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Growth rate performance of Sonadi sheep in terms of growth efficiency

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Abstract
The present investigation was undertaken to estimate the effect of different non-genetic factors affecting the growth performance traits of Sonadi sheep. The detailed information of 1396 Sonadi sheep regarding growth performance traits maintained over the period of 2012-2019 under the Mega Sheep Seed Project (ICAR) at College of Veterinary and Animal Science, Navania, Vallabhnagar, Udaipur district of Rajasthan was collected. The various growth performance traits like body weight, relative growth rate (RGR) and growth efficiency (GE) were studied and data's were classified into different groups (year of birth, season of birth, sex of animal and type of lambing) for different traits (BWT, 3 WT, 6 WT, 9 WT, 12 WT, 0-3, 3-6, 6-9, 9-12, 0-3, 3-6, 6-9, and 9-12) under investigation. The body weight at birth, 3, 6, 9 and 12 months were estimated during the period of 2012-2019. Lowest estimates were observed in the early period for all growth traits except 12 months body weight. Highest estimates were observed in late period for body weight at 3 M, 6 M, 9 M and 12 M, respectively. Year of lambing showed an increasing trend over the year for weight at 9months of age. The influence of year on body weight could be the result of changes in environmental factors. The increase in body weight over the year may be due to improvement in breeding and management practices. The relative growth rate and growth efficiency during the pre-weaning phase showed improvement over the years and it may be due to improvement in management practices for suckling lambs.

Keywords: Sonadi sheep, animal science, live stock

Introduction
The livelihood in rural India mainly depends on agriculture in the form of various land-based enterprises like crop farming. The constraints of low and irregular monsoon, lack of irrigation facilities etc. compelled the farmers of arid and semi-arid region to diversify from crop to livestock production to counter the risk of crop failure. Thus, livestock production is major activity of farmers in arid and semiarid region because livestock are more tolerant to harsh climatic conditions than crops. Large ruminant are less preferred by some of the community as well as landless and marginal farmers as it demands relatively large investment and higher maintenance cost.

A number of non-genetic factors like location and sex of lamb affecting the growth parameters of animals should be studied for evolution of best animal.

Under field conditions, the farmer's sale their animals on the approximate body weight based on visual observation to middle man due to non-availability of appropriate size balance in the field. The regression equation developed incorporating body measurements is the most appropriate method for estimating body weight particularly under field conditions asbody parameters like body length, body height and heart girth can be easily measured by measuring tape.

The informations on body weight, growth rate and prediction equation for estimation of body weight at different age are scanty in Sonadi sheep particularly under field conditions.

Considering the above facts, "The Study of growth parameters in Sonadi sheep maintained under field conditions" was proposed with the following objectives.

- To evaluate body weight and conformation traits at different stages in pure Sonadi breed and other crosses of sheep maintained by farmers of Bhilwara district.
- To compare the growth performance of Sonadi and other crosses of sheep maintained under field conditions.
- To develop equation for prediction of body weight at different ages and recommend most appropriate one.

Traits for study

Body weight and morphometric traits of young stock (Both Male and Female)

- Body weight at birth, 3, 6, 9, 12, 15,18 and 21 months
- Body height at birth, 3, 6, 9, 12, 15,18 and 21 months
- Body length at birth, 3, 6, 9, 12, 15,18 and 21 months
- Heart girth at birth, 3, 6, 9, 12, 15,18 and 21 months

Body weight and morphometric traits of adult stock (Female only)

Body weight and measurements of ewe (adult female) at lambing for I to V & above lambing (parities) and after every months of pregnant and non-pregnant animals were recorded. Following body weight and morphometric traits were recorded.

- Body weight AT I to V & above lambing and after every month.
- Body height AT I to V & above lambing and after every month.
- Body length AT I to V & above lambing and after every month.
- Heart girth AT I to V & above lambing and after every month.

Growth rate

Growth rates were calculated between 0-3, 3-6, 6-9, 9-12, 12-15, 15-18 and 18-21 month of age as well as 0-6, 0-9, 0-12, 0-15, 0-18 and 0-21 months of age using following methods:

- Absolute growth rate.
- Relative growth rate.

Computation of growth rates

Growth rates were computed using formula as given below

Absolute growth rate

The absolute growth rate is the gain in the given magnitude per unit time or average daily gain (ADG), represented by following equation (Ahmad M, 2004) [5].

$$\text{ADG} = \frac{\text{w2} - \text{w1}}{\text{t2} - \text{t1}}$$

Where, w_2-w_1, is the observed weight difference for the corresponding time difference t_2-t_1.

Relative growth rate

The relative growth rate is the weight gain during a given time interval in relation to the weight at the beginning of the time interval and can be expressed as (Bahreini B, 2007) [8].

$$\text{RGR} = \frac{\text{w2} - \text{w1}}{\text{w1}} \text{x } 100$$

Where, w_1 and w_2 are the weights at beginning and end of the time interval respectively.

Classification of data

In order to study the effect of different factors, the data were classified accordingly. The factors included in the present Study were Tehsils (----------), Sex of lamb (Male and female) and Breed (pure Sonadi and Crosses).

Statistical Analysis

For young stock

The effect of different factors, viz., tehsils, sex of lamb and breed on the different body weight and measurement and growth rates for young stock were estimated through least-squares method (AbbasSF, 2010) [1] using following mathematical model.

$$Y_{ijkl} = \mu + T_i + S_j + B_k + e_{ijkl}$$

Where,

Y_{ijkl}= body weight/ measurement/ growth rate of lth lamb of kth breed belongs tojth sex and ith tehsil

μ = overall population mean.

T_i= effect of ith tehsil

S_j= effect of jth sex of lamb

B_k= effect of bth breed

e_{ijkl} = residual error, NID $(0,\sigma^2)$

For adult stock

The effect of different factors, viz., tehsils and breed on the different body weight and measurement and growth rates for adult animals were estimated through least- squares method (AbbasSF, 2010) [1] using following mathematical model.

$$Y_{ijk} = \mu + T_i + B_j + e_{ijk}$$

Where,

Y_{ijk}= body weight/ measurement/ growth rate of kth animal of jth breed belongs to ith tehsil

μ = overall population mean.

T_i= effect of ith tehsil

B_j= effect of bth breed

e_{ijk} = residual error, NID $(0,\sigma^2)$

Comparison of sub-means

Duncan's Multiple Range Test as modified by Kramer, (1956) [23] used to make pair-wise comparison among the least-squares means.

$$R_p = r_{\alpha\rho\gamma}\sqrt{\frac{MSE}{n}}$$

Where,

R_p= Least significant range for subsets of p sample mean.

$r_{\alpha\rho\gamma}$= Duncun's Significant Range Value with parameter p (range-value), γ (MSE degree of freedom) and α (Significance level).

n = Sample size for each treatment.

Prediction of body weight

Prediction equations will be developed to study the predictive value of body conformation traits like body height, body length and heart girth to predict body weight at different stages of life using following regressions methods.

Simple linear regression- The following model was fitted for ith record.

$$Y_j = a_{(i)} + b_j X_{(i)j} + e_{(i)j}$$

Where,

Y_j is the observed body weight of jth animal, $a_{(i)}$ is the constant for ith record, b_j is the regression coefficient of Y on X for the

i^{th} record of the j^{th} animal and $e_{(i)j}$ is the residual random error associated with the i^{th} record of the j^{th} animal assumed NID $(0,\sigma^2)$.

Multiple linear regression

$$Y_j = a_k + \sum_{i=1}^{k} b_{(i)} X_{(i)j} + e_{(i)j}$$

Step-wise regression equation

Where, $Y_j, X_{(i)j}$ and Step-wise regression- through Draper and Smith, (1981) [21] the efficiency of predictability by independent variable will be judged by the square of multiple correlation coefficients (R^2).

Least-squares mean of absolute growth rate from 3 to 6 month of age (AGR-2)

In sheep kept in the Bhilwara district, the overall least-squares mean of absolute growth rate from 3 months to 6 months of age (AGR-2) was found to be 55.411.101 g/day (Table 1). The growth rate of 61.742.23 g/day in Harnali sheep was reported by Bangar *et al.* (2020) [12], which is nearly identical to the current data. Draper NR (1981) [21] found that Madras Red sheep had lower growth than that seen in the current study, averaging 47.891.24 g/day. Venkataramanan (2013) [24] measured 38.32 g/day in Nilagiri sheep, Balasubramanyam *et al.* (2010) [10] measured 44.56 g/day in Madras Red sheep, and Balasubramanyam and Kumarasamy (2011) [9] measured 47.68 g/day in Madras Red sheep. Bardhan D, 2007 [8] measured 44.50 g/day in Marwari sheep. On the contrary, the average estimate of AGR-2 was lower than the value reported as 85.80±0.82 g/day by Bangar YC (2020) [12] in Muzaffarnagri sheep, 68.91±0.55 g/day by Chopra A (2010) [15] in Bharat Merino sheep, 83.17±1.07 g/day by Dangi PS (2006) [17] in Deccani sheep and 70.73±0.67 g/day by Devendran P (2014) [19] in Marwari sheep.

Effect of factors on body weight and confirmation traits at 3 month of age

Effect of Tehsil/ location was found to be significant on body weight, body length and height at withers at 3 months of age. However, the effect of sex and breed were non-significant on body conformation traits and body weight at 3 months of age (Table 1). In contradiction to this, Dass G (2019) [18], observed significant effect of sex on body weight at 3 months of age.

The body length, height at withers and body weight at 3 months of age were significantly higher for lamb born in tehsils having lower sheep population than tehsils having higher sheep population. This might be due to availability of more feed resources. The males lambs at 3 months of age had higher body weight than females but differences were non-significant. Similarly, the body weight at 3 months of Sonadi sheep had slightly higher than crosses but again it was non-significant.

Table 1: ANOVA for body weight and conformation traits at 3 months of age

Source	Degree of freedom	Mean sum of squares			
		Body length	Height at withers	Heart girth	Body weight
Total reduction	4	140.80	340.23	14.98	8.03
Mu-Ym	1	0.12	0.03	0.32	0.07
Tehsil	1	535.10**	1322.64**	32.82	31.59**
Sex	1	0.67	13.59	11.84	0.32
Breed	1	9.37	0.99	8.55	1.11
Remainder	576	11.59	10.79	10.39	1.33

Effect of factors on body weight and confirmation traits at 6 month of age

Effect of Tehsil/ location was found to be non-significant on body weight non-and all the body conformation traits except chest girth at 6 months of age. However, the effect of sex and breed were non-significant on body conformation traits and body weight at 6 months of age (Table 2).

The chest girth of lambs at 6 months of age was significantly higher in Tehsils having lower sheep than tehsils having higher sheep population. The body weight at 6 months of male and female as well as Sonadi and crosses were almost similar.

Table 2: ANOVA for body weight and conformation traits at 6 month of age

Source	Degree of freedom	Mean sum of squares			
		Body length	Height at withers	Heart girth	Body weight
Total reduction	4	1.99	8.93	122.70	2.01
Mu-Ym	1	1.15	0.97	4.86	1.11
Tehsil	1	0.85	24.14	476.74**	2.23
Sex	1	6.36	4.07	8.15	4.66
Breed	1	0.71	9.27	0.87	1.04
Remainder	332	15.17	12.78	17.83	2.27

Table 3: Least-squares means of absolute growth rate between 3-6 months of age

Effects	N	Mean ± SE 3-6
µ	336	55.41 ± 1.101
Tehsils		
T1	175	57.10 ±1.529[a]
T2	161	53.72± 1.577[a]
Sex		
Male	144	55.38 ± 1.665[a]
Female	192	55.45 ± 1.446[a]
Breed		
Sonadi	169	55.64 ± 1.549[a]
Crosses	167	55.18 ± 1.552[a]

Least-squares mean of absolute growth rate from 6 to 9 month of age (AGR-3)

Basic statistic of adult sheep (ewe) from IV & above parity in non-pregnant

The overall means of body weights and measurements of adult sheep from IV & above parity in non-pregnant are presented in Table 4. The coefficient of variation for body weight at different parities ranges from 12.45% (first parity) to 14.41% (fifth & above parity). The variation ranges from 4.39% (fourth parity) 6.77% (first parity) for body length, 4.28% (fourth parity) to 5.11% (second parity) for height at wither and 5.26% (first parity) to 5.83% (third parity) for heart girth, indicate scope of improvement by adopting proper selection programme. Further, it also suggested that scope of improvement is higher in body weight as compared to body conformation traits due to its high coefficient of variation.

Table 4: Mean, SD, SE and CV of body weight and conformation traits of adult non-pregnant sheep

First parity

Traits	Mean	SD	SE	CV%
Body Length	65.93	4.59	4.46	6.76
Hieght at wither	66.27	3.36	3.38	5.09
Heart girth	68.53	4.06	3.61	5.26√ L
Body weight	27.56	3.79	3.43	12.45

Second Parity

Traits	Mean	SD	SE	CV%
Body Length	65.93	4.59	4.46	6.77
Hieght at wither	66.27	3.36	3.39	5.11√
Heart girth	68.53	4.06	3.61	5.26
Body weight	27.56	3.76	3.44	12.47

Third Parity

Traits	Mean	SD	SE	CV%
Body Length	66.67	3.88	3.84	5.77
Hieght at wither	66.40	3.36	3.36	5.07
Heart girth	69.71	4.35	4.06	5.83 √
Body weight	29.04	3.92	3.67	12.62

Fourth Parity

Traits	Mean	SD	SE	CV%
Body Length	67.70	3.02	2.97	4.39
Hieght at wither	66.99	2.90	2.87	4.28 √
Heart girth	70.71	3.98	3.73	5.28
Body weight	30.10	4.11	3.88	12.91

Fifth Parity

Traits	Mean	SD	SE	CV%
Body Length	67.77	3.46	3.34	4.93
Hieght at wither	67.16	3.14	3.15	4.69
Heart girth	70.92	3.97	3.82	5.39
Body weight	29.88	4.54	4.31	14.41

Basic statistic of adult sheep (ewe) from IV & above parity in pregnant

The overall means of body weights and measurements of adult sheep from IV & above parity in pregnant are presented in Table 5. The coefficient of variation for body weight at different parities ranges from 12.08% (first parity) to 13.21% (second parity). The variation ranges from 4.37% (fifth & above parity) 6.63% (first parity) for body length, 4.50% (second parity) to 5.39% (third parity) for height at wither and 4.72% (first parity) to 5.61% (third parity) for heart girth, indicate less scope of improvement in body parameters as compared to body weight. Further, it also suggested that considerable scope of improvement in body weight of adult sheep during pregnancy.

Table 5: Mean, SD, SE and CV of body weight and conformation traits of adult pregnant sheep

First Parity

Traits	Mean	SD	SE	CV%
Body Length	65.92	4.70	4.37	6.63
Hieght at wither	66.54	3.24	3.21	4.83
Heart girth	69.37	4.22	3.28	4.72
Body weight	29.21	3.95	3.53	12.08

Second Parity

Traits	Mean	SD	SE	CV%
Body Length	67.22	3.48	3.25	4.83
Hieght at wither	66.61	3.10	3.00	4.50
Heart girth	70.60	4.43	3.87	5.48
Body weight	30.37	4.41	4.01	13.21

Table 6: ANOVA for body weight and conformation traits of non-pregnant sheep of first parity

Source	DF	MSS			
		Body Length	Height at Wither	Chest girth	Body Weight
Total Reduction	18	111.81	1.94	268.60	185.37
MU-YM	1	146.75	.06	312.04	292.93
Tehsil	1	1398.14**	14.20	1312.91**	75.15**
Breed	1	20.40	.02	103.46*	16.54
Month of parturition	15	13.86	1.89	128.56**	195.31**
Reminder	1308	19.87	11.39	13.00	11.77

Second

Effect of Tehsil/ location was found to be highly significant on body length, heart girth and body weight of sheep in second parity, while its effect on height at wither was non-significant. The body length, heart girth and body weight were significantly higher in Tehsils having higher sheep population than Tehsils having low sheep population.

The effect of breed was found to be highly significant on body length, height at wither and body weight of adult non pregnant sheep of second parity. However, its effect on heart girth was non-significant. The body conformation traits viz, body length and height at withers were significantly higher in crosses as compared to Sonadi (Table 6), this might be due to breed differences.

The effect of month of parturition in the sheep of second parity was found to be highly significant on body length, heart girth and body weight. However, its effect on height at withers was non-significant. The results indicated that no definite trend was observed with respect to body length, heart girth and body weight across month of parturition but in broad way the body conformation and body weight increases as advancement in parturition period.

Conclusion

Lambing seasons were categorized into three seasons as Season I (monsoon), Season II (winter) and Season III (summer) lambing season. On the basis of year data was categorized into eight categories and coding from 1-8. The data related to gender of lamb was classified according to male and female and coded as 1 and 2, respectively while according to type of lambing, data was categorized into 2 categories i.e. single and twin and coded as 1 for single and 2 for twin.

The data was analyzed using one two data set namely body weight, relative growth rate and growth efficiency.

The growth of sheep from birth to grown-up age was assessed utilizing indicator characteristics as body weights at birth, 3, 6, 9 and 12 months of age, relative growth rate and growth efficiency amid 0-3, 3-6, 6-9 and 9-12 month age group. The overall least square mean along with standard error of body weight were observed as 2.82±0.03, 10.06±0.27, 14.62±0.38, 17.0±0.43 and 21.96±0.55 at birth, 3, 6, 9 and 12 months of age separately. The overall least square means along with standard error of relative growth rate characteristic were estimated as 1.32±0.03, 0.42±0.02, 0.22±0.19 and 0.27±0.02 for 0-3, 3-6, 6-9 and 9-12month age group respectively whereas the overall least square mean along with standard error of growth efficiency was evaluated to be 2.57±0.10, 0.496±0.03, 0.244±0.24 and 0.266±0.04 for 0-3, 3-6, 6-9 and 9-12month age group respectively. It was observed that relative growth rate and growth efficiency amid 0-3month age group was higher as compared to other groups. The appraise of body weight of Sonadi sheep was in agreement with the weight of mutton breeds.

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