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Impact of climatic parameters on milk production in *murrah* buffaloes

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ABSTRACT

The impact of climatic parameters on milk production in Murrah buffaloes were investigated using monthly milk production record of 379 lactations of Murrah buffaloes in Dairy Farm, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during the years from 1985-2009. Correlation and multiple regression analysis were used to investigate various sources of variation for milk yield. The calving of Murrah buffaloes were not equally distributed in all seasons of the year. However the maximum number of calving occurred in winter season (44.59 per cent) followed by rainy season (31.40 per cent) and summer season (24.01 per cent). The influence of environmental factors on peak milk yield was significant (P< 0.01). It was observed that peak milk yield was highest (7.801 ± 0.16 lit.) among the buffaloes calved during winter season as compared to rainy (7.35 ± 0.14 lit.) and summer season (6.51 ± 0.12 lit.).The influences of season of calving on lactation milk yield and lactation length were also significant. The highest milk yield and lactation length were also significant. The highest milk yield (1257.15 ± 29.55 lit.) and longer lactation length (310.65 ± 2.25 days) were observed among buffaloes calved during winter season. The buffaloes calved during winter, rainy and summer season had lactation yield of 1257.15 ± 29.55 lit., 1088.00 ± 18.41 lit. and 982.42 ± 15.56 lit., respectively. It was also observed that buffaloes calved during winter season had longest lactation length (310.65 ± 2.25 days). On the other hand rainy and summer calved buffaloes showed shorter lactation length (301.52 ± 1.97 days) and (293.12 ± 2.35 days) respectively.

***Keywords*:** Environmental variables, heat stress, lactation milk yield, lactation length, peak yield, THI

Heat stress seems to be one of the intriguing factors making animal production challenging in many geographical locations in the world (Koubkova *et al.* 2002). Heat stress is caused by a combination of environmental factors (ambient temperature, relative humidity, solar radiation, air movement and precipitation) and has a negative impact on the livestock production both directly and indirectly. Animal's health and productivity is closely interacted with environment in which they perform.

Buffaloes play a major role in Indian dairy industry and contributing about 56 per cent share of total milk production. Buffaloes are more sensitive than cattle to direct solar radiation and ambient temperature because of dark body colour, absence of sweat glands and thick epidermal layer of skin which cause reduction in their milk production with shorter lactation period (Upadhayay *et al.,* 2007). Marathwada region of Maharashtra state is characterized by hot dry summer and moderately cool winter. Department of Animal Husbandry and Dairy Science, Vasantrao Naik Marathwada Agriculture University, Parbhani, Maharashtra located in subtropical region of India has maintaining Murrah buffaloes for study of suitability of these animal in this region. The information on the effect of climatic variables on lactation performance of Murrah buffaloes in this region is lacking. Hence this study was planned to measure variation in lactation performance (lactation yield, lactation length and peak yield) due to environmental factors in Murrah buffaloes.

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MATERIALS AND METHODS

This study was conducted at Department of Animal Husbandry and Dairy Science, VNMKV, Parbhani, Maharashtra, India, which is located at 19 °16' North latitude and 76° 74' East longitude and 409 m above mean sea level. The climate of the region is subtropical and having assured rainfall zone with an average annual rainfall of 885 mm mostly received in about 70 days during June to September. On seasonal basis, it oscillates from humid to sub humid in monsoon, sub humid to semi-arid during post-monsoon and hot and dry in summer. The mean daily maximum temperature varies from 29.1°C in December to 42.5°C in May. The mean daily minimum temperature varies from 6.9ºC in December to 25.4 ° C in May. The relative humidity ranges from 11 to 90 %. Normally, the summer is hot and general dryness persists throughout the year.

Systematic record of buffalo herd in respect to daily milk yield, date of calving, lactation length, dry period, peak milk yield is maintained at this farm. The data of Murrah buffaloes in respect of above characters in different season for the period of 1985-2009 with 379 records of lactation and buffaloes having at least three offspring were selected for analysis. Meteorological data (1985-2009) were

obtained from the University meteorological observatory station. The complete year was divided into 3 seasons as rainy (June to September), winter (October to January) and summer (February to May).

The management details at this farm were somewhat identical with variation due to reason beyond control. The daily routine for milch animals started at 4.30 a m. The animals were milked by about 5.30 am to 6.30 am after feeding concentrate mixture. The udders were washed with water and cleaned dry with cloth before milking. The animals were allowed to graze from 8.30 am to 2.30 pm daily. The animals were then tied and stall fed required quantities of dry *kadbi* and seasonal greens. They were again cleaned at 3.30 pm and fed concentrates and milked subsequently at 4.30 pm. The milk recording started after 4th day from calving. The dams remained in barn for the first five days during which they were provided with green fodder, concentrate diet and transferred to the milking herd afterwards.

All animals were routinely checked for any incident of health problem and treatments were given if any abnormality exists. Additionally, animals were regularly vaccinated and shaved regularly.

Determination of temperature humidity index (THI): THI is a useful and easy way to assess the risk of heat stress. THI is calculated as follows (Kadzere *et al.*2003):

$$THI = 0.72\,(dbt\,^{0}C + wbt\,^{0}C) + 40.6$$

where, dbt ^{0} C = dry bulb temperature (^{0} C); wbt ^{0}C = wet bulb temperature (^{0}C)

Determined THI values were used to identify heat stress and to examine the monthly variation of THI.

To investigate the effect of environmental variables on lactation milk yield and lactation length, the data were analysed by using correlation and multiple regression model. The main environmental variables were also compiled as monthly minimum and maximum temperature, monthly minimum and maximum relative humidity, monthly wind speed *(km hr^{-1})* and monthly sunshine hours as well as THI.

Data were analysed by using the statistical analysis system software programe (SAS, 2002). The following regression model was utilized to study the effect of different independent variables (climatic factors) on lactation length, lactation milk yield and peak milk yield.

Where, Y is dependent variable; X's are independent variables; a is constant; b's are coefficient of X and u_{ij} is error term.

This multiple regression equation describes an average relationship between dependent and independent variable, which is used to predict the dependent variables. The variability of model was tested with the help of coefficient of multiple regressions (R^2). The significance of R^2 was tested with 'F' test and significance of individual partial regression coefficient was tested with't' test. Basically, regression helps to estimate the functional relationship between the independent and dependent variables.

Table 1: Average meteorological data during the period of study (1985-2009).

Month	Temperature (°C)		Relative humidity		SH (hrs)	WS	THI
	Max	Min	Max	Min			
Jan	29.70	12.00	74.60	32.30	9.70	3.40	66.80
Feb	32.10	15.60	64.00	27.00	10.03	7.66	70.60
Mar	36.80	17.40	55.10	23.30	10.60	4.42	74.20
Apr	40.30	21.30	47.60	19.40	10.70	5.50	78.60
May	41.09	24.60	29.20	20.80	11.30	7.40	80.09
June	37.60	24.70	71.40	40.90	8.90	8.71	78.30
Jul	31.50	22.80	81.60	59.00	4.60	7.04	76.44
Aug	30.50	21.90	84.30	64.80	4.70	5.60	75.70
Sep	31.60	22.10	83.00	62.24	6.90	4.60	74.00
Oct	32.00	18.04	78.70	47.00	9.60	3.80	73.60
Nov	31.80	14.05	78.90	39.40	9.96	3.33	69.70
Dec	29.80	10.05	77.30	34.03	9.50	3.04	66.80
Average	33.73	18.71	68.81	39.18	8.87	5.38	73.74

SH – Sunshine hour, WS- Wind speed, THI- Temperature humidity index

RESULTS AND DISCUSSION

Environmental variables during the period of study

The average monthly environmental variables *viz.,* ambient temperature, relative humidity, sunshine hours, wind speed and temperature humidity index during the period of study (1985-2009) are presented in table 1. The environmental condition observed in the table clearly indicate that the study area is under humid to sub humid in monsoon, sub humid to semi-arid during winter and hot and dry in summer.

Effect of environmental variables on lactation milk yield and lactation length in Murrah buffaloes

It is observed from table 2 that as temperature is decreased; lactation milk yield and lactation length is increased. As temperature, wind velocity and THI increased there is increase in lactation yield and lactation length. The average sunshine hours, wind speed and THI value were 08.87 ± 0.65, 05.38 ± 0.56 and 73.74 ± 1.29, respectively. Upadhyay (2007) reported that ambient temperature and humidity were having significant correlation with milk yield and lactation length. Bouraoui *et al.* (2002) observed that THI value increased from 68-78 milk production decreased by 21 per cent. Many research workers like Thomas and Acharya (1981), Shinde *et al*. (1990) Kale and and Basu (1993) observed ambient temperature and humidity were having significant correlation with milk yield and lactation length. To determine the relative importance and role of various environmental factors in the variation of milk yield and lactation length, stepwise regression coefficients were calculated and presented in Table 3. Climatic variables *i.e.* maximum temperature, minimum temperature, maximum humidity, minimum humidity, sunshine hours, wind speed and THI together accounted for 84.90 per cent variation in lactation milk yield and 87.10 per cent variation in lactation length. However the R^2 value did not reach the level of significance for milk yield and lactation length. It was also revealed that all climatic parameters under study except minimum humidity and sunshine hours had negative non significant association with milk yield, whereas minimum humidity, wind speed and THI showed negative non significant association and maximum temperature shows negative significant association with lactation length of Murrah buffaloes.

Table 2: Correlation coefficients for lactation milk yield and lactation length in *Murrah* buffaloes

Variables	LMY		LL	
	Mean ± SE	r	Mean ± SE	r
Max Temp. °C	33.73 ± 1.78	-0.683*	33.73 ± 1.78	-0.762*
Min Temp. °C	18.71 ± 1.43	-0.803**	18.71 ± 1.43	-0.888*
Max Hum	67.98 ± 5.53	0.505 NS	67.98 ± 5.53	0.544 NS
Min Hum	39.18 ± 4.65	0.485 NS	39.18 ± 4.65	0.469 NS
SH (hrs)	08.87 ± 0.65	0.098 NS	08.87 ± 0.65	0.128 NS
WS (km/hr)	05.38 ± 0.56	-0.748**	05.38 ± 0.56	-0.788*
THI (%)	73.74 ± 1.29	-0.870**	73.74 ± 1.29	-0.937*
	LMY =1070.96 ± 25.86 kg		LL = 293.058± 3.017 days	

** Significant at 5 per cent** Significant at 1 per cent*

Table 3: Regression coefficients for lactation milk yield and lactation length in *Murrah* buffalo

Variables	Mean ± SE	LMY			LL		
		b	SE of (b)	t value	b	SE of (b)	t value
Max Temp (°C)	33.73 ± 1.78	-0.85	31.18	-0.02	-2.92	1.14	-2.57*
Min Temp (°C)	18.71 ± 1.43	-13.46	30.00	-0.44	0.76	1.09	0.69
Max Hum (%)	67.98 ± 5.53	-0.10	2.87	-0.03	0.11	0.10	1.06
Min Hum (%)	39.18 ± 4.65	4.17	1.95	2.13	-0.16	0.33	-0.49
SH (hrs)	08.87 ± 0.65	20.78	8.15	2.55*	3.19	0.79	4.06**
WS (km/hr)	05.38 ± 0.56	-4.69	23.77	-0.19	-1.73	0.87	-2.00
THI	73.74 ± 1.29	-29.57	26.47	-1.12	-0.01	1.10	-0.01
		R^2 = 0.849 F value = 3.22			R^2 = 0.871 F value = 28.96		

**Significant at 5 per cent level, ** Significant at 1 per cent level LMY = Lactation milk yield LL = Lactation length.*

Table 4: Correlation and regression coefficient for peak milk yield of *Murrah* buffaloes on climatic variables in rainy season

Variables	Mean ± SE	Peak milk yield			
		r	b	SE of (b)	t value
Max Temp (°C)	33.13 ± 0.14	0.435*	-0.03	0.30	-0.07
Min Temp (°C)	23.06 ± 0.14	-0.153^{NS}	-0.23	0.26	-0.89
Max Hum (%)	81.10 ± 0.52	0.513**	-0.06	0.08	-0.76
Min Hum (%)	56.61 ± 0.92	0.472*	0.02	0.05	0.04
SH (hrs)	06.12 ± 0.21	-0.251^{NS}	-0.05	0.36	-0.15
WS (km/hr)	06.50 ± 0.19	0.466*	0.06	0.22	0.30
THI	72.82 ± 0.31	-0.147^{NS}	0.03	0.12	0.27
Average peak milk yield = 7.35 ± 0.14 litre R^2 = 0.495 F value = 0.254					

** Significant at 5 per cent level** Significant at 1 per cent level*

Effect of environmental variables on peak yield in Murrah buffaloes in rainy season

Average peak milk yield was recorded as 7.35 ± 0.14 lit in rainy season. It is evident from table-4 that different environmental factors established significant association with peak milk yield of Murrah buffalo in rainy season. All the correlation coefficient values except, minimum temperature, sunshine hours and THI were positively significant and were of moderate magnitude. The values were of moderate degree being 0.435 to -0.153 for temperature and 0.513 to 0.472 for humidity. This trend indicated that decrease in the milk yield with increase in maximum temperature and maximum humidity in rainy season. The contribution of the rest factor *viz*. minimum temperature, sunshine hours and THI on the variation of peak yield in rainy season was low as the r values begin from -0.251 to -0.147. In agreement with result of study Shinde *et al.* (1990) observed that high temperature coupled with high humidity was the cause to record minimum peak milk yield during rainy season.

All the considered environmental variables accounted for 49.50 per cent variation in peak milk yield. The value of coefficient of determination (R^2) did reach the level of significance. This show that peak milk yield could not be influenced consistently by climatic parameters in rainy season in Murrah buffaloes.

Effect of environmental variables on peak yield in Murrah buffaloes in winter season

Average peak milk yield was recorded as 7.80 ± 0.16 lit in winter season. These indicated that peak milk yield in Murrah buffalo was more in winter season, confirming the general consideration of suitability of Murrah under cold climate. It is evident from table-5 that climatic factors *viz.* maximum humidity, wind speed and THI established negative non significant association with peak milk yield in Murrah buffaloes in winter season. In contrast, minimum temperature and sunshine hours exhibited positive significant association with that of peak milk yield. The values were of moderate degree being 0.550 to 0.176 for minimum and maximum temperature and 0.383 to -0.195 for minimum and maximum humidity, respectively. This trend indicated that increase in the milk yield with decrease in temperature and humidity level. This trend supported necessity of cold climate for more peak milk yield in Murrah buffaloes. All the considered environmental variables accounted for 41.70 per cent variation in peak milk yield. The one unit increase in minimum temperature, maximum humidity, wind speed and THI has resulted decrease in peak yield by -0.21, -0.03, -0.55 and -0.23units, respectively.Kundu and Bhatnagar (1985) observed fall in peak milk yield average for every 3.06 per cent increase of THI over 70.30 per cent. Shinde *et al.* (1990) observed decrease in peak milk yield average by 1kg for every increase of 11.70 per cent over 71.33 percent. The THI observed in the present study was supporting to this trend that generally winter conditions favoured milk production in animals due to pleasant climate and availability of quality fodder. Therefore, it can be inferred that there was no severe heat stress in winter season in the study area.

Effect of environmental variables on peak yield in Murrah buffaloes in summer season

Summer climate of study area was hot dry. In this environment peak milk yield was recorded as 6.51 ± 0.12 litre. It is evident from table-6 that correlation coefficient values for rest of environmental attributes were positive and except maximum humidity, wind speed and THI which showed negative non-significant correlation with peak yield. The ambient temperature

Table 5: Correlation and regression coefficient for peak milk yield of *Murrah* buffaloes on climatic variables in winter season

Variables	Mean ± SE	Peak milk yield			
		r	b	SE of (b)	t value
Max Temp (°C)	30.91 ± 0.17	0.176	0.16	0.24	0.65
Min Temp (°C)	13.43 ± 0.26	0.550**	-0.21	0.10	-2.04
Max Hum (%)	77.62 ± 0.68	-0.195	-0.03	0.06	-0.42
Min Hum (%)	37.12 ± 0.61	0.383	0.05	0.02	2.65*
SH (hrs)	09.59 ± 0.08	0.435*	0.11	0.46	0.23
WS (km/hr)	03.28 ± 0.09	-0.240	0.55	0.39	-1.40
THI	69.98 ± 0.23	-0.340	-0.23	0.18	-1.24
Average peak milk yield = 7.80 ± 0.16 litre				R^2 = 0.417 F value = 1.01	

** Significant at 5 per cent level** Significant at 1 per cent level*

shows strong positive relationship with peak yield (0.435 to 0.334), r values postulated the massage of protecting the buffaloes from summer climate in order to maintain their production level.(0.492 to -0.121). The result of Kulkarni *et al*. (1998) supported the present trends.It is also observed from the Table 6 that environmental factors together accounted for 44.00 per cent variation in peak milk yield of Murrah buffaloes. Moreover the R^2 value was significant at 5 per cent level, indicating consistency in the effect of these climatic factors on peak milk yield. The regression coefficient attached to maximum temperature and minimum temperature was significant at 5 per cent level. This research indicates that Murrah buffaloes were sensitive to seasonal changes on their lactation milk yield, lactation length and peak milk yield. The temperature related parameters were found to have a positive relationship with decrease in peak yield, whereas relative humidity related parameters were found to have positive relationship with peak yield. Higher peak yield was observed during winter season as compared to rainy and summer season indicating winter environment was comfortable to Murrah buffaloes. The meteorological observation during the period of study confirmed that there was high value of THI in seven months (March- September) in a year, which suggests that most Murrah buffaloes were exposed to negative effects of heat stress in this region and demanding additional productive strategies like improving micro environment and comfort level of buffaloes for maintaining their lactation performance. It is also advocated that as far as possible dry climate should be maintained in buffalo byres during rainy season and direct exposure of buffaloes to summer heat should be avoided in order to get more production from buffaloes.

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Table 6: Correlation and Regression coefficient for peak yield of *Murrah* buffaloes on climatic variables in summer season

Variables	Mean ± SE	Peak milk yield			
		r	b	SE of (b)	t value
Max Temp (°C)	37.60 ± 0.27	0.435*	0.21	0.09	2.21*
Min Temp (°C)	22.55 ± 0.23	0.334	0.02	0.01	2.19*
Max Hum (%)	53.71 ± 0.56	-0.121	-0.06	0.04	-0.13
Min Hum (%)	25.91 ± 0.28	0.167	0.09	0.11	0.81
SH (hrs)	11.06 ± 0.08	0.492*	-0.04	0.34	-0.13
WS (km/hr)	06.26 ± 0.08	-0.147	0.17	0.34	0.49
THI	75.80 ± 0.19	-0.152	-0.06	0.13	-0.44
Average peak milk yield = 6.51 ± 0.12 lit				R^2 = 0.440 F value = 0.766	

** Significant at 5 per cent level** Significant at 1 per cent level*

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