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Genetic study on growth efficiency in Sirohi goats under field condition

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Abstract
A study was conducted to estimate the pre- and post-weaning growth efficiency (GE) in 6748 Sirohi goats born during 2005 to 2017 under field conditions. The overall least-squares mean for pre-weaning (0-3M) and post-weaning (3-12M) growth efficiencies were 4.31±0.09 and 1.10±0.031 Kg per kg, respectively. Sire, type of birth, sex of kid and cluster had highly significant ($P \leq 0.01$) effect on both pre and post-weaning relative growth efficiencies whereas year of birth, season of birth and parity had highly significant effect ($P \leq 0.01$) only on pre-weaning growth efficiency. Heritability estimates for pre- and post-weaning growth efficiencies were 0.53±0.06 and 0.44±0.06, respectively. Genetic and phenotypic correlation between two traits was negative.

Keywords: Sirohi goat, growth efficiency, least-squares mean, heritability, genetic correlation, phenotypic correlation

Introduction
Goat plays a significant role in providing supplementary income and livelihood to millions of resource poor farmers and landless laborers of rural India. As per 19th Livestock Census, 2012, goat with a population of 135.17million, constitutes 26.46% of total livestock population in India. Rajasthan, a leading state in goat husbandry, is endowed with 3 registered breeds i.e. Marwari, Sirohi and Jhakrana among 34 breeds of goat registered in the country [1]. Among these three registered breeds; Sirohi breed is predominant in central and southern Rajasthan covering the Arawali hilly area. The breed is also known as Parbatsari, Devgarhi and Ajmeri. Sirohi goat has the quality of disease resistance, adaptability in dry and hot climates and ability to perform under adverse climatic conditions.

To enhance the economic viability of a breed, improvement in its performance is an essential phenomenon. To achieve this aim, selection of elite animals having desirable performance regarding economic gain for future breeding is the only foundation stone for long term improvement in the whole population. Performance of a goat is determined by not only on quantity and quality of production but also on cost of production. Selection of the individuals having desirable performance at an early stage fastens the improvement and lowers the cost of rearing.

Rapid growth until slaughter weight is an important goal for increased meat production. Growth rate at different ages help to determine the right marketable age of kids' for higher economic return and carcass quality. It facilitates better survivability and faster genetic improvement by decreasing generation interval and increasing replacement rate [2]. Growth rate is also a useful check of the system of feeding and management [3].

Growth efficiency (GE) is the weight gain during a given time interval in relation to the weight at the beginning of the time interval [4]. It expresses the proportionate weight gain in comparison to initial weight. It may also be expressed in percentage. Higher growth efficiency in pre-weaning stage indicates early selection [5].

Scanty of research was conducted on growth efficiency in Sirohi goats. Hence, the present investigation was planned to estimate the pre- and post-weaning growth efficiencies and genetic and non-genetic factors affecting them with genetic parameters in Sirohi goats under field condition to be incorporated as one of the objectives in future breeding strategies.

Materials and Methods

The data were collected from Sirohi goats of registered farmers of different clusters under ICAR sponsored All India Co-ordinated Research Project *(*AICRP*)* on goat improvement, Sirohi Field Unit, Livestock Research Station, Vallabhnagar, Udaipur, Rajasthan during the period 2005 to 2017**.** The Sirohi goats are being maintained under field grazing **(**Extensive system**)** in project area**.** Goats remained on pasture every day six to eight hours for grazing. Kids are weaned at the age of 3 months.

For the study, sire was taken as random effect whereas year of birth, season of birth, sex of kid, type of birth, cluster and parity were taken as fixed effects. Season of birth was classified as rainy (July- October), winter (November-February) and summer (March-June).Sex was classified as male and female, type of birth as single and multiple, clusters as Vallabhnagar, Railmagra, Deogarh, Nathdwara, Bhadsoda, Karget, Bojunda and Salumber and Parity as 1 to 5.

The growth efficiency was calculated by following formula:-

$GE = (W_2-W_1)/W_1$

Where

GE= Growth efficiency

W_2-W_1 = Weight gain during a given time interval (In Kg.)

W_1 = Initial body weight (In Kg.)

Since the subclass numbers were unequal and disproportionate, data were analyzed through Mixed Model Least-Squares and Maximum Likelihood method designed by Harvey **[6]** to estimate the least-squares means and genetic parameters.

The model used for analysis was as follows:

$Y_{ijklmnop} = \mu + A_i + B_j + C_k + D_l + E_m + F_n + G_o + e_{ijklmnop}$

Where,

$Y_{ijklmnop}$ = performance record of the p^{th} progeny of i^{th} sire belonging to j^{th} cluster, k^{th} season of birth, l^{th}year of birth, m^{th} parity, n^{th} type of birth and o^{th} sex**.**

μ = Population mean

$\mathbf{A_i}$= Random effect of sire

$\mathbf{B_j}$= Fixed effect of j^{th} cluster **(**j = 1,2,3,4,5,6,7,8**)**

$\mathbf{C_k}$= Fixed effect of k^{th} season of birth **(**k = 1, 2, 3**)**

$\mathbf{D_l}$= Fixed effect of l^{th}year of birth **(**l = 1, 2, 3, 4…13)

$\mathbf{E_m}$= Fixed effect of m^{th} parity **(**m= 1,2,3,4, ≥ 5**),**

$\mathbf{F_n}$= Fixed effect of n^{th} type of birth**(**n = 1, 2**)**

$\mathbf{G_o}$= Fixed effect of o^{th} sex**(**o = 1, 2**)**

$e_{ijklmnop}$= Residual random error associated with $Y_{ijklmnop}$ and assumed to be identically and independently distributed with mean zero and constant variance**.**

Duncan's Multiple Range Test (DMRT) as modified by Kramer [7] was used to make pair wise comparison among the least squares means.

Results and Discussion

The overall least-squares mean for pre-weaning (0-3M) and post-weaning (3-12M) growth efficiencies were 4.31±0.09 and 1.10±0.031 Kg per kg, respectively which are shown in Table no. 1. From the findings, it could be concluded that 3M body weight is about 5.31 times of birth weight and 12M body weight is 2.1 times of 3M body weight in Sirohi kids. Further, it was also observed that growth efficiency was about 4 times higher during suckling stage than post-weaning period. This might be due to effect of dam's milk during suckling stage which serves as a complete nutritious food for kid. The finding during pre-weaning period was in close agreement as 4.26±0.16 kg/kg in Sirohi goats [3], 3.98±0.08 kg/kg in Pantja goats [5]. However, lower estimates were also reported in Chegu kids as 2.35±0.04 kg/kg [8], 3.1967±0.10 kg/kg [9] and 3.11±0.08 kg/kg in Tellicherry goats [10], 2.30±0.03 kg/kg in Black Bengal goats [11] and 3.71 kg/kg in Raieni Cashmere goats [12] which might be due to breed difference.

The mean during post-weaning period was similar to Tellicherry goats as 1.34±0.05 [10], as 0.9441±0.019 in Magra sheep [13] and 0.95±0.03 Kg/kg in Muzaffarnagari sheep [14]. However, lower estimate was also reported as 0.62 in Baluchi sheep [15].

Table 1: Least square means (±SE) of Growth Efficiency (Kg/kg) in Sirohi goat

Effect	GE1 (0-3M)	GE2 (3-12M)
Overall	4.31±0.09 (6748)	1.10±0.031(3070)
Sire	**	**
Year of birth	**	NS
2005	$3.55±0.15^{ab}$ (321)	1.07±0.066(191)
2006	$3.66±0.13^{b}$ (395)	1.05±0.054(183)
2007	$3.50±0.12^{a}$(467)	1.11±0.052(305)
2008	$3.99±0.12^{c}$(566)	1.05±0.051(267)
2009	$4.64±0.11^{e}$(540)	1.05±0.045(189)
2010	$4.59±0.11^{e}$(473)	1.10±0.047(209)
2011	$4.78±0.11^{f}$(528)	1.14±0.047(203)
2012	$4.62±0.11^{e}$(602)	1.11±0.046(218)
2013	$4.26±0.11^{d}$(417)	1.12±0.046(177)
2014	$4.32±0.12^{d}$(385)	1.08±0.052(192)
2015	$4.66±0.13^{e}$(757)	1.13±0.056(348)
2016	$4.60±0.13^{e}$(774)	1.13±0.058(358)
2017	$4.80±0.14^{f}$(523)	1.13±0.058(230)
Season of birth	**	NS
Rainy- July to Oct	$4.24±0.09^{a}$(2450)	1.08±0.032(1037)
Winter-Nov to Feb	$4.35±0.09^{b}$(3039)	1.10±0.031(1470)
Summer- March to June	$4.33±0.09^{b}$(1259)	1.11±0.033(563)
Type of birth	**	**
Single	$3.59±0.09^{a}$ (4423)	$1.04±0.031^{a}$(2199)
Multiple	$5.02±0.09^{b}$(2325)	$1.16±0.032^{b}$(871)
Sex	**	**
Male	$4.24±0.09^{a}$(3366)	$1.13±0.032^{b}$ (1002)
Female	$4.36±0.09^{b}$(3382)	$1.06±0.031^{a}$ (2068)
Cluster	**	**
Vallabhnagar	$4.87±0.13^{d}$(289)	$0.97±0.081^{c}$(54)
Railmagra	$5.41±0.11^{e}$(834)	$0.89±0.051^{bc}$(328)
Devgarh	$4.61±0.11^{c}$(3275)	$0.87±0.047^{b}$(1905)
Nathdwara	$5.35±0.17^{e}$(169)	$0.68±0.09^{a}$(40)
Bhadsoda	$4.85±0.10^{d}$(1333)	$1.11±0.047^{d}$(311)
Karget	$2.46±0.15^{a}$(319)	$2.03±0.069^{e}$(169)
Bojunda	$2.52±0.14^{a}$(436)	$1.12±0.064^{d}$(263)
Salumber	$4.37±0.20^{b}$(93)	----
Parity	**	NS
1	$4.42±0.09^{d}$(1513)	1.11±0.033(802)
2	$4.31±0.09^{bc}$(1346)	1.09±0.032(632)
3	$4.33±0.09^{c}$(1201)	1.11±0.033(537)
4	$4.23±0.09^{ab}$(891)	1.09±0.034(403)
5 & above	$4.24±0.09^{a}$(1797)	1.09±0.033(696)

Effect of Sire

Sire had highly significant effect ($P \leq 0.01$) on pre- and post-weaning growth efficiencies in Sirohi goats under field condition. Similar results were found by in Sirohi goats [3] and in Pantja goats [5] for GE (0-3M).

Effect of year of birth

Year of birth had highly significant effect ($P \leq 0.01$) on pre-

weaning growth efficiency whereas its effect was non-significant on post-weaning growth efficiency. Pre-weaning growth efficiency was the maximum in year 2017 whereas it was the minimum in year 2007. Post-weaning growth efficiency was higher in year 2011 whereas it was the minimum in year 2006, 2008 and 2009, though difference was non-significant. Thus, it was clear that growth efficiency had somewhat increasing trend from 2005 to 2017 which might be due to continuous selection programme. The difference in performance for GEs over the years may be due to variation in climatic conditions and availability of fodder. Similar results were obtained in Chegu kids [8], Sirohi goats [3], Tellicherry goats [10] and in Raieni Cashmere goats [12].

Effect of season of birth

Season of birth had highly significant effect ($P \leq 0.01$) on pre-weaning GE but non-significant on post-weaning GE. For 0-3M age, GE was higher of kids born during winter or summer season and lower in rainy season which might be due to more environmental stress and disease risk during monsoon which negatively affects the growth rate. In southern Rajasthan, there is plenty of grazing material having high dry matter content from March to June whose grazing provides more nutrients to animals. On other hand, being its post-harvest time and more grazing time due to increased day length, goats had more feed intake. As a result of all these reasons, kids had higher growth rate during summer.

The results were in concordance with Chegu kids [8], Sirohi goats [3] and Tellicherry goats [10]. However, non-significant effect of season on 0-3M growth efficiency was also reported in Tellicherry goats [9], in Black Bengal kids [11] and in Pantja goats [5] which might be due to difference in population and environmental conditions.

Effect of type of birth

Type of birth had highly significant ($P \leq 0.01$) effect on both pre- and post-weaning growth efficiencies in Sirohi goats. For both age durations, kids born as multiples had higher growth efficiency than single born due to compensatory growth phenomenon. Another reason may be use of initial body weight as denominator in calculation of GE which is usually lower in multiple than single for same age group. Same findings were noted in Sirohi goats [3], in Pantja goats [5] and in Raieni cashmere goats [12].

However, non-significant effect of type of birth was also reported in Tellicherry goats [9, 10] as well as in Black Bengal goats [11].

Effect of sex of kid

Sex of kid had highly significant ($P \leq 0.01$) effect on both pre- and post-weaning growth efficiencies in Sirohi goats. In both age durations, male had higher growth efficiency than females which is due to testosterone hormone effect. The results were in concordance with Chegu goats [8] and Pantja goats [5]. Non-significant effect of sex on growth efficiency was reported in Sirohi goats [3], in Tellicherry goats [9, 10], in Black Bengal goats[11]and in Raieni cashmere goats [12]. The difference may be due to variation in population under study.

Effect of Cluster

Cluster had highly significant ($P \leq 0.01$) effect on both pre- and post-weaning growth efficiencies in Sirohi goats. For GE (0-3M) Railmagra was first whereas Karget stood first regarding post-weaning GE. The cause of variation among clusters might be due to management practices and availability of feeds. Similar finding were observed in Sirohi goats [3] and in Pantja goats [5]. The estimate of post-weaning GE for cluster 'Salumber' could not be calculated due to non-availability of data of 12M body weight.

Effect of Parity

Parity had highly significant ($P \leq 0.01$) effect on pre-weaning GE whereas its effect was non-significant on post-weaning RGR. Kids born in first or second parity had higher growth efficiency than kids born in later parities which might be due to optimum physiological stamina of dam during early age to produce more milk. After weaning, growth rate chiefly depends on grazing that's why; the effect of parity in post weaning GE was non-significant. Significant effect of parity on pre-weaning GE was also recorded in Tellicherry goats [9] and in Black Bengal goats [11] whereas non-significant effect of parity on pre-weaning GE was reported in Sirohi goats [3], Tellicherry goats [10] and Pantja goats [5] which may be due to spatial or temporal difference in sample.

Genetic parameters

Heritability estimates of both traits were estimated from sire component of variance by paternal half sib relationship by Mixed Model Least-Squares and Maximum Likelihood method [6].Heritability estimates for pre- and post-weaning growth efficiency were 0.53±0.06 and 0.44±0.06. The results showed that pre- and post-weaning GEs are medium to highly heritable traits. The heritability estimates provides a scope that individual selection alone may be used for selection in case of non-availability of other information.

Lower estimates for GE (0-3M) were reported in Chegu goats as 0.03±0.044 [8], 0.315±0.117 in Sirohi goats [3], in Tellicherry goats as 0.224±0.10 [10], as 0.24±0.08 in Pantja goats [5] and as 0.07±0.03 in Raieni cashmere goats [12]. Heritability for post-weaning GE was also reported as 0.246±0.201in Tellicherry goats [10]. Heritability estimates of the growth efficiencies in the present study was found on higher side from other references which might be due to difference in population under study or method of estimation or environmental variation.

The genetic correlation between two traits was -0.64±0.10 whereas phenotypic correlation was -0.38. Thus, both the correlations were negative showing that kids having higher GE in pre-weaning stage had lower GE during post-weaning stage which might be due to compensatory growth effect. Similar findings were reported by in Pantja goats [5].

Conclusion

The present investigation revealed that in Sirohi goats, pre-weaning growth efficiency was very higher than post-weaning growth efficiency. Multiple born kids had higher growth efficiencies which suggest for setting of breeding plan to get multiple births which would provide more economic gain to farmers. Medium to high heritability of growth efficiency offer a scope for individual selection for further genetic improvement.

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