher growth rate, feed efficiency, physical size, greater climatic adaptation, disease resistance, and market demand should be favored (Shinde, 2021). Selective breeding should be used to improve native sheep, and low-producing nondescript sheep should be upgraded by well-defined dominant breeds with high genetic value (Kumar et al., 2021). Lambs sprung from superior rams are worth more on the open market. Fat-tailed sheep, for example, should be introduced in areas where environmental conditions and feed supplies are optimal for boosting meat output in the country's meat industry (Naqvi et al., 2016). At three and six months of age, fat-tailed lambs weighed 28.50 kg and 43.20 kg, respectively. Fat-tailed sheep are in high demand in the Indian market and sell for a premium price.

Opportunities for sheep meat (mutton) in India

With the increasing human population and living standard, there is a rising interest in animal protein and thus demand meat. In India due to certain religious and legal restrictions major meat sources are sheep, goats, and poultry. The Indian Council of Medical Research (ICMR) recommends a minimum amount of 30 gm of meat/day/head should be taken, but the gap between demand and supply (11 kg of meat/head/annum vs. 5.6 kg/head/annum in India) is predicted to further widen in future. Rising demand and less supply has resulted in record prices of mutton in India over the past years: 1980 (Rs. 18-20), 2000 (Rs. 90-100), 2021 (Rs. 700-800), 2023 (Rs. 1000-?).

Wool production

Wool was the first commodity to be traded internationally and is the product the public most commonly associates with sheep. However, the importance of wool (as a product) relative to meat is less because of the quality of the wool produced. In India because of various reasons and changing agro-climatic conditions, the hair type of the

majority of Sheep is coarse and carpet type. So, the production of fine wool is very limited. Fine wool brings the most money in the commodity market. Unfortunately, in India fine wool production is very much limited to Ley-Lehdak region of Jammu & Kashmir. Feeding, housing, health care, handling, and harvesting are all critical to the production of high-quality wool.

Due to lower wool output (0.9 kg/sheep/year) than the global average (2.4 kg/sheep/year), India is the 7th largest producer of wool and contributes around 2% to total world wool production. The total wool production in India is 36.76 Million Kg (2020) and wool production has declined by -9.05% as compared to the previous year (40.42 Million Kg in 2019). The Indian wool output fell to 43.05 million kg in 2016-17 and stayed at the same level in 2017-18 due to difficulties in sheep rearing and an increase in the slaughter rate of sheep from 38 to 65 percent (43.2 million kgs). In 2018-19, it declined to 40.2 million kilograms. Wool production is predicted to rise as a result of increased environmental consciousness and efforts to reduce climate change's negative effects on human health (Kadam, 2021).

The top 5 wool production states are: Rajasthan 12.71 Million Kgs (34.59%), Jammu & Kashmir 7.47 Million Kgs (20.34%), Telangana 3.96 Million Kgs (10.77%), Gujarat 2.23 Million Kgs (6.07%) and Karnataka 1.74 Million Kgs (4.74%) during 2020 (Table 10). The species-wise share in wool production in 2020 is Ewes (70.61%), Ram (17.10%), and Lamb (12.30%). The state-wise annual growth rate in 2020, Jharkhand (5.73%) has the highest annual growth rate among all states followed by Haryana (1.53%) and Chhattisgarh (1.27%). The average yield per season of wool from Ram/Wether in India during 2020 is 1.44 kg per season, which is much lower than the world average of 2.4 kg per sheep. The state-wise average yield per season of wool from Ram/Wether during 2020, Jammu & Kashmir has the highest by 5.45 kg per season followed by 2nd is Punjab with 3.45 kg per season and 3rd is Himachal Pradesh with 2.80 kg per season. Rajasthan during 2020 has an average yield per season of wool from Ram/Wether with 1.87 kg per season.

Table 10-Contribution of major states in wool production

States /UTs	Wool ('000 kg)	% share
Rajasthan	12716.83	34.59
Jammu & Kashmir	7477.12	20.34
Telangana	3960.14	10.77
Gujarat	2232.72	6.07
Karnataka	1742.14	4.74
Himachal Pradesh	1516.44	4.13
Maharashtra	1412.27	3.84
Uttar Pradesh	1328.64	3.61
Andhra Pradesh	801.14	2.18
West Bengal	762.96	2.08
Haryana	729.52	1.98
Uttarakhand	496.69	1.35
Punjab	525.36	1.43
Madhya Pradesh	411.85	1.12
Bihar	310.78	0.85
Other states	336.41	0.92
India Total	36760.57	100.00

Source: Basic Animal Husbandry Statistics (2020).

In general, Indian wool is coarse, and considered to be of low quality (28 microns and above); it is primarily used to manufacture hand-made carpets. During the initial stages, efforts for improving sheep were aimed at fine wool production by introducing exotic fine wool inheritance. The crossbreeding programs have yielded encouraging results for improving the quality of wool, through developing several fine wool strains/ synthetics (mainly Bharat Merino, Kashmir Merino, and Hisardale). Bharat Merino, a fine wool strain of sheep that evolved at CSWRI with 75% exotic inheritance is now being exhaustively used in the southern region of the country especially Kodai and Nilgiri hills in Tamilnadu and Karnataka for improving the local sheep breed for wool and body growth. Kashmir Merino has succeeded in retaining its charm in the Kashmir valley and is being used for improving local breeds. The wool produced in the temperate region is suitable for apparel and finer carpets, therefore, apparel wool production may be intensified only in the northern temperate hilly region and Nilgiri and Kodai hills of the southern region. In these areas, 3/4th crosses of Rambouillet or Merino including Bharat Merino may be propagated and annual clips may be obtained to meet the requirements for apparel manufacture. In the case of carpet wool, sheep breeds belonging to Rajasthan, Haryana, Gujarat, Madhya Pradesh, and the plains of Uttar Pradesh produce good quality carpet wool except for the wool of Malpura and Sonadi sheep. Presently in the year 2020, about 46.29

Million kg of raw wool is being imported (www.texmin.nic) to meet the requirements of the industry. While it may not be possible to produce the apparel wool in the required quantity there is every possibility of meeting the requirement of carpet wool if suitable and effective development programs are undertaken. India can thrust export trade by making hand-knotted carpets, druggets, hosiery items, etc. Therefore, improving the quantity and quality of carpet wool has to be given priority. As far as carpet quality wool production is concerned, CSWRI Avikanagar developed a strain Avikalin with 50% exotic inheritance that could achieve the defined targets concerning carpet wool quality. However, at present, the native breeds with superior carpet quality traits such as Nali, Chokla, Patanwadi, Marwari, Magra, Jaisalmeri, Pugal, Bhakarwal, Gurez, Gaddi and Rampur Bushair are being favored for enhancing the carpet quality traits and production through selection programs.

Milk production

Sheep husbandry is common for mutton and wool production in almost all the sheep-rearing countries of the world. However, sheep rearing for milk production is not common and is mostly confined to the Middle East and Mediterranean countries. About two-thirds of the total sheep milk produced in the world comes from these countries. In Mediterranean countries, 60% of milk is transformed into special milk products like cheese. The dairy sheep industry is very small in India. Indian sheep breeds produced a small quantity of milk to meet their offspring's requirements and contribute little to human nutrition (Shinde and Naqvi, 2015). Surplus milk if any produced in the villages is consumed as fluid milk and in certain areas converted into ghee and curd (Karim and Shinde, 2008). There is no dairy sheep breed in India. Sheep breeds like Patanwadi and Malpura produced 0.8-1.0 kg of milk daily in early lactation (Saha et al., 2009). The majority of sheep breeds in India produce <0.5 kg milk daily. The milk yield of Patanwadi and Malpura sheep can be improved by crossbreeding with dairy breeds of the Middle East and developed as triple purpose (meat, wool, and milk) animals. This approach will increase milk production besides mutton and provide regular income to farmers from the sale of milk (Shinde and Naqvi, 2015).

Sheep milk is widely produced in different parts of the world. As per the report of FAOSTAT (2019) China, the mainland produced 1.22 million tonnes of fresh sheep milk followed by Turkey (1.19 million tonnes) and Greece (0.83 million tonnes). In India fresh sheep milk is produced in small quantities and not reported in the literature. In most of the countries (China, Syria, Iran, Algeria, Afghanistan, Mali, Niger, Indonesia, Mauritania, Egypt, Albania, Burkino Faso) where the traditional system of sheep rearing is practiced, the average milk mil yield of sheep ranges from 300 to 600 g/day while in other countries like Turkey, Greece, Romania, Italy, and Bulgaria where semi-intensive system and improved breeds are introduced for dairy sheep farming, milk yield ranges from 600 to 1000 g/day.

Indian sheep breeds and milk yield: No attempts have been made in India for improving the milk yield of native sheep either through selection or by crossbreeding with dairy sheep of the Mediterranean region. The milk yield of Indian sheep breeds is presented in (Table 11). A flock of 30 improved dairy sheep of the fat-tailed breed was imported by Nimbkar Agriculture Research Institute (NARI), Phaltan (Maharashtra) from Israel to improve the milk production and growth rates of the local Deccani sheep through crossbreeding. Pure Awassi ewes at NARI produced 475 kg milk (fat content 7-9%) in 238 days (www.nariphaltan.org). At Central Sheep and Wool Research Institute, Avikanagar (Rajasthan) Awassi rams brought from NARI were crossed with Malpura. Awassi × Malpura ewes produce 29% more average daily yield than its counterpart Malpura ewes (366 g) (Arora et al., 2004). Narula et al. (1999) reported that average daily milk yield of 416.86 g and 447.57 g in Malpura and Awassi × Malpura sheep, respectively. Malpura ewes produced a daily milk yield of 531±11.25 g (Mishra et al., 2009). Daily milk yield of 783.75±16.64 g in patanwadi and 515.71±16.46 g in Malpura sheep was recorded in a semi-arid region of Rajasthan under standard feeding and management (Saha et al., 2009).

Sheep milk composition

Sheep milk is rich in proteins, minerals and lipids and its composition is closed to that of buffalo milk. It contains more calcium, phosphate and magnesium and the lipid fraction contains higher proportions of middle-chain fatty acids (Fig. 7). For many people, especially infants, milk and dairy products from sheep are also a medicinal necessity (Haenlein, 1992) as an alternative to cow milk. Sheep milk contains higher total solids and major nutrients than goat and cow milk (Table 12). The composition of sheep goat and cow milk are different and depends upon several factors like diet, breed, parity, season, management, environment, stage of lactation etc. Colostrum content is higher in sheep than in cows: fat is 13.0 and 5.1%, protein 11.8 and 7.1%, lactose 3.3 and 3.6%, mineral 0.9 and 0.9%, total solid 28.0 and 15.06%, respectively (Anifantakis, 1986). Sheep milk has a higher specific gravity (1.0347-1.0384), viscosity (2.86-3.93), freezing point (0.22-0.25) than goat (1.029-1.039, 2.12, and 0.54-0.57) and cow milk (1.0231-1.0398, 2.00 and 0.15-0.18) (Shinde and Naqvi, 2015). Lactose in sheep milk in comparison to goat and cow is similar and less in proportion to their total solid (Ramos and Juarez, 2003). Casein is the major

protein in sheep milk (76-83% of total protein). Sheep milk whey protein accounts for 17-22% of total protein. Sheep milk rich in cysteine and methionine (Shinde and Naqvi, 2015).

Other Challenges

The critical gaps in Indian sheep farming are summarized in (Fig. 8).

Table 11- Milk production traits of Indian sheep breeds and crossbred sheep

Breed/strain	Daily milk yield (g)	Milk yield (kg) in 90 days	Total lactation yield (kg)	Reference
Malpura	418.59±4.54	-	-	Narula <i>et al.</i> , (1999)
	366.07±5.42	-	-	Arora <i>et al.</i> , (2004)
	531.63±11.25	-	-	Mishra <i>et al.</i> , (2009)
	-	Autumn: 66.4; Spring: 53.6	-	Sahni <i>et al.</i> , (1975)
	250.0-500.0	-	21.36 kg in 105 days	Acharya (1982)
Awassi × Malpura	472.32±5.09	-	-	Arora <i>et al.</i> , (2004)
Rambouillet × Malpura	-	Autumn: 69.9; Spring: 53.6	-	Sahni <i>et al.</i> , (1975)
Rambouillet × Chokla	-	Autumn: 60.7; Spring: 46.3	-	
Chokla	-	Autumn: 50.6; Spring: 41.4	-	
Garole × Malpura	436.64±8.43	-	-	Mishra <i>et al.</i> , (2009)
Gaddi	-	-	35.98 kg	Mahajan and Singh (1978)
			40.27 kg in 84 days	
Sonadi	-	-	23.75 kg in 105 days	Acharya (1982)
Muzaffarnagri	100-500	-	-	
Jalauni	300-500	-	-	
Bharat Merino	514±1.0	-	45.3±1.7	Singh (1997)
Rambouillet	418±1.0	-	36.3±2.1	
Patanwadi	783.75±16.64	-	-	Saha <i>et al.</i> , (2009)
Malpura	515±7116.46	-	-	

Table 12- Average composition of basic nutrients in goat, sheep and cow milk

Composition	Sheep	Goat	Cow
Fat %	7.9	3.8	3.6
Solid-not-fat %	12.0	8.9	9.0
Lactose %	4.9	4.1	4.7
Protein %	6.2	3.4	3.2
Casein %	4.2	2.4	2.6
Albumin, globulin %	1.0	0.6	0.6
Non-protein nitrogen %	0.8	0.4	0.2
Ash %	0.9	0.8	0.7
Calories/100 ml	105	70	69

Source: Park *et al.*, 2007 and Anifantakis *et al.*, 1986.

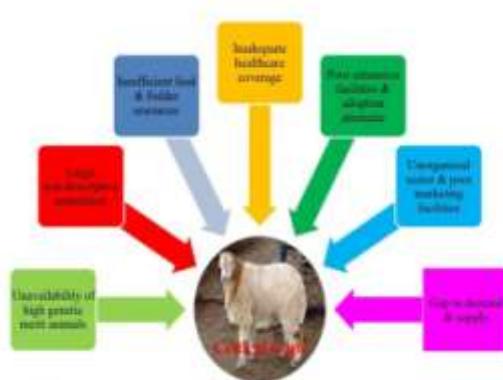


Fig. 8: Critical gaps in Indian sheep farming

Conclusion and recommendations

Sheep husbandry in India is an age-old business where the real stakeholders of the genetic diversity of sheep have been the rural poor farmers and graziers. However, it was seen that the real stakeholders were kept out of the picture while formulating breeding strategies and executing the research objectives. The new-age approach must ensure the active participation of the end-user along with his involvement in carrying out the research and development programs. The following points may be emphasized while formulating the breeding and management objectives.

Farmer's participatory approach should be followed by working hand in hand with the farmers on their sheep flocks with scientific data recording and management. Genetic improvement of sheep for mutton and wool using both farm and field units should be strengthened.

Selection on body weight gain, or live weight at market age, usually six months, which is heritable, should be encouraged to improve the body weight gains and efficiency of conversion of most indigenous breeds. Prolificacy may be incorporated in the breeds wherever possible using prolific Garole sheep, looking into the fact that nutritional and environmental stress is avoided at the best possible and availability of milk with nourished ewes.

Apparel wool production may be intensified only in the temperate areas such as the northern temperate hilly region and Nilgiri and Kodai hills of the southern region. In these areas, 3/4th crosses of Rambouillet or Merino including Bharat Merino may be propagated in addition to Kashmir Merino and annual clips may be obtained to meet the requirements for apparel manufacture. The carpet-type wool-producing breeds such as Nali, Chokla, Patanwadi, Marwari, Magra, Jaisalmeri, Pugal, Bhakarwal, Gurez, Gaddi and Rampur Bushair etc. should be further improved through selective breeding by the distribution of good quality rams of the respective breeds. Efforts should also be made to introduce luster in indigenous carpet wool breeds to harvest maximum returns.

Selection within breeds and pure breeding for most native breeds should be followed for bringing genetic improvement in body weights and mutton characteristics. Selection intensity should be enhanced and germplasm of outstanding merit must be used by covering a large sheep population. Grading up with native breeds such as Muzaffarnagri, Malpura, Mandya etc. may be tried for the non-descript poor-performing breeds for higher growth rate.

The scientific approach for management of breeding, lambing, nutrition, housing, and healthcare must be followed for reducing the losses and fetching more returns to the end-user. A co-operative approach in sheep husbandry at least at a village level may be tried and adopted for better breeding practices, fixation of the prices and net economic benefit to the end-user.

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