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Impact of Non-genetic Factors on Kleiber Ratio in Field Flocks of Marwari Goat

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ABSTRACT

Background: The Kleiber ratio in a goat is an important parameter related to feeding and health care. The present study was undertaken to assess the kleiber ratio of 3079 Marwari goats (born from 2016 to 2021) of registered farmers under the All India Coordinated Research Project on goats (Marwari goat field unit) in semi-arid region of Rajasthan.

Methods: The linear mixed model used for kleiber ratio estimation included: year of birth, sex, cluster, birth type and age of dam as fixed factors.

Result: Overall least-squares means (LSM) for Kleiber ratio (KR) from birth to 3 months (KR1), 3 to 6 months (KR2) and 6 to 12 months (KR3) were 12.89±0.03, 9.69±0.05 and 4.59±0.06, respectively. Year of birth and cluster had highly significant effect on all KR. The birth type had significant on all KR except KR1. The non-significant effect of sex and age of dam were observed on all KR except KR1. The study revealed that the KR was affected by different non-genetic factors. The heritability estimates for KR1, KR2 and KR2 were 0.66±0.28, 0.07±0.07 and 0.54±0.26, respectively.

Key words: Kleiber ratio, Marwari goat, Mixed model, Non-genetic factors, Heritability.

INTRODUCTION

Natural pasture is the major source of food for goat in India. The capability of pasture productivity is not expected throughout the year, particularly during the autumn and winter months and as a result, animals must be hand fed for a portion of the year (up to 6 months). For all types of animal production systems, feed is a major expense for the most typical farm animal species accounting for 60 to 80 per cent of total expenditures (Montanholi *et al.,* 2008). Improved feed conversion efficiency is an important criterion for any selection program to be effective in terms of growth and production. The Kleiber ratio (KR), defined as growth rate/body mass was suggested for measuring growth efficiency (Kleiber, 1947). KR and feed efficiency are strongly correlated and animals having a higher KR need less energy to maintain their fitness. The effectiveness of food transformation in animal products is essential for the profitability of production systems. Selection of animals based on feed utilization and conversion ratio is one technique to improve the efficiency of meat output. Because individual goat varies in their capacity to utilize feed effectively, selection of the most efficient animals results in a much-reduced cheaper production, selecting the most efficient animals results in a much-reduced cheaper production cost. While direct selection for lesser regular maintenance is challenging, we may identify efficient feed converter animals by examining at their Kleiber ratio (Eskandarinasab *et al.,* 2009; Talebi, 2012; Santana *et al.,* 2014). The Kleiber ratio has been recommended as a valuable measure for growth rate and feed efficiency in goat production. The higher correlation between Kleiber ratio and feed efficiency suggests that animals with a higher Kleiber ratio use less energy to maintenance. We can find effective feed converter animals using KR (Mandal *et al.,* 2015; Areb *et al.,* 2021). The Marwari goat breed is a dual-purpose breed of Rajasthan that grows fast, bred efficiently, has a higher salt tolerance and requires less water than any other species in the region (Rohilla and Patel, 2003). The purebred individuals of the Marwari goat have a primarily black coloration, a short head and a narrow tail (NBAGR, 2022). Non-genetic factors such as year of birth, sex and birth type are fixed factors that contribute to variation in the animal population and trait of concern. There have been few genetic investigations on KR in Indian goats. Hence, a study was undertaken to identify genetic parameters and various non-genetic factors that influence KR in Marwari goat.

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MATERIALS AND METHODS

The data for the present investigation were collected from farmers' flocks of Marwari goat maintained under ICAR

sponsored "All India Co-ordinated Research Project (AICRP) on goat improvement," Bikaner, Rajasthan. The information of the Marwari goat was collected during the period 2016 to 2021 from the different cluster villages of the Bikaner district. During the present study, the different non-genetic factors that were considered for analysis of data are categorized as follows- The data were grouped into six years (2016-2021) based on year of birth. The cluster information was classified into five groups *viz.* Daiya, Deshnoke, Kalyansar, Kan singhkisid and Raisar. The type of birth was either single or twin and no triplets were noticed and sexes as male and female. Age of dam classified into three class *viz.* up to 3 years, 3-4.5 years and >4.5 years. Average daily gain (ADG) (g/day) were estimated as:

$$\frac{w_2-w_1}{t_2-t_1} \times 1000$$

Where,

W_2= Body weight at the end (kg).

W_1= Body weight at the start (kg).

t_2 = Animal's age at the end of the period (days).

t_1 = Animal's age at the start of the period (days).

Arthur *et al.* (2001) explained KR as a fraction of ADG and live weight $(LWT)^{0.75}$ as both observations were under a similar unit (Kg.). Kleiber ratio from birth to 3-months (KR1), Kleiber ratio from 3-months to 6 months (KR2) and 6 months to 12 months (KR3) were calculated by following formulae:

$$KR1=\frac{ADG1}{(3MWT)^{0.75}},\ KR2=\frac{ADG2}{(6MWT)^{0.75}},\ KR3=\frac{ADG3}{(12MWT)^{0.75}}$$

The data were assigned to linear mixed model equation (LMME) analysis using IBM SPSS (2005) version 25.0. The LMME included fixed covariates were year of birth, sex of the kid, cluster, type of birth and dam's age at kidding. Duncan's multiple range test (Kramer, 1957) was used for analysing subclass differences.

The statistical model used to investigate the effect several factors on kleiber ratio were as follow:-

$$Y_{ijklmn}= \mu + A_i + B_j + C_k + D_{-l} + G_m + e_{ijklmn}$$

Where,

Y_{ijklmn}= Performance of the n^{th} kid born in i^{th} year of j^{th} sex in k^{th} cluster of l^{th} birth type and belonging to m^{th} age of dam.

μ = Mean of the whole population.

A_i = Fixed effect of i^{th} year period of birth (i=1 to 6).

B_j = Fixed effect of j^{th} sex (j=1 and 2).

C_k = Fixed effect of k^{th} cluster (k=1 to 5).

D_l = Fixed effect of birth type l^{th} (l=1 and 2).

G_m = Fixed effect of m^{th} age of dam (m=1 to 3).

e_{ijklmn} = Is a residual random error associated with Y_{ijklmn} which is assumed to be normally and independently distributed with mean zero and error variance $(0,\sigma^2)$.

After normalising data for important non-genetic factors, paternal half-sib correlation approach was used to evaluate heritability, genetic (r_g) and phenotypic (r_p) correlations (Harvey, 1990).

RESULTS AND DISCUSSION

Kleiber ratio

The Kleiber ratio (KR) measures the metabolic weight gain in animals. The overall least-squares means (LSM) of KR1, KR2 and KR3 were observed to be 12.89±0.03, 9.69±0.05 and 4.59±0.06, respectively (Table 1). This proves that animals are more capable of converting food at a younger age. KR reduced as the animal became older, which indicated that as animals grow older, their efficiency of feed conversion weakens. The mean of KR was comparable with those of Khadda *et al.* (2018) in Pantja goat; Gupta *et al.* (2016) in Mehsana goat and Barazandeh *et al.* (2012) in Raini Cashmere goat.

Effect of non-genetic factors

The effects of different non-genetic factors are shown in Table 1. The effect of year of birth was found highly significant (P≤0.01) on all KR. The increasing trend of KR in Marwari kids shows the performance of productive animals for the transformation of feed. In years with greater average rainfall, post-weaning KR (KR2 and KR3) was seen to be higher. The significant influence of year of birth on KR obtained was similar to those reported by Gupta *et al.* (2016) in Mehsana goat and Casey and Webb (2010) in Boer goats.

The effect of sex and age of dam had highly significant (P≤0.01) effect on pre-weaning KR (KR1). The sex difference may be related to the anabolic action of hormones that allow them to gain weight. It showed that males grew at faster rate, conversion of feed and acquired more body weight upto weaning age. The significant influence of sex on KR1 was similar to reports of Khadda *et al.* (2018) in Pantja goat, Moghbeli *et al.* (2013) in Raini Cashmere goats and Pralomkarn (2012) in native goats. The effect of sex and age of dam had non-significant effect on post-weaning KR (KR2 and KR3). The non-significant effect of sex on post weaning KR were also observed by Gupta *et al.* (2016) in Mehsana goat and Khadda *et al.* (2018) in Pantja goat.

The effect of the cluster was found highly significant (P≤0.01) on all KRs. In pre-weaning period KR1 was reported significantly higher in Daiya cluster while in post weaning period it was significantly higher in Kan singh ki sid and in Kalayansar, respectively. There was no clear cut consistency observed in different clusters. Environmental differences such as difference in managemental practices followed by the goat rears, agro-climatic conditions, goat management strategies used by goat herders, socio-economic heterogeneity among goat rears and difference in maternal effect in pre and post weaning period might be the cause of significant effect of cluster on KRs.

The effect of type of birth was found highly significant (P≤0.01) on KR2 and significant (P≤0.05) on KR3 whereas it was found non-significant on KR1. At both pre-and post-weaning ages, twins performed better in terms of food conversion. The significant effect of birth type on pre-weaning age was observed by Khadda *et al.* (2018) in Pantja goat and Pralomkarn (2012) in native goats.

Table 1: Least-square means (± S.E.) for main effect on kleiber ratio in Marwari goat.

Effects	KR1	KR2	KR3
Over all mean (μ)	12.89±0.03 (3079)	9.69±0.05 (1648)	4.59±0.06 (392)
Year of birth	**	**	**
2016	12.57±0.05^{a} (249)	9.91±0.12^{c} (110)	4.20±0.07^{a} (72)
2017	12.76±0.04^{b} (555)	9.76±0.09^{b} (223)	4.50±0.09^{b} (53)
2018	12.66±0.04^{a} (720)	10.20±0.08^{d} (374)	4.22±0.12^{a} (29)
2019	12.75±0.04^{a} (584)	9.52±0.07^{b} (343)	4.80±0.08^{c} (76)
2020	13.02±0.03^{b} (882)	9.06±0.07^{a} (528)	4.82±0.07^{c} (106)
2021	13.58±0.09^{c} (89)	9.74±0.08^{b} (70)	4.97±0.09^{d} (56)
Sex	**	NS	NS
Male	12.95 ±0.03 (1622)	9.66±0.06 (880)	4.64±0.08 (131)
Female	12.83±0.03 (1457)	9.72±0.06 (768)	4.53±0.06 (261)
Cluster	**	**	**
Daiya	13.40±0.04^{d} (889)	9.50±0.08^{a} (297)	4.27±0.09^{a} (78)
Deshnok	12.95±0.05^{c} (372)	9.80±0.10^{c} (166)	4.75±0.12^{b} (52)
Kalayansar	12.57±0.06^{b} (228)	9.63±0.12^{b} (159)	4.87±0.13^{c} (48)
Kan singh ki sid	13.04±0.04^{c} (619)	9.83±0.08^{c} (434)	4.21±0.08^{a} (89)
Raisar	12.49±0.03^{a} (971)	9.69±0.06^{b} (592)	4.82±0.08^{c} (125)
Birth type	NS	**	*
Single	12.87±0.02 (2716)	9.30±0.04 (1405)	4.45±0.05 (295)
Twins	12.91±0.05 (363)	10.08±0.09 (243)	4.72±0.11 (97)
Dam age	**	NS	NS
3 years	12.99±0.04^{b} (832)	9.73±0.08 (429)	4.51±0.09 (103)
3-4.5 years	12.84±0.04^{b} (855)	9.75±0.07 (473)	4.59±0.08 (134)
>4.5 years	12.83±0.03^{a} (1392)	9.60±0.06 (746)	4.65±0.07 (155)
Adjusted R^2 (%)	21.8	17.0	39.1

KR1= Kleiber ratio from birth to weaning, KR2= Kleiber ratio from weaning to six months, KR3= Kleiber ratio from six to twelve months. Numbers of observations are given in parenthesis.

Means within subclasses with different superscripts are significantly (P≤0.05) different from each other.

** - Highly significant (P≤0.01); * - Significant (P≤0.05); NS- Non-significant.

The model that was used to describe the different KRs was able to explain that KR3 was the most accurate (adjusted R^2=39.1%), followed by KR1 and then KR2.

Genetic parameters

The heritability estimates for KR1, KR2 and KR3 were 0.66±0.28, 0.07±0.07 and 0.54±0.26, respectively, which were medium and comparable with the findings of Gupta *et al.* (2016) in Mehsana goat and Khadda *et al.* (2018) in Pantja goat. The genetic correlation between KR1-KR2 (-0.50±0.59), KR2-KR3 (-0.08±0.67) and KR1-KR3 (-0.84±0.20) was very high, negative. However, phenotypic correlation between KR1-KR2 (-0.49), KR2-KR3 (-0.33) and KR1-KR3 (-0.41) was moderately negative. Pre- and post-weaning KRs had medium to high heritability estimates, suggesting that a selection procedure might increase the flock's feed conversion efficiency. Because of the substantial genetic connection between pre- and post-weaning KRs, it may be possible to select kids even at the time of weaning to increase performance based on a six-month weight and it may also be feasible to cull kids even before weaning because of the correlated response to selection. Furthermore, selection for higher early body weights may lead to genetic improvements in subsequent body weights.

CONCLUSION

It can be concluded that the Kleiber ratio was higher before weaning, indicating that the kids were provided complete care throughout this time. Through better kid management, the post-weaning Kleiber ratio can be improved. As a result, for greater economic benefit, selection should be performed at a younger age, particularly between 3 and 6 months of age. The male kid might be more profitable to raise because they have a faster growth rate and feed conversion efficiency. KR is one of the indices suggested and used to assess the energy efficiency of goats and it offers a decent indicator of how efficiently an animal grows. So, KR could be used as a selection criterion for genetic improvement of Marwari goat growth and feed efficiency.

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