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Genetics of some reproduction traits in some sheep breeds from India: A review

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Abstract
Sheep farming is a major source of income for small and marginal farmers of the country besides providing nutritional security during crises. Sheep constitute an important AnGR (Animal Genetic Resource) of the country. For any sheep improvement program, reproductive traits are essential. However, compared with production traits such as growth and wool traits, reproduction traits have received very little emphasis in selection programmes owing to their lower heritability, due to their closer association with fitness traits. Therefore, an attempt is being made in this article to accumulate the research efforts of various researchers and animal scientists on various reproduction traits of various sheep breeds of India.

Keywords: Genetics, reproductive traits, sheep

1. Introduction
Sheep is one of the most promising livestock in the India owing to abundant marketing prospect for its products. Sheep farming is a major source of income for small and marginal farmers of the Country besides providing nutritional security during crises. Sheep is good converter of poor-quality grass and crop residues into high quality protein. Since sheep is an integral part of any agricultural system as well as a great source of income for poor household, sustained genetic improvement of this breed is the need of the hour. In this regard, the reproductive traits are the most important traits in all sheep production systems [1]. However, compared with production traits such as growth and wool traits, reproduction traits have received little emphasis in selection programmes owing to their lower heritability, due to their closer association with fitness traits. Further, since reproduction traits are sex limited traits, they are expressed later in life. Therefore, accurate evaluation and prediction of genetic worth of sheep based on reproduction traits is very difficult due to relatively longer generation interval. Reproductive efficiency as revealed by age at first lambing, lamb crop per year and inter lambing period is one of the most important factors affecting production rate in livestock profitability in sheep breeding. The reproductive efficiency of flock is always determined by reproductive performance of breeding rams and ewes in the flock. Higher level of reproductive efficiency improves the biological and economic efficiency of sheep. The increased reproduction rate spreads the high input costs of maintaining breeding ewes and replacement ewes due to sale of surplus offsprings. The efficient and economic sheep production mainly depends on daily weight gain and ewe reproduction performance i.e conception rate and litter size. Therefore, an attempt is being made in this article to accumulate the research efforts of various researchers and animal scientists on various reproduction traits of various sheep breeds of India.

2. Reproduction Traits in Different Breeds
a. **Age of ewes at first service or first mating (AFS):** For maximum economic returns and genetic gain, reduced age at first mating is a prerequisite as it reduces the generation interval. The age at first service or age at first mating (AFL) of different breeds of sheep from India as reported in literature is presented in Table 1. Least squares means varies among breeds from India and ranged from 11.10±0.10 months in Coimbatore [2] to 775.83±12.94 days in Nali [3].
b. **Weight of ewes at first service (WFL):** There is scanty literature available in print and

electronic media regarding WFL for sheep breeds from India. The trait (kg) was reported for sheep breeds from India as 24.92±0.22 [3], 28.94±0.28 [4], 26.05 ± 0.08 [5] and 29.06±0.16 [6] in Nali, Marwari, Magra, Malpura and Munjal, respectively.

c. Age at first fertile service or conception (AFFS): The trait has been estimated by some researchers for sheep breeds from India and is presented in Table 1. The least squares means for sheep breeds from India varied from 252.67±10.35 days in Garole to 727.17±2.03 days in Rambouillet [7].

d. Weight at first fertile service or first conception (AFFS): [5] in Malpura sheep and [8] in Deccani sheep found WFFS of 26.74 ± 0.09 kg and 24.74 + 0.50 days, respectively.

e. Age at lambing: The age at first lambing is the number of years/months/days between birth and the first time the female animal lambs. The age at first lambing, ultimately influences the lifetime productivity of the animal since, an early lambing results in much faster population turnover and genetic progress within the flock. Average age at first lambing have been worked out by various workers for Indian breeds of sheep with minimum age 330-365 days in Garole breed and maximum age of 1232.91±119.43 days in Gaddi [10]. The average age at first lambing has been reviewed in different breeds from India and is presented in Table 1.

f. Weight at first lambing (WFL): The average weight at first lambing (kg) in sheep breeds from India was 35.44±0.63, 24.46±0.00, 27.94 ± 0.10, 26.91±0.10, 28.29+0.53 and 31.30±0.16 in Munjal ewes, Nali, Malpura, Harnali, Deccani and Munjal sheep reported by [11, 3, 5, 11, 8, 6], respectively. [12] reported WFL in Kashmir Merino sheep of 36.97±0.56 kg and 32.50±0.37 kg under field and farm conditions, respectively.

g. Gestation period (GP): Gestation period is number of days from service to lambing. It is a genetically controlled biological trait. The trait has been worked for Indigenous Meat sheep as 149.90±0.08 days by [12], 153.58±38 days by [13], 149.54±0.06 days by [14] and 5.00±0.00 months [12] in indigenous meat sheep, Pugal, Edka sheep and Kashmir Merino sheep, respectively.

h. Inter-lambing period (ILP): The inter-lambing period is the period between two successive births and depends upon service period and gestation period. Former trait can be controlled to some extent in sheep whereas the latter is a biological trait and controlled genetically. Therefore, ILP can be improved by breeding, proper feeding and management. Inter lambing period has been worked out for some breeds from India and is presented in Table 1 with minimum of 151.95±0.08 by [15] in Nellore and maximum of 439.18±4.84 days [5] in Malpura sheep.

i. Litter size (LS): Litter size is expressed in discrete numbers and is total number of lambs born per lambing. Higher litter size relates to higher selection pressure on other traits in sheep. [7] reported litter size of 1.05±0.00 in Rambouillet Sheep, [17] in Kashmir Merino and Kashmir Merino x Swarna Merino crossbred reported LS of 1.08±0.03 and 1.40±0.04.

j. Service period (SP): The service period was estimated in some Sheep Breeds is from India and is presented in Table 1. The trait was reported in Bharat Merino as 142 ± 26 days by [17] and 155.03 ± 10.71days in Nellore Brown by [9]

Table 1: Average estimates of reproduction traits in different sheep breeds from India.

Breed	Average ± S.E (days)					Reference
	AFS (days)	SP	AFFS	AFL	ILP	
Muzaffarnagri				609±20	-	[18]
Rambouillet Gaddi x Rambouillet				979.07±107.48	430.84±69.21 461.51±60.26	[10]
Merino Gaddi x Merino				963.02±109.88	446.65±70.76 457.60±61.61	[10]
Australian Merino x Rambouillet				911.00±57.66	425.09±37.13 449.03±32.33	[10]
Australian Merino				856.11±64.05	421.27±41.25 485.27±35.9	[10]
Rambouillet				947.32±58.75	471.51±37.8 465.67±32.94	[10]
Gaddi				1232.91±119.43	305.94±76.9 359.76±66.96	[10]
Bharat Merino		142 ± 26	580 ± 13 (FC)	730 ± 13	290 ± 26	[17]
Marwari	579.27 ± 2.24			730.50±2.47	358.09 ± 3.66	[19]
Ganjam (M)			11.36±0.11(FC)	16.49 ± 0.12		[12]
Nali	775.83±12.94			925.08±13.02	351.79±2.56	[20]
Djallonka				622.4±55.6	242.6±20.8	
Coimbatore	11.10±0.10 (M)			16.60±0.10	7.70±0.10	[2]
Indigenous Meat sheep		63.13±0.25	368.81±0.79	518.67±0.81	214.01±0.33	[12]
Muzzafarnagri				16-18	6-8	[21]
Pugal		93.24±0.88		15.47±0.07	283.13±0.95	[13]
Sonadi		124.98±4.22		709.67±8.38	275.08±4.22	[22]
Malpura	650			810	370	
Munjal				530.53±12.39	247.66±4.88	[11]
Chokla (M)				31.9±0.6		[23]
Vizianagaram	389.28±3.11			559.00±6.0	313.23±42.15	[23]
Marwari	640.78±16.97	238.12±8.98		794.15±21.84	384.21±10.10	[24]

Nellore	610.00±3.81			788.39±3.94	420.93±2.76	
Nellore	689.09±1.23			841.04±1.21	151.95±0.08	[15]
Magra	632.76±13.54	216.72±15.13		784.82±14.71	366.13±9.12	[4]
Edka sheep				379.33±1.28	210.66±0.06	[14]
Deccani			632.12±16.93	778.62±6.92	256.40±4.63	[25]
Balochi				731.67±0.3	256.60±0.3	
Malpura	632.52 ± 4.47		689.48 ± 5.28	838.55±5.34	439.18±4.84	[5]
Deccani			489.21±3.55	638.91±3.56	307.90±1.37	[26]
Kashmir Merino				19.74±0.04 (M)		[27]
Harnali				707.05±2.07	402.85±2.40	[11]
Corriedale				882.50±11.33 (M)		
Kashmir Merino(Farm)				37.24±0.60 (M)	13.96±0.47	[11]
Kashmir Merino(Field)				25.23±0.57	10.84±0.19	[11]
Harnali				707.05±2.07	402.85±2.40	[29]
Rambouillet			727.17±2.03	871.04±7.51	368.34± 0.82	[7]
Nellore Brown		155.03 ± 10.71	742.53±6.75	742.53±6.75	304.41±10.71	[9]
Deccani			578.78 + 23.74	728.60 + 25.11		[8]
Harnali				789.91±10.40	-	
Munjal	*563.08±14.43*			713.48±14.02	351.82±1.12	[6]
Kashmir Merino				1090.22±19.45	401.45±22.29	[17]

3. Effect of sire and non-genetic factors different traits:

i. **Effect of sire on different:** Effect of sire was significant (p<0.01) on AFS, WFS, AFL non-significant on SP and ILP [24]. Sire highly significant (0.01) on AFS, WFS, AFL, SP and ILP.

ii. **Effect of period:** The effect of period on AFS, WFS and ILP was highly significant (P≤0.01) whereas significant (P≤0.05) on SP and non-significant on AFL [24, 6] in Munjel reported highly significant effect of period on AFS, WFS, AFL, WFL and FLI, respectively.

iii. **Effect of year of birth:** Variation due to years arises mainly due to difference due to in management and availability of grazing in pastures. The highly significant effect of year on ILP1 (first inter-lambing period) and ILP2 (second inter-lambing period) was observed by [10] in different genetic groups. The highly significant (p<0.01) effect of the year on the AFFS and AFL in Bharat Merino sheep was reported by [17, 4] In Magra, it was observed that year had significant effect on AFS, WFS, AFL, SP and ILP. [26] observed significant effect of year on ILP in Deccani. [8] in Deccani reported highly significant (p<0.01) effect of year on AFC, WFC, AFL and significant (p<0.05) effect on ILP. [9] in Nellore brown reported a highly significant (p>0.01) effect of year on AFC, AFL, SP and ILP. [7] in Rambouillet and [16] Kashmir Merino x Swarna Merino crossbred reported highly significant effect of year on LS. [6] reported highly significant (p<0.01) effect of period on AFS, WFS, AFL, WFL and FLI in Munjal sheep. The significant (p<0.05) effect of year on AFL was observed by [10] in different genetic groups and [16] on AFL in Kashmir Merino sheep. However, [17] reported a non-significant effect of year on SP and ILP in Bharat Merino sheep. Non-significant effect of year on WFS, WFL, GP, AFL and ILP in Nali sheep was observed by [3, 27] reported non-significant effect of year on AFFS and AFL in Kashmir Merino. Non-significant effect of year on AFC and AFL in Deccani sheep were reported by [26, 7, 16] also reported non-significant effect of year on AFFS, AFL ILP and ILP in Rambouillet and Kashmir Merino, respectively. [29] also reported highly significant effect on weight at lambing significant effect on AFL (0.05) and non-significant effect on ILP.

iv. **Effect of season of birth:** [17] in Bharat Merino reported significant effect (p<0.01) of season on AFFS and AFL and non-significant effect on SP and ILP. [20] in Nali reported significant effect of season on AFS and AFL and non-significant effect on ILP. [3] in Nali reported non-significant effect of season on WFS, WFL, GP, AFL and ILP. [7] reported non-significant effect of year on AFFS, AFL, LS and ILP. [27] reported non-significant effect of season in AFFS and AFL in Kashmir Merino. [8] in Deccani reported significant (p<0.01) effect of year on AFC, WFC (p<0.05), AFL (0.05) and ILP. [9] in Nellore brown found a significant (p<0.01) effect of season on SP and ILP and non-significant on AFC, AFL.

v. **Effect of month of birth:** [4] in Magra reported that month of birth had significant effect on AFS whereas non- significant effect on WFS, AFL, SP and ILP0. Effect of sire was significant (p<0.01) on AFS, WFS, AFL and non-significant on SP whereas only significant (P<0.05) on ILP (Gohil, 2010).

vi. **Effect of type of birth:** Rather (2019) in Kashmir Merino reported a non-significant effect of birth type on AF AFL and ILP in Kashmir Merino, respectively.

vii. **Effect of dam's weight:** [3] in Nali reported non-significant effect of age of dam on WFS, WFL, GP, AFL and ILP.

viii. **Effect of age of dam:** [16] non-significant effect of (p>0.01) on LS in Kashmir Merino x Swarna Merino crossbred. [6] reported non-significant effect of period on AFS, WFS, AFL, WFL and FLI in Munjal sheep.

ix. **Effect of parity:** [17] in Bharat Merino reported significant effect (p<0.01) of parity on Sp and ILP and non-significant effect on AFFS and AFL. [9] in Nellore brown significant (0.01) effect of parity on SP and ILP. [16] reported non-significant effect of parity on AFL and ILP in Kashmir Merino.

x. **Effect of farm of birth:** [10] in Rambouiliet Merino and their crosses with indigenous sheep breeds of Northwestern Himalayan region and [16] in Kashmir Merino sheep reported non-significant effect of farm of birth on AFL and first second ILP and AFL ILP, respectively.

4. Heritability estimates of reproduction traits in sheep

Knowledge on genetic parameters and heritability are crucial for the genetic evaluation and for choosing the best selection schemes. Heritability is a pivotal concept in modern animal breeding as it is used to plan breeding programs, determine management strategies, estimate breeding values of individual animals and predict response to selection. It provides an estimate of the degree to which difference between animals are repeated in their progeny. It is thus used to predict the degree of genetic transmission of performance difference between the animals [31]. The heritability estimates for reproductive traits is usually due to presence of lower additive genetic variance and large environment influences. Environment plays a key role in the expression of traits [28]. The heritability of AFL and ILP is presented in Table 2.

5. Estimated average breeding and trends

[6] reported average breeding value of Munjal sires for Age at first service (AFS), Weight at first service (WFS), Age at first lambing (AFL), Weight at first lambing (WFL) and First lambing interval (FLI) were estimated as 555.43 days, 29.09 kg, 706.10 days, 31.30 kg and 352.44 days, respectively. [16] reported average breeding value of Kashmir Merino sires for AFL and ILP as 1098.68±6.28 days and 395.46±7.71 respectively.

i. Phenotypic, genetic and environmental trends

Genetic trend for AFS, WFS, AFL, WFL and FLI estimated by regressing breeding values of traits on year of the birth of the animals were obtained as 11.83 days/year, -0.45 kg/year, 12.53 days/ year, -0.46 kg/year and 3.57 days/year, respectively. Phenotypic trend for AFS, WFS, AFL, WFL and FLI were obtained as 10.93 days/year, -0.42 kg/ year, 11.04 days/year, -0.43 kg/year and 3.93 days/year, respectively. Environmental trends for AFS, WFS, AFL, WFL and FLI were were0.9 days/year, -0.03 kg/year, 1.49 days/year, -0.03 kg/year, -0.36 days/year. [16] reported environmental trends for AFL and ILP as 0.518 and 0.164. [16] reported phenotypic 0.48days /year trends for AFL and ILP as0.48 days/year and 0.727 days/year. [16] reported genetic trends for AFL and ILP as 0.287 days/year and 0.586 days/year.

6. Conclusion

The efficient and economic sheep production mainly depends on daily weight gain and ewe reproduction performance i.e conception rate and litter size. And it may be concluded that reproductive traits should be taken into consideration while making breeding decisions.

Table 2: Heritability estimates age at first lambing period and inter lambing period

Breed	AFS (days)	WFS (kg)	SP	AFL	WFL	ILP	Author (s)
Corriedale x Sonadi				0.85±0.67		0.12±0.07 0.089±0.05 (2)	[30]
Different genetic groups				0.20±0.09		0.12±0.07 0.089±0.05	[10]
Bharat Merino	0.07±0.1			0.12±0.14			[17]
Multibreed meat sheep				0.04		0.06	
Marwari	0.615±0.221	1.369±0.277	0.403±0.194		0.605±0.219	0.431±0.198	[24]
Magra	>1.0	0.70±0.22	0.32±0.19		>1.0	0.26±0.19	[4]
Malpura	0.09±0.05	0.39 ± 0.06		0.11±0.0.05	0.11 ± 0.05	0.00±0.04	[5]
Harnali				0.02±0.05	0.05±0.06	0.01±0.05	[29]
Harnali				0.38±0.16			
Synthetic sheep				0.70±0.19		0.39±0.15	
Corriedale				0.11 ±0.06		-	
Rambouillet				0.05±0.03		0.01±0.03	[7]
Munjal	0.19 ± 0.12	0.24 ± 0.15		0.17.±0.10	0.27 ± 0.15	0.05±0.01	[6]
Harnali				0.38±0.16			
Kashmir Merino				0.06±0.06		0.15±0.09	[16]

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