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Genetic investigation on Kleiber ratio in Sonadi sheep

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Abstract
Data of 1408 Sonadi lambs born during 2012-2019 under Mega Sheep Seed Project at CVAS Navania Udaipur (Rajasthan) were analyzed to assess the influence of period, season, sex and type of birth on Kleiber ratio. The overall least-squares means along with standard error of Kleiber ratio - KR1 (0-3M), KR2 (3-6M), KR3 (6-9M) and KR4 (9-12M) were 13.16±0.30, 6.59±0.33, 4.04±0.31 and 5.24±0.35, respectively. Effect of sire was highly significant ($P \leq 0.01$) on KR1, KR2 and KR3 whereas significant ($P \leq 0.05$) on KR4. Period of birth had highly significant ($P \leq 0.01$) effect on all the KRs. Season of birth had highly significant ($P \leq 0.01$) effect on KR4 only whereas sex of lamb had highly significant ($P \leq 0.01$) effect on KR2 only. Type of birth had significant ($P \leq 0.05$) effect on KR4 only. Estimates of heritability forKR1, KR2, KR3 and KR4 were 0.82±0.18, 0.38±0.11, 0.51±0.15 and 0.23±0.13, respectively. Genetic correlation was negative between KR1 and other KRs whereas it was positive among other KRs. The estimate of phenotypic correlation among Kleiber ratios was negative and low to high.

Keywords: Kleiber ratio, Sonadi sheep, least-square mean, heritability, genetic and phenotypic correlation

Introduction
Sheep (*Ovis aries*) is one of the important species of livestock contributing to meat and wool production. Sheep are capable of living in all kind of environment and thrive well in hot and arid regions. India ranks 3rd in sheep population having a number of 74.26 Million and contributes for 13.8% of India's total livestock population [1]. Rajasthan with 7.9 million of sheep population is the 4th largest sheep (10.63% of total sheep in India) rearing state of the India.

Sonadi sheep is an important mutton breed of southern Rajasthan and prevails in southern sub-humid zone comprising Udaipur, Chittorgarh, Rajsamand, Dungarpur, Banswara districts of Rajasthan. It is generally reared under semi extensive system. It has the unique characteristic of golden fibre and survival on scarce fodder condition during drought. The fleece of Sonadi sheep is extremely coarse and hairy. Belly and legs are devoid of wool. Sonadi sheep has good potential for meat (13.72 kg at slaughter) and wool (0.5-1.2 kg/annum) production.

Kleiber ratio (KR), defined as growth rate divided by metabolic body weight ($W^{0.75}$), was suggested for growth efficiency [2]. The relation of growth rate to metabolic weight or Kleiber ratio (KR) was developed as an alternative ratio to address problem in rangeland animals [3]. In order to increase the efficiency of feed conversion, use of Kleiber ratio (KR) in selection programs is very essential [4]. The greater correlation between Kleiber ratio and feed efficiency indicates that animals with higher Kleiber ratio require lower energy for their maintenance [5].

Materials and Methods
Data for the investigation were collected from the farm unit of Sonadi sheep maintained under Mega Sheep Seed Project (MSSP) at Vallabhnagar, Udaipur (Rajasthan). A total record of 1408 lambs of Sonadi sheep having 718 females and 690 males spread over period of 8 years from 2012 to 2019 comprised the material for this study.The breeding tract of Sonadi sheep falls under southern sub-humid plain zone of Rajasthan. The Sonadi Sheep are being maintained under semi-intensive management system. Sheep are remained on pasture everyday for 6-8 hours for grazing. The lambs are weaned at 3 months of age.

Kleiber ratio is ratio of Average Daily Gain (ADG) in gm and Metabolic Body Weight ($W^{0.75}$) in Kg. Kleiber ratio KR1 (0-3 months), KR2 (3-6 months), KR3 (6-9 months) and KR4 (9-12 months) were calculated by following formula:-

Kleiber Ratio (KR) = ADG / $W^{0.75}$

Where,
ADG = Average daily gain for the period expressed in g/day
$W^{0.75}$ = Metabolic body weight in Kg. at the older age of the period for which KR is calculated.
Year of birth were grouped into four periods as P1 (2012-2013), P2 (2014-2015), P3 (2016-2017) and P4 (2018-2019). Season of birth was classified into three seasons as S1 (monsoon), S2 (winter) and S3 (summer). Sex of lamb was classified into male and female whereas type of birth into single and twins. The data on Kleiber ratio was analyzed through Mixed Model Least-Squares and Maximum Likelihood method designed by Harvey (1990) [6]. Effect of various non-genetic factors on Kleiber ratio was estimated through the following statistical model:

$$Y_{ijklmn} = \mu + A_i + B_j + C_k + D_l + E_m + e_{ijklmn}$$

Where,
Y_{ijklmn}= Growth record of the n^{th} progeny of i^{th} sire belonging to l^{th} sex, k^{th} season, j^{th} period and m^{th} type of birth
μ = Population mean
A_i = Random effect of i^{th} sire
B_j= Fixed effect of j^{th} period of birth (i = 1, 2, 3, 4)
C_k= Fixed effect of k^{th} season of birth (j = 1, 2, 3)
D_l= Fixed effect of l^{th} sex of birth (k = 1, 2)
E_m= Fixed effect of m^{th} type of birth (l = 1, 2)
e_{ijklmn}= Residual error, NID (0, σ^2)
Duncan's Multiple Range Test (DMRT) as modified by Kramer *(*1956*)* [7] was used to make pair wise comparison among the least squares means.

Result and Discussion

The least-squares means for KR1, KR2, KR3 and KR4 were 13.16±0.30, 6.59±0.33, 4.04±0.31 and 5.24±0.35, respectively (Table 1). The finding of KR1 was in close agreement with Mecheri sheep [8] as13.07±0.06 whereas higher estimate was reported in Nilagiri sheep [9] as 14.37±0.16and 14.52±0.16 in Sandyno sheep [9]. The finding of KR2 was in close agreement with 6.71±0.20 in Harnali sheep [10], 6.19±0.04 in Bharat Merino sheep [11], 6.83±0.11 in Nellore sheep [12] and 6.10±0.07 in Mecheri sheep [8]. The finding of KR3 was in close agreement with reports as 3.82±0.22 in Sandyno sheep [9] and 3.72±0.22 in Nilagiri sheep [9]. The finding of KR4 was higher than the value reported as 3.72±0.21 in Nilagiri sheep [9], 3.80±0.22 in Sandyno sheep [9] and 3.34 in Baluchi sheep [13].

Effect of sire

Sire had highly significant (P≤0.01) effect on Kleiber ratio KR1, KR2 and KR3 whereas significant (P≤0.05) on KR4.Similar results were reported in Pantja goat [14] for KR1, KR2 and KR4.

Table 1: Least-squares means (±SE) of Kleiber ratio in Sonadi sheep

Effect	KR1	KR2	KR3	KR4
Overall	13.16±0.30 (1060)	6.59±0.33 (831)	4.04±0.31 (630)	5.24±0.35 (506)
Sire	**	**	**	*
Period of birth	**	**	**	**
P1 (2012-2013)	11.68^{a}±0.34 (318)	7.41^{b}±0.37 (257)	4.99^{b}±0.35 (210)	6.83^{d}±0.39 (184)
P2 (2014-2015)	11.65^{a}±0.34 (226)	7.83^{b}±0.37 (191)	4.82^{b}±0.35 (145)	5.50^{c}±0.39 (133)
P3 (2016-2017)	14.22^{b}±0.33 (292)	5.79^{a}±0.38 (196)	3.26^{a}±0.35 (143)	4.67^{b}±0.39 (121)
P4 (2018-2019)	15.10^{c}±0.34 (224)	5.32^{a}±0.37 (187)	3.11^{a}±0.35 (132)	3.95^{a}±0.42 (68)
Season of birth	NS	NS	NS	**
S1 (July-Oct.)	12.89±0.31 (413)	6.53±0.34 (354)	4.14±0.31 (272)	5.03^{a}±0.36 (216)
S2 (Nov.-Feb.)	13.15±0.30 (517)	6.90±0.33 (384)	3.74±0.31 (283)	4.82^{a}±0.36 (220)
S3 (March-June)	13.45±0.39 (130)	6.33±0.44 (93)	4.25±0.40 (75)	5.87^{b}±0.44 (70)
Sex of lamb	NS	**	NS	NS
Male	13.31±0.31 (509)	6.94^{b}±0.34 (400)	4.22±0.32 (295)	5.37±0.37 (236)
Female	13.02±0.31 (551)	6.24^{a}±0.34 (431)	3.87±0.32 (335)	5.11±0.36 (270)
Type of birth	NS	NS	NS	*
Single	13.70±0.11 (1031)	6.45±0.12 (810)	4.31±0.11 (614)	4.53^{a}±0.11 (495)
Twin	12.62±0.58 (29)	6.72±0.64 (21)	3.77±0.60 (16)	5.95^{b}±0.69 (11)

**=Highly significant (*P*≤0.01), *=Significant (*P*≤0.05), NS= Non-significant (*P*>0.05) Figures in parentheses are the number of observations

Effect of period of birth

Period of birth had highly significant (*P*≤0.01) effect on KR1, KR2, KR3 and KR4. Similar results were reported as highly significant in Harnali sheep [10], Bharat Merino sheep [11] and Nellore sheep [8] for KR1 and KR2. On the contrary, Nilagiri and Sandyno sheep [9] observed non-significant effect of period of birth on KR3 and KR4. Over the periods, there was increase the Kleiber ratio of Sonadi lambs, indicating production of more efficient animals for feed conversion.

Effect of season of birth

Season of birth had highly significant ($P \leq 0.01$) effect on KR4 whereas non-significant effect on KR2, KR3 and KR4. Similar results were reported as non-significant effect in Mehsana goat [15] and Pantja goat [14] for KR1.Similar results were reported as non-significant effect in Harnali sheep [10] and Pantja goat [14] for KR2. On the contrary, results were reported in Pantja goat [14] on KR3 and KR4.There was increase the Kleiber ratio of Sonadi lambs during summer season, indicating production of more efficient animals for feed conversion.

Effect of sex of lamb

Sex of lamb had highly significant ($P \leq 0.01$) effect on KR2 whereas non-significant effect on KR1, KR3 and KR4. Similar results were reported as non-significant effect in Deccani sheep [16] and Nellore sheep [12] for KR1. Similar results were reported as highly significantin Harnali sheep [10], Bharat Merino sheep [11] and Nilagiri and Sandyno sheep [9] for KR2. Similar results were reported as non-significant in Pantja goat [14] for KR3 and KR4. Males usually have more feed conversion than females at all stages of growth.

Effect of type of birth

Type of birth had significant ($P \leq 0.05$) effect on KR4 whereas non-significant effect on KR1, KR2 and KR3. Similar result was reported as non-significant effect in Raeini Cashmere goat [17] for KR1 and KR2. Similar results were reported as non-significant in Nilagiri and Sandyno sheep [9] and Pantja goat [14] for KR3. On the contrary, reported non-significant effect of type of birth in Pantja goat [14] and Nilagiri and Sandyno sheep [9] for KR4.Single lamb had higher Kleiber ratio than twin lambs because of compete feeding of mother milk in twin lambs.

Genetic parameters

Estimates of heritability for Kleiber ratio KR1, KR2, KR3 and KR4 were observed as 0.82±0.18, 0.38±0.11, 0.51±0.15 and 0.23±0.13, respectively (Table 2). The estimates of heritability for KR1 and KR2 were higher than reports as 0.38±0.11 and 0.02±0.06 in Harnali sheep [10], 0.17±0.02 and 0.17±0.01 in Bharat Merino sheep [11] and 0.106±0.03 and 0.106±0.03 in Nilagiri and Sandyno sheep [9], respectively. The present finding of heritability for KR3 and KR4 were higher than reports as 0.22±0.08 and 0.04±0.03 in Pantja goat [14] and 0.035±0.03 and 0.048±0.03 in Nilagiri and Sandyno sheep [9], respectively. The heritability estimates provides a scope that individual selection may be used for selection in case of non-availability of other information.

The estimates of genetic correlation among Kleiber ratio traits were high in magnitude and ranged from -0.69 (KR3-KR4) to -1.00 (KR1-KR4). The present finding of genetic correlation among Kleiber ratio for KR1-KR2, KR1-KR3 and KR1-KR4 were higher than reports as -0.285, -0.572 and -0.817in Nilagiri sheep [9] and 0.41, -0.68 and -0.22 in Pantja goat [14], respectively. Positive genetic correlations between Kleiber ratio traits indicated that the selection of one trait can improve other traits simultaneously. Negative genetic correlation between Kleiber ratios were estimated due to maternal compensatory effect.

The estimates of phenotypic correlation among Kleiber ratio traits were negative and magnitude is very low to high and ranged from -0.03 (KR2-KR4) to -0.52 (KR1-KR2). The present finding of phenotypic correlation for KR1-KR2, KR1-KR3 and KR1-KR4 were higher than reports as -0.358, -0.077 and -0.167 in Nilagiri sheep [9] and-0.43, -0.30 and -0.01 in Pantja goat [14], respectively. Negative phenotypic correlation between Kleiber ratio traits were estimated due to maternal compensatory effect.

Table 2: Estimates of heritability (diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations along with standard error among Kleiber ratio traits in Sonadi sheep

Traits	KR1	KR2	KR3	KR4
KR1	0.82±0.18	-0.76±0.28	-0.79±0.19	-1.00±0.31
KR2	-0.52	0.38±0.11	0.78±0.28	0.86±0.39
KR3	-0.38	-0.05	0.51±0.15	0.69±0.32
KR4	-0.33	-0.03	-0.04	0.23±0.13

Conclusions:

Assessment of non-genetic factors plays an important role to formulate effective breeding programme for improvement of growth traits of Sonadi sheep and measure to be taken for standardizing the management of flock for suitable production. More lambing should be planned in conductive season such as summer season for maximizing the growth rate and survivability of lambs. Lambs showing multiple birth must be given preference in breeding programme to improve prolificacy of the flock. Kleiber ratio is more important trait for efficiency of feed utilization. Medium to high heritability of Kleiber ratio offer a scope for individual selection for further genetic improvement.

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