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Effect of temperature and temperature humidity index on growth performance of Deccani sheep

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Abstract
Preset trial has been conducted at Networth Project on Sheep Improvement (Deccani field unit), Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar, Maharashtra. For this study 9year data from 2006 - 2015 has been collected from Networth Project on Sheep Improvement (Deccani field unit). Sufficient housing accommodations for sheep are available. The sheds with asbestos roofing with brick floor are provided. The sheep are housed in a shed during night hours especially in winter as well as in the rainy season. Sheep were allowed to graze for about 5-6 hours per day in the harvested field as well as the silvi-pastoral area. The lambs up to six months of age were fed at the barn and they were allowed to be out of sheds for one hour for exercise. The animals were selected for various growth trait body weights at birth, 3 months, 6 months, 9 months, 12 months of age. The data was analyzed by using the least square method. It is concluded from this trial, year of birth had significant effect on average daily weight gain upto twelve months. However season of birth, sex, mostly temperature and THI has no influence on daily weight gain.

Keywords: Deccani sheep, Thi, temperature, DMRT, least square

Introduction
During monsoon season sheep are grazed on grassland but during the rest of the year they thrive on weeds in the orchard, bunds, harvested field and tree lopping, pods, leaves, shrub, etc. In environmental factors temperature and humidity are very important factors which govern metabolic and physiological activities. Increased body temperature and respiration rate are the most important signs for heat stress in sheep. The increase in body temperature is associated with marked reduction in feed intake, increased respiratory rate, loss in weight and increased water consumption. Another significant factor is the relative humidity, given its great effect on the sheep, affecting the well-being and consequently, their productivity. Therefore high values of temperature and humidity can be helpful to sheep production. Temperature Humidity Index is a single value depicting the integrated effect of air temperature and humidity associated with the level of heat stress. During the heat stress period, with the aim of minimization of the effects of heat stress, it is necessary to regulate management strategies in the dairy herd (Gantner *et al.* 2011) [1]. The Temperature Humidity Index was used to assess sheep‟s potential heat stress. The analysis showed that sheep were exposed to moderate, severe, extreme severe heat stress. A poor thermal environment can affect the incidence and severity of certain diseases as well as the Animals thermal comfort, growth rate, and milk yield (Sejian *et al*. 2012). THI is extensively used in hot regions all over the world to evaluate the effect of heat stress on dairy animals and is currently used to estimate cooling necessity of dairy animals in order to improve the efficiency of management strategies to alleviate the negative effect of heat stress. Therefore, the present investigation was planned and concluded.

Material and Methods
The present investigation entitled, "Effect of temperature and temperature humidity index on growth performance of Deccani Sheep" was undertaken by utilizing the data recorded at Networth Project on Sheep Improvement (Deccani field unit), Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar, Maharashtra. Where a semi-intensive system of housing & management is being practiced. Sheep are allowed for grazing in morning hours for a period of 3-4 and afternoon for 2-3 hours. Concentrate is being supplemented along with green and dry fodder *viz.,* Lucerne, sorghum, maize and by products of gram and tur. Lambs up to six months of age are fed at the barn. Enough protection to lambs and adult sheep is also provided in extreme seasons.

Feeding Practices

Lambs are kept age wise separately and provided @ 2% of body weight ration/head/day besides they are allowed for grazing for 3-4 hours daily. First shearing is done at 6 months age followed by subsequent shearing every six months. Shearing of sheep is carried out in the month of January and July of every year. Adult sheep are fed a concentrate ration containing 16-18 per cent crude protein.

Growth traits

1. Body weights at birth
2. Body weights at 3 months of age
3. Body weights at 6 months of age
4. Body weights at 9 months of age
5. Body weights at 12 months of age

Statistical analysis

In order to overcome non-orthogonality of data resulting from unequal and disproportionate subclass frequencies, the least squares method, as suggested by Harvey (1990) [3] was used for analysis of data on growth traits of Deccani Sheep.

Model I: Model for estimation of growth traits considering effects of season, year of birth and sex type

$$Y_{ijkl} = \mu + Y_i + S_j + T_k + e_{ijkl}$$

Where

Y_{ijkl} = Observation on growth traits of lth Individual for i^{th} year of birth, j^{th} season of birth and K^{th} sex of lamb
μ = The overall mean
Y_i = Effect of ith year of birth (Y=1 to 10)
S_j = Effect of jth season of birth (j=1 to 2)
T_k = Effect of kth type of sex (k=1 to 2)
e_{ijkl} = The random error associated with independently and normally distributed about a mean zero and variance $\sigma^2 e$.

Model II: Model for estimation of temperature and THI

$$Y_{ijk} = \mu + T_i + T_j + THI_k + e_{ijkl}$$

Where

Y_{ijkl} = Observation l^{th} individual in i^{th} Maximum Temperature and j^{th} Minimum Temperature and k^{th} THI value
μ = The overall mean
T_i = The effect of i_{th} Maximum Temperature group
T_j = The effect of j_{th} Minimum Temperature group
THI_k = The effect of k_{th} THI of completion of the corresponding age
e_{ijkl} = Random error

Formula for THI

THI index were calculated, by adopting National Research Council Formula (NRC, 1971)

$$THI = [1.8 \times (T_{db}) + 32] - (0.55 - 0.0055 \times RH) \times [1.8 \times (T_{db}) - 26]$$

Where

T_{db} = Dry bulb temperature (°C),
RH = Relative humidity.

Correction of data

The data were corrected for the significant effects of season and year of birth by using the method suggested by Gacula *et al*. (1968) [5] and the corrected data were used to examine the effects of temperature and THI on growth traits of Deccani lambs.

Duncan's Multiple Range Test (DMRT)

Duncan's multiple range test as modified by Kramer (1957) [6] was used to make pairwise comparison among the least squares means with the use of inverse elements and root mean squares for error. If the values

$$(\bar{Y}i - \bar{Y}j) \times \sqrt{2Cii} + Cjj + 2\,Cij > \sigma 2e\,Z\,(P, ne)$$

Where

$\bar{Y}i - \bar{Y}j$ = Difference between two least squares means
C_{ii} = Corresponding ith diagonal elements of C matrix
C_{jj} = Corresponding jth diagonal elements of C matrix
Z (P, ne) = Standardized range value in Duncan's table at the chosen level of probability for the error degrees of freedom
P = Number of means involved in the comparison
$\sigma^2 e$ = Root mean squares for error.

Results and Discussion

The least square means of daily gain in body weight are presented in (Table 1). The overall daily body gain upto 3, 6, 9, 12 months age were 0.095 ± 0.001, 0.076 ± 0.0001, 0.059 ± 0.0001 and 0.049 ± 0.001 kg, respectively.

1. Effect of year, season of birth, sex of lamb, temperature and THI groups on daily gain upto three months

The influence of year of birth on daily gain upto three months was highly significant ($P < 0.01$). The highest daily gain (0.113 ± 0.003 kg) was obtained in the lambs born during year 2012 which was at par with lambs born during year 2007 and 2006 while the lowest daily gain obtained in the lamb born during year 2014 (Table 1). The analysis of variance showed non-significant effect of season of birth and sex of lamb (Table 2) on three month body daily gain (g) upto three months. The highest daily gain (0.098 ± 0.001 kg) was obtained in the lambs born during the main season and lowest in off season born lambs (0.097 ± 0.002 kg) (Table 1).

Bhosale (2017) [7] reported that the year of birth was significant ($P < 0.01$) and season of birth were non-significant on three month daily gain and overall mean is (0.059 ± 0.001 kg) on three month daily gain.

It was observed that maximum temperature showed non-significant effect on daily gain upto three months (Table 3). The highest daily gain (0.097 ± 0.003 kg) was obtained in lambs reared at <25 °C. The influence of minimum temperature on daily gain upto three months was significant ($P < 0.01$) (Table 3). The highest daily gain (0.097 ± 0.001 kg) was obtained in lambs maintained under 15-20 °C (Table 4). Effect of THI on daily gain upto three months was significant ($P < 0.05$) (Table 3). The highest daily gain (0.098 ± 0.005 g) was obtained in lambs during THI range <80.

2. Effects of year, season of birth, sex of lamb, temperature and THI groups on daily gain upto six months

The analysis of variance showed highly significant ($P < 0.01$) effect of year of birth and season of birth ($P < 0.01$) while sex of lamb was non-significant daily gain upto six months (Table 2). The highest daily gain (0.087 ± 0.002 kg) was obtained in the lambs born in the year 2007 which was at par with lambs

born during 2012 (Table 1). While lower daily gain exerted in 2014 (0.05±0.002 kg) (Table 1). It was observed that season of birth had significant (*P*< 0.01) effect on daily gain upto six months (Table 3). The highest daily gain (0.077±0.001 kg) was obtained in the main season born lambs and lowest in off season born lambs (0.074±0.001kg) (Table 1) male is heavier than female. Effect of maximum temperature on daily gain upto six months was non-significant (Table 3). The highest daily gain (0.078±0.002 kg) was obtained in the lambs during 35-40 °C temperature (Table 4).

Effect of minimum temperature on daily gain upto six months was non-significant (Table 3). The highest daily gain (0.079±0.004 kg) was obtained in lambs reared at <10 °C temperature (Table 4). The influence of THI on daily gain upto six months was non- significant (Table 3). The highest daily gain (0.078±0.002 kg) was obtained in the lambs exposed to THI range >89 (Table 4).

Bhosale (2017) [7] reported that the analysis of variance showed a highly significant (*P*< 0.01) effect of year of birth on daily gain upto six months. The highest daily gain (0.052 kg) was obtained in the kids born in the year 2012.

3. Effect of year and season of birth, sex of lamb, temperature and THI groups on daily gain upto nine months

The analysis of variance showed a significant (*P*< 0.01) effect of year of birth on daily gain up to nine months. The highest daily gain (0.067±0.001 kg) was obtained in born during year Y2 (2007) which was at par with lambs born during year Y1 (2006), Y4 (2009), Y5 (2010) and Y6 (2011) and Y7 (2012) and lowest daily gain obtained in year Y10 (0.047±0.001kg) (Table 1). The influence of season of birth on daily gain up to nine months was significant (*P*< 0.05) (Table 2). The highest daily gain (0.061±0.001 kg) (Table 1). was obtained in the main season born lambs. Similar results reported by Bhosale (2017) [7] in Sangamneri goat.

Effect of maximum temperature on daily gain up to nine months was non-significant (Table 3). The highest daily gain (0.064±0.004 kg) was obtained in lambs reared at >400C temperature (Table 4). The results showed that minimum temperature had non- non-significant effect on daily gain up to nine months (Table 3). The highest daily gain (0.064±0.005

kg) was obtained in lambs under <100C temperature (Table 4). Effect of THI on daily gain up to nine months was non-significant (Table 3). The highest daily gain (0.060± 0.002kg) was obtained in lambs during THI range <80 (Table 4).

Bhosale (2017) [7] reported that the analysis of variance showed significant (*P*< 0.01) effect of year of birth on daily gain up to nine months. The highest daily gain (0.046 kg) was obtained in kids born during 2012.

4. Effect of year and season of birth, sex of lamb, temperature and THI groups on daily gain upto twelve months

The influence of year of birth on daily gain upto twelve months was significant (*P*< 0.01) (Table 2). The highest daily gain (0.058± 0.003kg) was obtained in the lambs born in the year (2012) which was at par with lambs born in other years except lambs born during the year (2014) (Table 1). Effect of season of birth on daily gain upto twelve months was non-significant (Table 2). The highest daily gain in main season and lowest in off season (0.053±0.001kg) and (0.050±0.002 kg) respectively. The results showed non-significant effect of sex of lamb on daily gain upto twelve months (Table 1). The highest daily gain in male and lower in females (0.052± 0.001kg) and (0.050±0.001 kg) respectively. The analysis of variances showed non-significant effect of temperature (minimum and maximum) and THI at twelve month daily gain (Table 3). The highest daily gain obtained at maximum temperature range <250C (0.051±0.002 kg) and lowest at >40°C (0.047±0.005 kg) (Table 4). At the minimum temperature range highest daily gain obtained at 10-15°C (0.051±0.003 kg) and lowest at 15-20°C (0.048±0.003 kg) (Table 4).

The analysis of variances showed non-significant effect of THI on daily gain upto twelve months (Table 3). The highest daily gain (0.051±0.004 kg) was obtained in the lambs exposed to THI range <80 and lowest daily gain was obtained to THI range 83-86 (0.047±0.003kg)

Bhosale (2017) [7] reported that the influence of year of birth on daily gain upto twelve months was significant (*P*< 0.01). The highest daily gain (0.042 kg) was obtained in the kids born in the year 2012. Effect of season of birth on daily gain upto twelve months was non-significant.

Table 1: Analysis of variance for daily gain in body weights as affected by various factors

Source of variation	Daily gain upto							
	3 months		6 months		9 months		12 months	
	d.f.	M.S.S	d.f.	M.S.S	d.f.	M.S.S	d.f.	M.S.S
YOB	9	0.001**	9	0.0008**	9	0.004**	9	0.0016**
SOB	1	0.01	1	0.008**	1	0.009*	1	0.0009
Sex	1	0.0007	1	0.002	1	0.0002	1	0.0005
Error	1111	0.0008	1111	0.0003	832	0.0001	653	0.0005

**=*P*< 0.01 *=*P*<0.05

Table 2: Least squares means for daily gain in body weight (kg) in Deccani sheep

Source of variation	Daily gain upto			
	3 months	6 months	9 months	12 months
	Mean±S.E. (N)	Mean±S.E. (N)	Mean±S.E. (N)	Mean±S.E. (N)
Overall mean(μ)	0.09±0.00(1123)	0.075±0.001(1123)	0.060±0.001(844)	0.051±0.01(665)
Effect of year of birth				
2006 Y1	0.104±0.003bc(86)	0.077±0.002 cd (86)	0.065±0.001ab(80)	0.057±0.003a(79)
2007 Y2	0.110±0.003ab(125)	0.087±0.002a(125)	0.067±0.001a(114)	0.055±0.002a(112)
2008 Y3	0.101±0.003cd(100)	0.078±0.002 cd (100)	0.061±0.002bc(81)	0.051±0.003abc(180)
2009 Y4	0.079±0.004f(64)	0.072±0.002d(64)	0.062±0.002abc(39)	0.051±0.005abc(121)
2010 Y5	0.086±0.002ef(138)	0.076±0.002 cd (138)	0.062±0.002ab(72)	0.049±0.005abc(39)

2011 Y_6	$0.110\pm0.002^{ab}(166)$	$0.080\pm0.001^{bc}(166)$	$0.064\pm0.001^{ab}(119)$	$0.052\pm0.003^{ab}(79)$
2012 Y_7	$0.113\pm0.003^{a}(132)$	$0.085\pm0.002^{ab}(132)$	$0.066\pm0.001^{a}(97)$	$0.058\pm0.003^{a}(61)$
2013 Y_8	$0.093\pm0.003^{de}(124)$	$0.065\pm0.002^{e}(124)$	$0.050\pm0.001^{d}(98)$	$0.047\pm0.002^{bc}(81)$
2014 Y_9	$0.082\pm0.003^{f}(110)$	$0.059\pm0.002^{f}(110)$	$0.047\pm0.001^{d}(86)$	$0.042\pm0.003^{c}(74)$
2015 Y_{10}	$0.095\pm0.003^{cd}(78)$	$0.076\pm0.002^{cd}(78)$	$0.057\pm0.002^{c}(58)$	$0.047\pm0.002^{abc}(39)$
Effect of season of birth				
Main (S_1)	$0.098\pm0.001(767)$	$0.077\pm0.001^{a}(767)$	$0.061\pm0.001^{a}(574)$	$0.053\pm0.001(460)$
Off (S_2)	$0.097\pm0.002(356)$	$0.074\pm0.001^{b}(356)$	$0.059\pm0.001^{b}(270)$	$0.050\pm0.002(205)$
Effect of sex of lamb				
Male(1)	$0.098\pm0.001(561)$	$0.075\pm0.001(561)$	$0.061\pm0.001(414)$	$0.052\pm0.001(334)$
Female(2)	$0.097\pm0.001(562)$	$0.076\pm0.001(562)$	$0.060\pm0.001(430)$	$0.050\pm0.001(331)$

The means under each class in the same column with different subscripts differed significantly.

Table 3: Analysis of variance for daily gain as affected by temperature and THI in Deccani sheep

Source of variation	Daily gain upto							
	3 months		6 months		9 months		12 months	
	d.f.	MSS	d.f.	MSS	d.f.	MSS	d.f.	MSS
Temp. max.	3	0.0003	2	0.0002	4	0.0009	4	0.0001
Temp. min.	3	0.0053**	3	0.0000	4	0.0001	3	0.0002
THI	3	0.0029*	3	0.0002	4	0.0001	4	0.0002
Error	1113	0.0008	1114	0.0003	831	0.0001	653	0.0005

$** = (P< 0.01) * = (P< 0.05)$

Table 4: Least squares means for daily gain (kg) as affected by temperature and THI in Deccani sheep

Source of variation	Daily gain upto			
	3 months	6 months	9 months	12 months
Overall mean(μ)	**0.095**	**0.076**	**0.059**	**0.049**
Effect of temperature maximum (^{0}C)				
<25	0.097	-	0.052	0.05
25-30	0.095	-	0.059	0.051
30-35	0.093	0.076	0.061	0.051
35-40	0.095	0.078	0.06	0.049
>40	0.097	0.076	0.064	0.045
Effect of temperature minimum (˚C)				
<10	0.08^{b}	0.079	0.064	0.047
10-15	0.10^{a}	0.076	0.06	0.051
15-20	0.09^{b}	0.075	0.06	0.048
>20	0.09^{b}	0.076	0.058	0.051
Effect of THI				
<80	0.098^{a}	0.075	0.06	0.051
80-83	0.089^{a}	0.077	0.059	0.047
83-86	0.095^{a}	0.076	0.058	0.049
86-89	0.093^{a}	0.076	0.06	0.05
>89	0.098^{a}	0.078	0.058	0.05

Conclusion
The effects of temperature and THI groups on body weights were non-significant and minimum temperature and THI were significant on three months body weight, which indicated that the Deccani sheep are well acclimatized to the available climatic conditions. The year of birth had a significant effect on average daily weight gain upto twelve months. However season of birth, sex, mostly temperature and THI has no influence on daily weight gain.

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