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Studies on Different Temperature Humidity Index Models in Relation with Production Traits for Phule Triveni Cattle

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ABSTRACT

The data on production performance of Phule Triveni cattle maintained at Research cum Development Project on Cattle (RCDP), Mahatma Phule Krishi Vidyapeeth, Rahuri district, Ahmednagar, (M.H) were utilized for present study. The least squares means of total milk yield (kg), lactation length (days), dry period (days) and peak milk yield (kg) were estimated by considering the effects of period of calving, season of calving and lactation order as non-genetic factors. Then data were corrected for significant non genetic factor effect and effect of THI was estimated. The frequency distribution patterns for MMY according to THI were worked out. The overall least squares means for TMY, LL, DP and PMY are 2612.88 ± 75.48 kg, 306.43 ± 5.51 days, 144.12 ± 11.38 days and 14.87 ± 0.30kg, respectively in Phule Triveni cattle. The THI had significant influence on production traits TMY, LL, PMY, indicating that the Phule Triveni cows were acclimitised to the local climate due to optimum feeding with sound management are provided. However, the THI had non-significant influence on trait DP. The overall observations reveals the result that THI3 is the most suitable model of THI for Phule Triveni cattle.

Introduction

Increased pressure for intensified milk production and simultaneous rise in environmental temperature due to global warming has increased the thermal load on dairy animals. Elevated environmental temperature combined with high humidity causes discomfort and escalates the stress level in animals which is reflected in terms of reduced physiological and metabolic activities that results in reduced growth, drop in production and reproduction in farm animals. Heat stress is one of the most vital environmental stressor that has negative impact on milk yield, milk composition (fat%, SNF%, protein % etc). Construction of Temperature Humidity Index (THI) by combining several climatological parameters like dry bulb, wet bulb temperature along with relative humidity to quantify the thermal stress is one of the best methods to assess heat stress on animals. Several research workers have reported that there exists a threshold THI value, above which the negative effects of heat stress is observed on animals. Mitigation strategies to combat heat stress includes selection of heat tolerant animals and their breeding, inclusion of heat tolerance as a trait while constructing selection index, providing balanced nutrition to the animals and implementation of good ventilation along with suitable cooling system in the farm (Behera *et al.*, 2020).

Materials and Methods

The data of Phule Triveni cows maintained at Research Cum-Development Project on Cattle, M.P.K.V., Rahuri for a period from 2009 to 2019 (10 years) were collected for present investigation for following Traits:

a)Productive traits:1) Total lactation milk yield (kg),2) Lactation length (days),3) Dry period (days),4) Peak milk yield (kg).

To examine the Production traits, the research data was classified into 3 periods of calving viz. P_1 (2009-2011), P_2(2012-2014),P_3 (2015above);3 seasons of calving, viz. S_1 (Rainy) June- September, S_2 (Winter) October-January and S_3 (Summer) February-May; 5 order of lactation viz. L_1first lactation, L_2 second lactation, L_3third lactation, L_4 fourth lactation, L_5fifth lactation; 7 different THI values as THI1 in 6 Ranges THI11 (71-74), THI12(74-77), THI13 (77-80), THI14 (80-83), THI15 (83-86), THI6 (86-89); THI2 in 5 Ranges THI21 (60-64), THI22 (64-68), THI23 (68-72), THI24 (72-76), THI25 (76 - 80);) ; THI3 in 5 Ranges THI31 (58-62), THI32 (62-66), THI33 (66-70), THI34 (70-74), THI35 (74 -78);) ; THI4 in 4 Ranges THI41 (65-69), THI42 (69-73), THI43 (73-77), THI44 (77-81); THI5 in 6 Ranges THI51 (72-75), THI52 (75-78), THI53 (78-81), THI54 (81-84), THI55 (84-87), THI56 (87 - 90); THI6 in 4 Ranges THI61 (65-70), THI62 (70-75), THI63 (75-80), THI64 (80-85); THI7 in 4 Ranges THI71 (65-69), THI72 (69-73), THI73 (73-77), THI74 (77-81)

The effects of non-genetic factors like period of calving, season of calving and parity were estimated by using least-square analysis as suggested by Harvey (1990). The model was used with the assumption that different components being fitted into the model were as linear, independent and additive. The model used was as follows:

Model I

$$Y_{ijkl} = \mu + A_i + B_j + C_k + e_{ijkl}$$

where Y_{ijkl}, observation of l^{th} animal, k^{th} parity, j^{th} season of calving, i^{th} period of calving; μ overall mean, A_i fixed effect of i^{th} period of calving (1 to 3), B_j fixed effect of j^{th} season of calving (1 to 3), C_k fixed effect of k^{th} parity (1 to 5); e_{ijkl} random error ~ NID (0, $\sigma^2 e$).

Correction of data

Whenever the effects found significant data were corrected and used for further analysis. The data on different production traits were corrected for the significant effects of period of calving, season of calving and lactation order. The corrected data were used to find out the effect of THI on production traits.

Temperature humidity index models

Seven reported THI models were used to compute temperature humidity index as follows:

THI model reference

THI1 = [0.4 × (Tdb + Twb)] × 1.8 + 32 + 15 Thom (1959)

THI2 = (0.35 × Tdb + 0.65 × Twb) × 1.8 + 32 Bianca (1962)

THI3 = (0.15 × Tdb + 0.85 × Twb) × 1.8 + 32 Bianca (1962)

THI4 = (Tdb + Twb) × 0.72 + 40.6 NRC (1971)

THI5 = (0.55 × Tdb + 0.2 × Tdp) × 1.8 + 32 +17.5 NRC (1971)

THI6 = (1.8 × Tdb + 32) - (0.55 –0.00 55 × RH) ×(1.8 × Tdb – 26.8) NRC (1971)

THI7 = (0.8 × Tdb) + [(RH/100)×(Tdb – 14.4)] + 46.4 (Mader *et al.*, 2006)

Tdb: dry bulb temperature; Twb: wet bulb temperature; RH: relative humidity; Tdp: dew point temperature. Tdb, Twb and Tdp were measured in °C and RH was measured in %.

Monthly THI will be computed using the environmental parameters and effect of THI was seen on traits under study by using following model.

Model II

$Y_{ij=}\ \mu + THI_i + e_{ij}$

Y_{ij} - Observation on j^{th} parameters for i^{th} THI value range

μ - Overall mean

THI_i - Effect of i^{th}THI value range

e_{ij} - Random error associated with NID ~ (0, σ^2e)

Duncan's Multiple Range Test (DMRT)

Duncan's Multiple Range Test as modified by Kramer (1957) was used to make pair wise comparison among the least square means with the use of inverse elements and root mean squares for error.

If the values:-

$$(Y_i - Y_j) \times \sqrt{\frac{2}{C_{ii} + C_{jj} + 2\,C_{ij}}} > \sigma^2 e,\ Z(P,ne)$$

Where,

$Y_i - Y_j$: Difference between two least squares means

C_{ii}: Corresponding i^{th} diagonal elements of C matrix

C_{jj}: Corresponding j^{th} 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

σ^2e: Root mean squares for error

Results and Discussion

Effect of THI on total milk yield

The overall least squares mean of total milk yield in Phule Triveni cattle was 2442.83± 241.84kg. According to the above investigation the effect of THI1, THI2, THI3, THI4, THI6 and THI7 on total milk yield of Phule Triveni cattle was non-significant, except THI5. The differences in the total milk yield of Phule Triveni cows in THI 53 significantly higher than THI 52, THI 54 and THI 51.The differences in the total milk yield of Phule Triveni cows in THI 54 and THI 51, THI 56 and THI 55 were at par to each other. The maximum total milk yield was in THI 53 (4422.87 ± 1369.86) and minimum total milk yield was in THI 56 (849.69 ± 1248.88).This results was in accordance with GhaviHossein-Zadeh *et al.*, (2012), Gantner *et al.,* (2012), H. Hammami *et al.,* (2013), ForoughZare-Tamami *et al.*, (2017), Behera *et al.*, (2017), Habeeb (2020) in dairy cows (Table 1).

Table.1 Total milk yield (Kg), Lactation length (Days), Dry period (Days), Peak milk yield (Kg) as affected by THI in Phule Triveni cattle

Effect	N	LEAST SQUARE MEANS			
		Total Milk Yield	Lactation Length	Dry period	Peak milk yield
μ		2442.83± 241.84	287.934± 15.43	156.49±32.41	14.43±0.925
THI11	4	2497.54± 1368.43	126.77± 87.30	253.57± 183.40	25.27^{a}±5.22
THI12	22	617.48± 1427.29	106.85± 91.06	190.35± 191.29	16.41^{c}±5.47
THI13	17	1184.26±1154.99	307.24± 73.68	210.70± 154.79	16.62^{b}±4.41
THI14	47	3184.02± 918.89	405.41± 58.62	34.11± 123.15	7.37^{f}±3.51
THI15	39	3561.00± 1015.19	397.90± 64.77	90.36± 136.05	10.90^{d}±3.87
THI16	8	3612.70± 1308.82	383.40± 83.50	159.86± 175.41	10.00^{e}±4.99
THI21	6	1982.78± 1111.20	219.10± 70.89	231.35± 148.92	12.12^{c}±4.24
THI22	24	2248.17± 659.57	374.43± 42.08	176.52± 88.39	10.89^{d}±2.51
THI23	17	1609.74± 552.93	313.84± 35.27	183.82± 74.10	09.71^{e}±2.11
THI24	56	2958.07± 518.91	276.06± 33.10	84.80± 69.54	18.00^{b}±1.98
THI25	34	3415.40± 679.78	256.21± 43.37	105.97± 91.10	21.42^{a}±2.59
THI31	8	2434.94± 696.11	343.77± 44.41	145.78± 93.29	13.82^{c}±2.65
THI32	26	2632.35± 404.62	243.94± 25.81	133.12± 54.22	17.05^{b}±1.54
THI33	23	3015.61± 429.66	250.12± 27.41	155.75± 57.58	18.38^{a}±1.64
THI34	58	1996.52± 512.94	286.11± 32.72	195.53± 68.74	1261^{d}±1.95
THI35	22	2134.74± 529.26	315.70± 33.76	152.29± 70.93	10.29^{e}±2.02
THI41	11	1768.03± 769.77	320.41± 49.11	35.28± 103.16	9.33±2.98
THI42	31	2552.91± 662.81	343.14± 42.28	141.62± 88.83	11.9±2.54
THI43	59	3363.24± 648.47	255.60± 41.37	194.43± 86.91	20.05±2.48
THI44	36	2087.15± 761.86	232.56± 48.60	254.64± 102.10	16.43±2.91
THI51	9	2241.15^{d} ±726.00	333.40^{b}± 46.31	119.15± 97.30	12.25^{d}±2.79
THI52	22	3793.19^{b}± 877.24	354.8^{a}± 55.96	164.62± 117.57	18.26^{a}±3.38
THI53	18	4422.87^{a}± 1369.86	269.01^{e}± 87.39	127.19± 183.59	18.12^{b}±5.23
THI54	49	2403.78^{c}± 765.25	278.62^{c}± 48.82	112.80± 102.56	16.87^{c}±2.93
THI55	30	946.32^{e}± 1024.34	218.42^{f}± 65.35	286.59± 137.28	11.02^{e}±3.93
THI56	9	849.69^{f} ± 1248.88	273.31^{d}± 79.68	128.62± 167.37	10.06^{f}±4.78
THI61	18	3620.07± 670.49	370.05± 42.77	168.38± 89.86	14.44±2.64
THI62	27	2634.31± 535.48	312.81± 34.16	94.21± 71.76	11.72±2.04
THI63	88	1742.77± 538.60	275.02± 34.36	177.97± 72.18	13.84±2.06
THI64	4	1774.18± 438.48	193.84± 53.49	185.40± 112.37	17.72±3.20
THI71	10	2876.40± 1149.28	309.58± 73.32	149.69± 154.03	14.80±4.39
THI72	28	2138.40± 663.11	249.75± 42.30	166.36± 88.87	14.46±2.54
THI73	48	1658.86± 598.40	264.95± 38.17	259.07± 80.20	12.74±2.29
THI74	41	3097.67± 1327.12	327.44± 84.67	50.86± 177.86	15.72±5.09

Effect of THI on lactation length

The overall least squares mean of total milk yield in Phule Triveni cattle was 287.934± 15.43days. According to the above investigation the effect of THI1, THI2, THI3, THI4, THI6 and THI7 were non significant on lactation length of Phule Triveni cattle, except THI5.The differences in THI5 within range 2 shows significantly higher than THI51, THI54, THI56, THI55, THI53 were at par to each other. The maximum lactation length was in THI 52 (354.8± 55.96) and minimum lactation length was in THI 55 (218.42±65.35). This results was in accordance with GhaviHossein-Zadeh *et al.*, (2012), Gantner *et al.*, (2012), Hammami *et al.*, (2013), Forough Zare-Tamami *et al.*, (2017), Behera *et al.*, (2017), Habeeb,(2020) in dairy cows.

Effect of THI on dry period

The overall least squares mean of dry period in Phule Triveni cattle was 156.49± 32.41days. According to the above investigation the effect of THI1, THI4, THI5, THI6 and THI7 on dry period of Phule Triveni cattle, was non-significant. This results was in accordance with GhaviHossein-Zadeh *et al.*, (2012), Gantner *et al.*, (2012), Hammami *et al.*, (2013), ForoughZare-Tamami *et al*., (2017) in dairy cows.

Effect of THI on peak milk yield

The overall least squares mean of peak milk yield in Phule Triveni cattle was 14.43± 0.925kg.According to the above investigation the effect of THI1,THI2,THI3 and THI5 on peak milk yield of Phule Triveni cattle, was significant, except the effect of THI6, THI7. The differences in the dry period of cows in THI11 significantly higher than THI13, THI 12, THI 15 and THI 14. THI 25 significantly higher than THI24, THI21, THI22, THI23, THI 33significantly higher than THI 32 and THI 31, THI 34 and THI 35.THI 52 significantly higher than THI53, THI54, THI51, THI55, THI56. The maximum peak milk yield was in THI 11 (25.27 ± 5.22 kg) and minimum peak milk yield was in THI 14 (7.37± 3.51 kg). This results was in accordance with Ghavi Hossein-Zadeh *et al.*, (2012), Gantner *et al.*, (2012), Behera *et al.*, (2017) in dairy cows.

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