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Influence of non-genetic factors on growth traits of Deccani sheep

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Abstract
The present study was carried out to study the influences of various non-genetic factors on growth traits of 2590 Deccani lambs maintained at ICAR-Network Project on Sheep (Deccani) Improvement, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra (India) for the period from January 2011 to December 2020. The growth traits included birth weight (BWT), weaning weight (WWT), six months weight (SWT), nine months weight (NWT), and yearling weight (YWT). The general linear model comprising the effects of non-genetic factors such as year of birth, season of birth, sex of lamb, age and weight of dam at lambing on targeted growth traits was used in this study. The overall least-squares means (along with standard error) for BWT, WWT, SWT, NWT and YWT were 3.26 ± 0.01, 13.32 ± 0.05, 21.43 ± 0.08, 24.56 ± 0.09, 27.32 ± 0.10 kg, respectively. It was revealed from the results that year of birth had significant influence on all growth traits, with weights were increasing over the years. The weights were significantly higher for male lambs, lambs born during dry season (April to September) and lambs born from older ewes as well as from heavier ewes. It was concluded that special emphasis on managemental practices should be given according seasonal variations. Additionally, extra care of younger ewes and ewes who have less weight during pregnancy is required for better growth performance of Deccani lambs.

Keywords: Deccani sheep, growth traits, season, year and sex of lamb

1. Introduction
Sheep farming system is one of the most important farm systems in India which provides income mainly to rural livelihoods through meat and wool. The total Sheep in the country is 74.26 million in 2019, increased by 14.1% over previous Census (Livestock census, 2019) [12]. Deccani sheep is an indigenous breed of sheep, mainly found in semi-arid areas of Maharashtra, Andhra Pradesh, Telangana and Karnataka states of India. It ranks second total sheep population in India with 6.22 million heads. It is mutton purpose breed and plays a pivotal role in rural areas by providing income to livelihood.
Growth performance of lambs is directly associated with the economic viability of flock, which plays an important role in farm profitability (Topal *et al*., 2004; Abegaz *et al*., 2010; Nimase *et al*., 2017; Bangar *et al*., 2018; Mahala *et al*. 2019; Bangar *et al*., 2021) [21, 1, 18, 2, 15, 4]. Various effects influence growth of lambs and subsequently affects the farm income to farmers. Additionally, an increasing demand of fast-growing lambs with excellent meat yields warrants the possible ways for improving the growth traits in early age of life. As mentionedin the literature, the non-genetic effects such as year and season birth, sex of lamb and mothers' traits have been influencing the growth performance of lambs (Dixit *et al*., 2001; Ulutas *et al*., 2010; Gbangboche *et al*., 2011; Mandal *et al*. 2016; Karmakar *et al*., 2018; Bangar *et al*., 2020; Ghaderi-Zefrehei *et al*. 2021; Magotra *et al*., 2022) [5, 22, 6, 16, 10, 3, 9, 14]. The study of those factors is essential for directing managemental practices at the farm for improving the growth of the lambs. In addition to this, the knowledge of potential factors is crucial when performing genetic analysis for setting the breeding programs (Lambe *et al*. 2006; Lupi *et al*., 2016) [11, 13]. Thus, such studies have been performed with a purpose to obtain the greatest economic profit in the shortest time possible. Therefore, the present study was carried out to determine the influences of various non-genetic factors on growth traits of Deccani sheep.

2. Materials and Methods
2.1 Study area and data collection
The present study was conducted at ICAR-Network Project on Sheep (Deccani) Improvement, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra (India) by collecting the data records of 2590 lambs for the period from January 2011 to December 2020.

The body weights up to 12 months of age along with other information such as year and season of birth, sex of lamb and dam's age and weight at lambing were compiled from inventory and monthly weight registers. The farm managerial practices followed at the project were almost uniform throughout the year. The grazing of flock along with feeding of green and dry fodders was followed routinely at farm. Concentrate was also fed to animals according to nutritional requirements of animals. The weaning period for lambs was three months of age and the selection criteria for rams was based on their progeny's six months weights.

The non-genetic factors included year of birth, season of birth [Main (October-March) and Off (April-September)], sex of lambs (male and female), dam age at lambing (< 3, 3-4.5, 4.5-6, ≥ 6 years) and dam weight at lambing (<30, 31-32, 33-34, 35-36 and >36 kg). The growth traits used in this study were birth weight (BWT), weaning weight (WWT), six months weight (SWT), nine months weight (NWT), and yearling weight (YWT).

2.2 Statistical analysis

The following general linear model was used to determine significant influences of various non-genetic factors on growth traits in Deccani sheep.

$$Y_{ijklmn} = \mu + P_i + B_j + S_k + A_l + D_m + e_{ijklmn}$$

Where, Y_{ijklmn} represents observation of growth trait, μ represent Overall mean, P_i represents fixed effect of i^{th} year of birth (i = 1 to 10), B_j represents fixed effect of j^{th} season (j = 1, 2), B_j represents fixed effect of k^{th} sex (j = 1, 2), A_l represents fixed effect of l^{th} group of dam's age at lambing (l=1 to 4), D_m represents fixed effect of m^{th} group of dam's weight at lambing (l=1 to 5) and e_{ijkl} represents random error component NID (0, σ^2_e). The results of general linear model were presented as least-squares means along with standard error. The pairwise comparison was done using Duncan test. The statistical significance was considered if $p<0.05$. The statistical analysis was performed using SPSS software.

3. Results and Discussion

The least-squares means and effects of non-genetic factors on various growth traits in Deccani sheep are shown in Table 1. The overall least-squares means (along with standard error) for BWT, WWT, SWT, NWT and YWT were 3.26 ± 0.01, 13.32 ± 0.05, 21.43 ± 0.08, 24.56 ± 0.09, 27.32 ± 0.10 kg, respectively. These results were in close agreement with reports of Dixit *et al*. (2001) in Bharat merino, Mahala *et al*. (2019) [15] in Avikalin, Bangar *et al*. (2020) [3] in Harnali and Tesema *et al*. (2022) [19] in Dorper × indigenous sheep. However, the present estimates were higher than the reports of Sharma *et al*. (2022) [20] in Sonadi sheep.

Table 1: Least squares means (±standard error) for various growth traits in Deccani sheep

Factor	Level	BWT	WWT	SWT	NWT	YWT
Overall		3.26 ± 0.01 (2590)	13.32 ± 0.05 (2346)	21.43 ± 0.08 (1873)	24.56 ± 0.09 (1539)	27.32 ± 0.10 (1317)
Year of birth		**	**	**	**	**
	2011	3.23 ± 0.03^{b} (191)	10.81 ± 0.17^{a} (180)	16.44 ± 0.23^{a} (173)	19.9 ± 0.25^{a} (167)	23.98 ± 0.26^{a} (159)
	2012	3.41 ± 0.02^{d} (224)	11.16 ± 0.16^{a} (207)	17.22 ± 0.22^{b} (184)	21.18 ± 0.25^{b} (159)	24.84 ± 0.27^{b} (143)
	2013	3.27 ± 0.02^{bc} (233)	11.61 ± 0.16^{b} (204)	19.64 ± 0.22^{c} (172)	24.09 ± 0.25^{d} (153)	27.29 ± 0.27^{c} (140)
	2014	3.35 ± 0.02^{cd} (296)	14.29 ± 0.14^{d} (277)	20.22 ± 0.19^{d} (252)	22.66 ± 0.22^{c} (212)	25.22 ± 0.25^{b} (174)
	2015	3.33 ± 0.02^{cd} (349)	15.02 ± 0.13^{e} (320)	20.91 ± 0.18^{d} (265)	23.34 ± 0.23^{d} (198)	27.02 ± 0.27^{c} (147)
	2016	3.10 ± 0.02^{a} (228)	13.82 ± 0.16^{c} (197)	23.5 ± 0.24^{e} (158)	25.57 ± 0.28^{e} (123)	28.34 ± 0.33^{d} (101)
	2017	3.22 ± 0.02^{b} (250)	13.71 ± 0.16^{c} (210)	23.77 ± 0.31^{ef} (94)	26.65 ± 0.36^{ef} (77)	28.52 ± 0.44^{d} (58)
	2018	3.22 ± 0.02^{b} (248)	14.24 ± 0.15^{d} (228)	24.09 ± 0.21^{f} (196)	26.95 ± 0.28^{f} (134)	29.83 ± 0.31^{e} (118)
	2019	3.22 ± 0.02^{b} (313)	14.36 ± 0.13^{d} (288)	24.09 ± 0.19^{f} (240)	27.76 ± 0.23^{g} (194)	29.42 ± 0.25^{e} (174)
	2020	3.22 ± 0.02^{b} (258)	14.16 ± 0.16^{d} (235)	24.46 ± 0.26^{g} (139)	27.47 ± 0.30^{g} (122)	28.75 ± 0.34^{e} (103)
Season		*	NS	*	**	NS
	Main (Oct-Mar)	3.24 ± 0.01^{a} (1769)	13.32 ± 0.06 (1584)	21.25 ± 0.09^{a} (1249)	23.94 ± 0.10^{a} (1021)	27.16 ± 0.11 (865)
	Off (Apr-Sept)	3.28 ± 0.01^{b} (821)	13.32 ± 0.08 (762)	21.62 ± 0.12^{b} (624)	25.17 ± 0.14^{b} (518)	27.48 ± 0.16 (452)
Sex		**	**	**	**	**
	Male	3.33 ± 0.01^{b} (1364)	13.74 ± 0.07^{b} (1241)	22.71 ± 0.10^{b} (993)	26.26 ± 0.12^{b} (793)	29.45 ± 0.14^{b} (652)
	Female	3.18 ± 0.01^{a} (1226)	12.90 ± 0.07^{a} (1105)	20.16 ± 0.10^{a} (880)	22.85 ± 0.12^{a} (746)	25.19 ± 0.13^{a} (665)
Dam age (years)		*	NS	NS	NS	NS
	< 3	3.23 ± 0.02^{a} (662)	13.14 ± 0.10 (600)	21.28 ± 0.14 (466)	24.4 ± 0.17 (370)	26.96 ± 0.19 (318)
	3-4.5	3.28 ± 0.01^{b}	13.35 ± 0.09	21.28 ± 0.13	24.36 ± 0.15	27.46 ± 0.18

		(721)	(661)	(540)	(453)	(371)
	4.5-6	3.26 ± 0.02^{b} (566)	13.31 ± 0.10 (513)	21.54 ± 0.15 (407)	24.75 ± 0.17 (340)	27.51 ± 0.19 (309)
	≥ 6	3.27 ± 0.01^{b} (641)	13.48 ± 0.10 (572)	21.64 ± 0.14 (460)	24.72 ± 0.17 (376)	27.36 ± 0.19 (319)
Weight at lambing (kg)		**	**	**	*	*
	<30	3.18 ± 0.02^{a} (572)	13.05 ± 0.1^{a} (505)	20.88 ± 0.15^{a} (435)	24.63 ± 0.17^{ab} (363)	27.37 ± 0.19^{ab} (320)
	31-32	3.24 ± 0.02^{b} (361)	13.00 ± 0.13^{a} (334)	21.04 ± 0.19^{a} (266)	24.12 ± 0.22^{a} (227)	26.86 ± 0.24^{a} (187)
	33-34	3.23 ± 0.02^{bc} (589)	13.30 ± 0.10^{b} (537)	21.58 ± 0.15^{bc} (413)	24.41 ± 0.18^{a} (326)	27.17 ± 0.20^{ab} (270)
	35-36	3.29 ± 0.02^{c} (662)	13.56 ± 0.10^{b} (597)	21.63 ± 0.15^{c} (445)	24.47 ± 0.18^{a} (351)	27.36 ± 0.20^{b} (310)
	>36	3.35 ± 0.02^{d} (406)	13.69 ± 0.12^{b} (373)	22.05 ± 0.17^{b} (314)	25.15 ± 0.20^{b} (272)	27.84 ± 0.23^{b} (230)

Different superscripts (a, b, c, d, e, f, g) differ significantly among levels of same factor in same column. NS: Non-significant, *Significant at 5% level, **Significant at 1% level, Figures in parenthesis indicate number of observations

The results of general linear model showed that year of birth had significant (p<0.05) influence on all growth traits under the study. The significant influences of year of birth on growth traits in sheep also observed by Gbangboche *et al*. (2006) [7] in Djallonke, Mandal *et al*. (2016) [16] in Muzaffarnagari, Kannojia *et al*. (2016) [9] in Marwari, Karmakar *et al*. (2018) [10] in Garole, Ghaderi-Zefrehei *et al*., (2021) [8] in Lori Bakhtiari, Magotra *et al*. (2022) [14] in Munjal; Sharma *et al*. (2022) [20] in Sonadi and Tesema *et al*. (2022) [19] in Dorper × indigenous sheep. The birth weight of lambs did vary significantly across the years and it was maximum in initial years of the study specially up to year 2015, however, lower birth weight was observed post year 2015. The other growth traits such as WWT, SWT, NWT and YWT have been significantly increased over the years. The periodical variation for growth traits in the current study might be due to availability of fodder and managemental practices followed at the farm. Also, the breeding program for genetic improvement of Deccani sheep played significant role for increasing body weights over the years.

It was observed that season of lambing had significant (p<0.05) influence on BWT, SWT and NWT traits. In case of these growth traits, the higher weights were observed for lambs which born during off season that those during mean season. The effect of season of lambing on growth traits was in agreement with reports of Mandal *et al*. (2016) [16] in Muzaffarnagari and Karmakar *et al*. (2018) [10] in Garole sheep. Similar to the present findings, Tesema *et al*. (2022) [19] and Sharma *et al*. (2022) [20] also reported that body weight at birth and six month of age was higher during dry season than main season in Dorper × indigenous sheep and Sonadi sheep, respectively.

In case of sex of lambs, male lambs were significantly (p<0.05) heavier than female lambs at all stage of life under this study. It is well reported findings in various breeds of sheep by several authors (Dixit *et al*., 2001 [5]; Ulutas *et al*., 2010 [22]; Gbangboche *et al*., 2011 [6]; Mandal *et al*. 2016 [16]; Lupi *et al*., 2015; Kannojia *et al*., 2016 [10]; Karmakar *et al*., 2018 [10]; Ghaderi-Zefrehei *et al*. 2021 [9]; Magotra *et al*., 2022) [5, 22, 6, 16, 10, 9, 14]. Higher birth weight may be due to the availability of good quality grasses to dams during April to September for development of fetus (Sharma *et al*. 2022) [20]. The higher wights in male lambs than female lambs might be due to more influence of sex hormones (androgen) on muscle development of males than females (Tesema *et al*. 2022) [19].

The age of dam at lambing showed significant effect on birth weight of lambs in Deccani sheep. The other growth traits of lambs born to young or older dams at lambing were statistically (p>0.05) at par. The birth weight of lambs born out of younger dam which aged less than 3 years was lower than older dams at lambing. These findings were in accordance with reports of Dixit *et al*. (2001) [5] in Bharat Merino, Karmakar *et al*. (2018) [10] in Garole, Magotra *et al*. (2022) [14] in Munjal and Tesema *et al*. (2022) [19] Dorper × indigenous sheep. The younger dam had lower weights of lambs due to lack of development of their physical growth (Ghaderi-Zefrehei *et al*. 2021) [9].

The weight of dam at lambing was significantly associated with all growth traits in Deccani sheep and it was observed that higher weights were observed for heavier dams at lambing. The similar findings were also reported by Dixit *et al*. (2001) [5] in Bharat Merino lambs. Narula *et al*., (2017) [17] also observed significant influence of dam's weight at lambing on all growth traits in Magra sheep.

4. Conclusions

The present study investigated the effects of non-genetic factors on growth traits in Deccani sheep and it was observed that year of birth, season of lambing, sex of lamb, weight and age of dam at lambing had significant influences on targeted traits. Male lambs were heavier than female lambs. The body weights of lambs had increasing trends years but extra care is required during main season for further improvement of lambs. It was concluded that nutritional management of dams aged up to 3 years, pregnant ewes and dam with weight less than 30 kg is essential for better growth performance of their lambs.

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6. Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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