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ORIGINAL ARTICLE

THE RELATIONSHIP OF BODY CONDITION SCORES TO MILK PRODUCTION IN DAIRY BUFFALOES

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ABSTRACT

A retrospective study of body condition scores (BCS), milk yield, and lactation records of 34 purebreds and crossbred dairy Murrah buffaloes, and climatic parameters were used to determine their relationships with one another. The visual assessments developed for Murrah buffalo was used in BCS determination. Significant correlations (P<0.01) between all parameters except rainfall were found to have weak to moderate monotonic relationships: BCS was negatively correlated to milk yield and affected milk yield by 0.858 kg/day per unit change in BCS. Milk yield was positively affected by early lactation while BCS negatively affected. In early lactation stage, the estimated rate of milk yield increase was 1.519 kg/day and decrease in BCS by 0.267 units. Regarding breed differences, purebred milk yield was positively affected and BCS negatively affected. Purebreds produced significantly more milk (5.44 kg/day) than crossbreds (4.98 kg/day). The highest milk yield was observed both in March for purebreds and crossbreds while, the lowest in August and October for purebreds and crossbreds, respectively. BCS and milk yield were positively correlated with temperature while negatively for relative humidity. In conclusion, BCS, breed, stages of lactation, temperature, and relative humidity have significant effects to milk production.

Key words: *Body Condition Scores, dairy buffaloes, milk production, Murrah buffalo*

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INTRODUCTION

The Philippine dairy consumption in 2017 reached 2,486 million metric tons (liquid milk equivalent) amounting to $903.1 millon. Domestic milk production contributed only to an equivalent of 1% of the demand, leaving the country heavily reliant on importation to meet the national requirement. A sustained local milk supply can contribute to decreasing dependence on imported ready-to-drink milk and provide an additional source of income to smallholder farming communities. To stimulate the local dairy industry, a government strategy is the adoption of technology by farmers to increase animal efficiency, milk productivity, and farm profitability. One of the basic technologies transferred to farmers is animal nutrition and feeding management for dairy buffaloes. A technique employed as a feeding guide is body condition scores. Body condition scoring system has been widely recommended as a technique for evaluating nutritional management of dairy cows (Gillund *et al.*, 2001).

Several body condition scoring (BCS) systems were described and studied and all of these have a numerical scale assigning lower scores to thin animals and higher scores to fat animals. The extensive review of BCS in dairy cattle done by Bewley and Schutz (2008) summarized the internationally acclaimed BCS systems currently used around the world and revealed that the system described by Wildman *et al.* (1982), later modified by Edmonson *et al.* (1989) and Ferguson *et al.* (1994), performed without

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palpating the animal, and having 0 to 5 scale with 0.5 interval points, is as close to an international standard as any system (Schwager-Suter *et al.*, 2000; Kristensen *et al.*, 2006). A new BCS–system was developed by Anitha *et al.* (2010 and 2011) with a chart having 1-5 scale and 0.5 increments for Murrah buffaloes.

Waltner *et al.* (1993) described BCS as an accepted, noninvasive, subjective, quick, and inexpensive method to estimate the degree of fatness in dairy cows. The purpose of condition scoring is to obtain a balance between diet, production, and animal welfare (Souissi and Bouraoui, 2019). BCS technique is mainly used as a periparturient management of dairy cows to minimize dystocia, post-calving diseases (hypocalcemia, hypomagnesemia, and ketosis) and metabolic disorders in early lactation (ketosis, fatty cow syndrome). It is an important management tool because the overall physical condition of the animal will show dairy farmers if the ration that they provide to their herd properly nourish and meets the specific needs and function of the body at any point in the cycle, enabling cows to perform to their highest potential (Klopčič *et al.*, 2011). Mishra *et al.* (2016) defined BCS as a subjective assessment of energy reserves in adipose tissue important in managing dairy cows. In the early lactating stage, high-yielding dairy cows are usually in a state of negative energy balance (NEB) because the amount of energy required for the maintenance of body tissue functions and milk production exceeds what cows can consume (Reist, 2002; Narender Singh and Madhur, 2019). Mobilization of body energy reserves during this stage enables the cow to close the gap between the alimentary energy intake and its loss through the milk production (Schroder and Staufenbiel, 2006). There are expected changes in the body condition as cow moves through gestation, calving, and lactation and generally, BCS decreases from calving to about 100 days in milk and then increases until drying off. The main goal of a nutrition program is to ensure that dairy cows have appropriate body condition throughout the lactation cycle and minimize variations between high and low BCS and make necessary nutritional correction for apparent deficiencies. Animal health and production performance can both be affected when changes in body condition occur rapidly or cows accumulate too much or too little condition. Management of BCS optimizes animal potential by improving herd health status, reproductive performance, animal nutrition, animal husbandry, milk production, and the overall farm profitability. It can also help in understanding the past nutritional status of the herd, probable reasons for state of milk production and quality of milk, reproductive performance, and in anticipating future dairy herd challenges (Klopčič *et al.*, 2011).

The Philippine dairy industry is currently struggling with reproductive inefficiencies and very low milk production and the imminent challenge is to find practical and easy means to improve and boost milk production. The significance of this study is to show how the simple technique of body condition scoring can be learned by dairy buffalo farmers to significantly contribute to improving dairy cow management and milk production. BCS is being used in dairy herd management world-wide but the local adoption as a regular on-farm procedure in the Philippines is yet to be done. Presently, researches on BCS application, importance to herd management, and impact to animal and milk productivity of dairy animals raised under the Philippine setting is scarce.

In this regard, this study aimed to compare the monthly averages of BCS and milk yield of purebreds, crossbreds, early, mid, and late lactating dairy buffaloes raised in South Luzon, Philippines. The correlation between BCS, milk yield, breed, stages of lactation, and climatic parameters in dairy buffaloes were also determined.

MATERIALS AND METHODS

Records of BCS and milk production of 34 apparently healthy lactating dairy buffaloes (21 purebred Murrah and 13 crossbred (Murrah x Carabao) from March 16, 2015 to February 29, 2016, were used and analyzed in the study. The crossbreds have the following blood compositions and number of head: 93.75% x 6.25% (1), 87.5% x 12.5% (5), 75% x 25%C (1), and 50% x 50% (6) aged 3 to 6 years of age and having 2nd to 4th parities. The animals were also classified according to their lactation stage i.e. early (0 to 100 days), mid (101 to 200 days), late (more than 200 days) and their breed (purebred and crossbred).

The dairy buffaloes were raised under intensive management system and biosecurity protocols at the Philippine Carabao Center at UP Los Baños experimental farm. The dairy buffaloes were kept in individual pens starting at 2 weeks before calving. The animals were fed daily with fresh Napier grass, given *ad libitum* drinking water, supplemented with commercial mineral salt licks, and commercial dairy concentrate pellet adjusted depending on the milk production.

The dairy concentrate contained 16.49% crude protein.

Body Condition Scoring

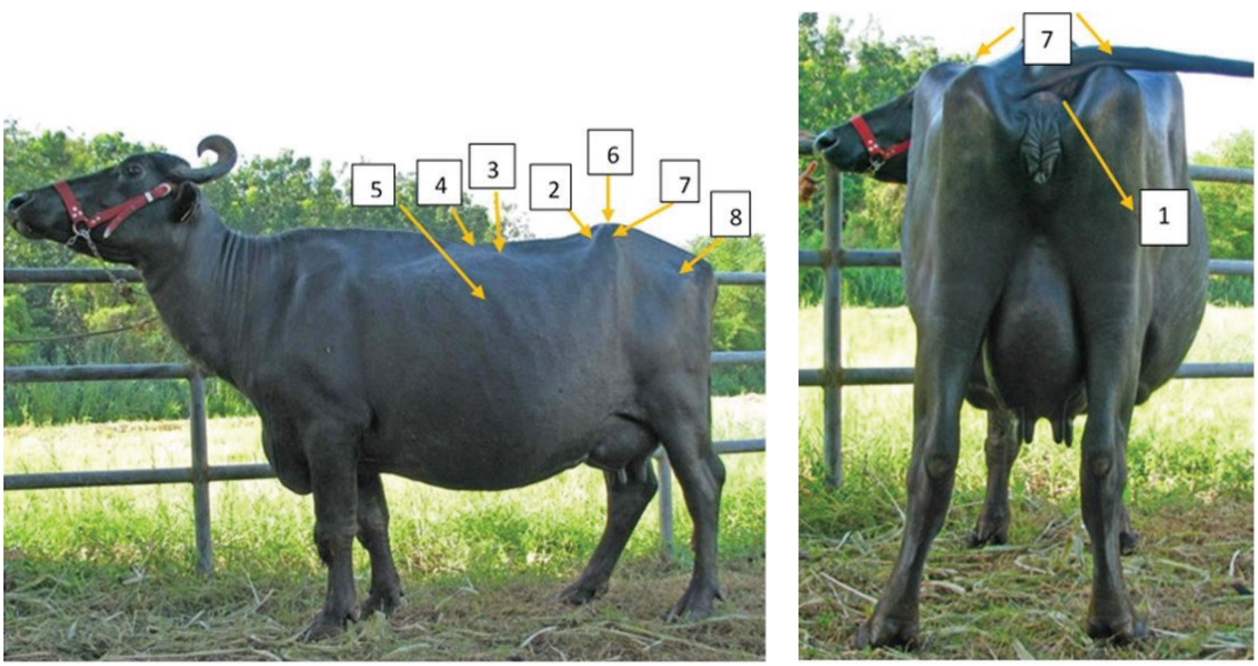
To come up with a BCS (adapted from Anitha *et al.* (2011), each animal, at the start, was visually assessed by a trained and experienced farm technical staff using the eight skeletal checkpoints (Figure 1). These checkpoints are: (1) Tail head to pin bones; (2) Spinous processes of the lumbar vertebrae; (3) Depression between the spinous and transverse processes; (4) Transverse processes of lumbar vertebrae; (5) Point between 12th and 13th ribs; (6) Sacral crest; (7) Depression between sacral crest and hooks; (8) Depression between hooks and pins. Based on amount of body fat reserves on these anatomical features, body condition scores are determined using a 5-point scale with 0.5 increments. A BCS of 1 indicates emaciated, BCS 2 indicates thin, BCS 3 indicates average, BCS 4 indicates fat, and BCS 5 indicates an obese condition. Body condition scoring of each animal was done weekly every Mondays and Wednesdays before milking in the afternoon.

Climate data corresponding to the days of body condition scoring i.e. temperature (°C), relative humidity (%), rainfall (mm) were collected from UPLB National Agrometeorological Station, UP Los Baños, College, Laguna.

Statistical Analysis

The averages of BCS, daily milk yield, temperature, relative humidity, and rainfall were used in the analysis of their relationships and its significance to month of observation, breed, and stage of lactation using Spearman's Correlation Analysis, ANOVA, t-test, and Tukey's HSD in all parameters using STATA and R programs. Statistical significance was set at P< 0.01. Trend analysis was used to describe data where no statistical analysis was possible.

Figure 1. The eight (8) skeletal checkpoints: (1) Tail head to pin bones; (2) Spinous processes of the lumbar vertebrae; (3) Depression between the spinous and transverse processes; (4) Transverse processes of lumbar vertebrae; (5) Point between 12th and 13th ribs; (6) Sacral crest; (7) Depression between sacral crest and hooks; (8) Depression between hooks and pins were examined and observed to indicate the body condition.



RESULTS AND DISCUSSION

Table 1 shows the ranges and means of BCS, milk yield (kg/day), purebred (100% Murrah), crossbred (Murrah x Carabao), early lactation stage (0-100 days), mid-lactation stage (101 to 200 days), late lactation stage (more than 200 days), temperature, relative humidity, and rainfall. There were 1,961 observations for BCS with a mean of 3.97 and ranged from 3.0 to 4.5. Milk yield had a daily average of 5.17 kg with a maximum production volume of 10.8 kg/day and a minimum volume of 1.2 kg/day. Purebreds had 1,246 observations. Crossbreds with percentage of Murrah ranging from 50 to 93.75% had 730 observations. Means of early, mid, and late lactation were 51.53, 147, and 300.98 days, respectively. The daily temperature ranged from 25.9°C to 29.8°C with a mean of 27.7 °C, relative humidity had 1,976 observations and had a mean of 82.98%, and the amount of rainfall had a mean of 5.2 mm. The number of observations were not equal because of morbidity, mortality, drying-off, and changes in stages of lactation.

Table 1. Ranges and means of body condition scores, milk yield, breed, lactation stage, temperature, relative humidity, and amount of rainfall.

Variables	Number of observations	Ranges of Values	Mean (μ±s.e)
Body Condition Score	1,961	3 - 4.5	3.97 ± 0.47
Milk Yield (kg/day)	1,976	0 - 10.8	5.17 ± 1.77
Breed:			
Purebred Murrah	1,246	100	100
Crossbred	730	50 - 93.75	66.36 ± 19.08
Lactation stage:			
Early Lactation	604	0 - 100	51.35 ± 29.09
Mid-lactation	581	101 - 200	147.24 ± 29.18
Late lactation	791	201 - 474	300.98 ± 67.13
Climatic Parameters:			
Temperature (°C)	1,976	25.89 - 29.86	27.71 ± 1.11
Relative Humidity (%)	1,976	71.57 - 90.43	82.98 ± 4.04
Rainfall (mm)	1,976	0 - 33.81	5.22 ± 6.17

Monthly Average BCS of Purebreds and Crossbreds and Climate Parameters

Figure 2 shows the monthly changes in the BCS of purebred and crossbred dairy Murrah buffaloes. Almost equal BCS were observed between the two breeds during the months of November to February. While crossbred animals were scored slightly higher BCS than purebreds in April, May, June, July, September, and October. Notable are the gaps in the BCS between purebreds and crossbreds to be highest in March (0.497) and in September (0.352) both in favor of crossbreds which is almost half unit increment in the body condition scores. At the beginning, crossbreds started with 3.960 BCS in March. The BCS of the crossbreds reached a score of 4 in April and May and afterwards decreased and maintained in the range of 3.8 to 3.9. Crossbreds were able to maintain a BCS of 4 in a span of seven months (April to October) compared to only two months of purebreds (April and May). Crossbreds with BCS of 4 and above started to decrease by 0.080 to 0.203 BCS unit in November to February. The climatic condition did not affect the BCS of purebreds and crossbreds even with the highest temperature, RH, rainfall recorded in May and June and in December for RH and rainfall. Likewise, the lowest temperature, RH, and rainfall in February (26.31 °C), May (74,84%), and April (0.54mm), respectively did not change the BCS of the animals.

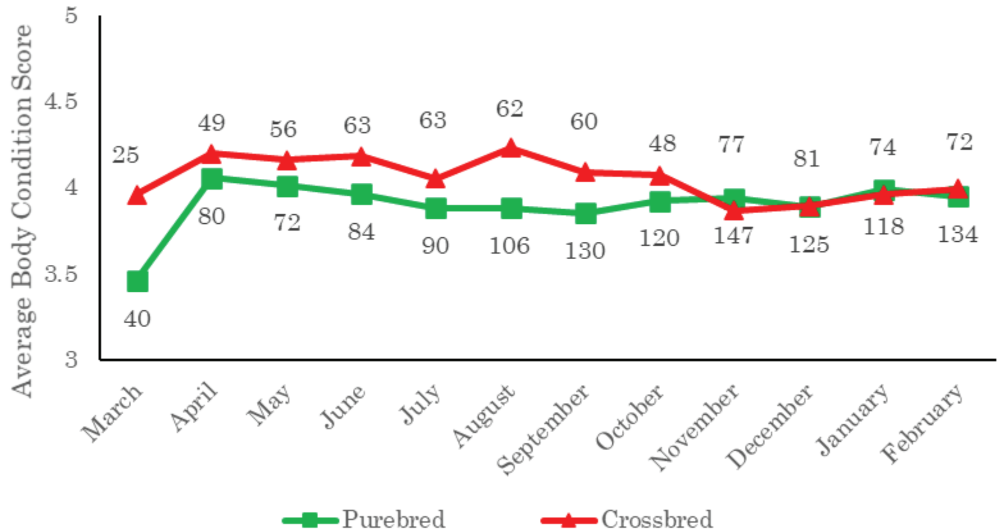


Figure 2. Monthly Average BCS of Purebreds and Crossbreds. The number denotes the number of animals averaged per month.

Monthly Average BCS of Dairy Buffaloes in the Early, Mid, and Late Lactation Stage

Figure 3 shows the monthly average BCS of early, mid, and late lactation stage dairy buffalos. Average BCS of early-stage lactating cows was the lowest at 3.75, followed by mid-lactating cows at 3.86, and late lactating animals have the highest average with a score of 4.21. Cows in the early stage attained the highest BCS in January (4.10) and the thinnest score in September (3.28). Mid-lactating dams got the lowest BCS in March (3.52) and the highest score in October (4.14). Late-lactating animals had the highest scores in May and scored lowest in July (3.97). The low BCS of dairy buffalo in early lactation can probably be explained by the cow's body fat mobilization during the first 60 to 90 days of lactation since they cannot eat enough feeds to support the increase in milk production and avoid weight loss. During this period, their body fat will be mobilized to support high milk production (Klopčič *et al*., 2011).

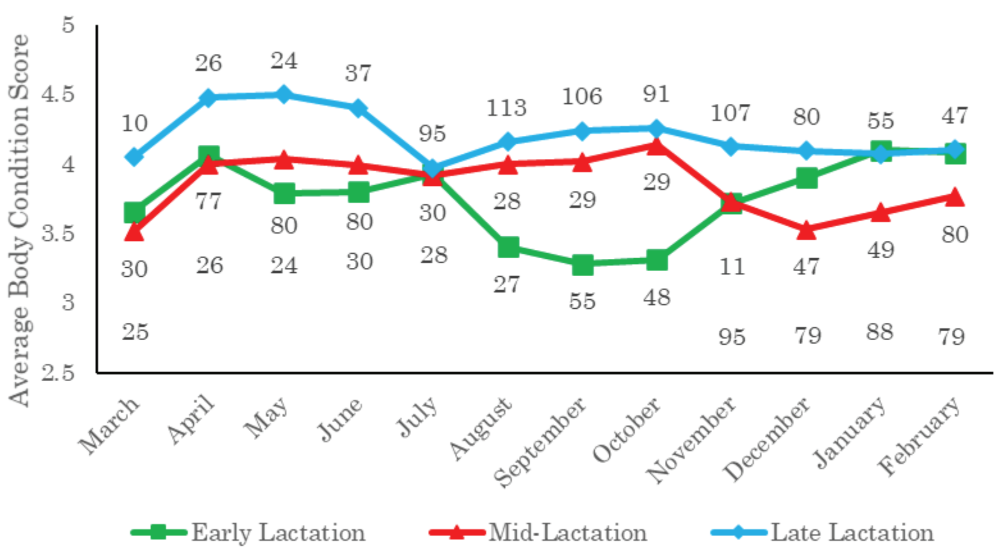


Figure 3. Monthly Average BCS of Dairy Buffaloes in the Early, Mid, and Late Lactation Stage. The number denotes the number of animals averaged per month.

Monthly Average Milk Yield of Purebred and Crossbred Dairy Murrah Buffaloes

The monthly average milk yield (kg/day) of purebred and crossbred dairy Murrah buffaloes are presented in Figure 4. Purebreds produced an average of 5.44 kg/day, while crossbreds had an average of 4.98 kg/day for the whole period. At the start of the study in March, both purebreds and crossbreds were at the peak of milk production. Purebreds produced the highest average value of 6.40 kg/day compared to 5.99 kg/day in crossbreds exhibiting a difference of 0.41 kg/day. After a peak of milk production in March, purebreds were not able to sustain their milk production in the following months with August (4.82 kg/day) and February (4.56 kg/day) having the lowest milk yield. The notable increase in milk yield in purebreds in November (5.30 kg/day) and December (5.65 kg/day) can probably be attributed to the calving season during said months when more lactating dams enter the milking line and increase milk production. Milk yield of purebreds again decreased until February (4.56 kg/day) of the following year due to drying off of some animals. In contrast, crossbreds started in March with a peak average milk yield of 5.99 kg/day. There was a sustained decline for seven months until the lowest recorded average monthly yield in October (4.23 kg/day). Crossbreds produced slightly more milk in April (5.92 kg/day) and February (4.63 kg/day) compared to purebreds with 5.85 kg/day and 4.56 kg/day, respectively. Milk yield of crossbreds started to decline in July with a maintained slight decrease and increase in volume until the last period (February). The abrupt increase of milk yield in November (4.77 kg/day) is probably due to more calvings during this month resulting to increase in cows in the line. Results of analysis of variance showed that there is no significant difference ($P>0.0001$) found in the monthly average milk yield of purebreds and crossbreds. Results of the t-test further conducted on data demonstrated that milk yield purebred milk yield is significantly ($P<0.01$) higher than crossbreds during the month of January. The milk yield of purebreds and crossbreds are not significantly different in the rest of the months of observation.

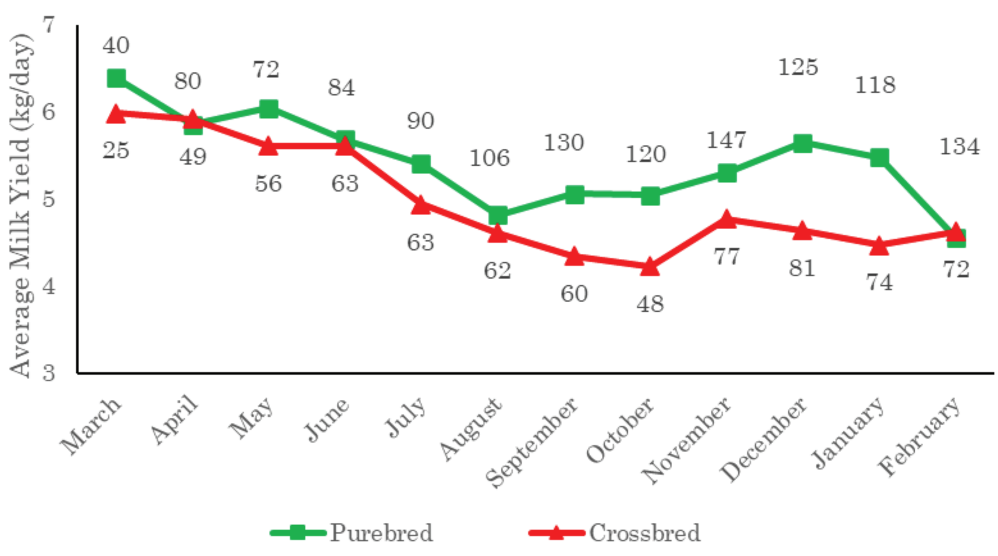


Figure 4. Monthly average daily milk yield of purebreds and crossbreds. The number denotes the number of animals averaged per month.

Monthly Average Milk Yield of Dairy Buffaloes in the Early, Mid, and Late Lactation Stage

The monthly average milk yield of dairy buffaloes in their early, mid, and late lactation stage is shown in Figure 5. Dairy buffaloes in the early stage of lactation have the highest average daily milk yield of 6.2 kg/day followed by cows in the mid-lactation phase (5.5 kg/day). Late lactating stage cows showed the lowest value with 4.0 kg/day. Early lactating buffaloes were at their peak in March with an average of 7.41 kg/day. The following April showed abrupt decline to 6.36 kg/day and continued a downward trend for two months in May (5.97 kg/day) and June (5.79 kg/day). There was small milk yield increase in July (5.92 kg/day) but again decreased in August (5.57 kg/day). From here on, average milk yield increased steadily for four months from September (6 kg/day) until December (6.85 kg/day). Another rapid milk yield decline occurred in January (6.05kg/day) and the lowest yield was recorded in February (5.42 kg/day). Meanwhile, mid-lactating cows showed peak milk yield in May (6.45 kg/day) and the least in February (4.49 kg/day). It slowly decreased in June (6.30 kg/day) and July (6.11 kg/day) then sharply declined in August (4.89 kg/day) and September (4.62 kg/day). In October to February, milk yield of mid lactating cows erratically went up and down. Dairy buffalos in the late lactation stage recorded the highest average milk yield in July (4.72 kg/day) and the lowest in February (3.35 kg/day). Starting March (4.23 kg/day) until July (4.72 kg/day), milk production of mid-lactating cows generally showed an increasing trend. However, it steadily declined in the next seven months from August (4.50 kg/day) to February (3.35 kg/day).

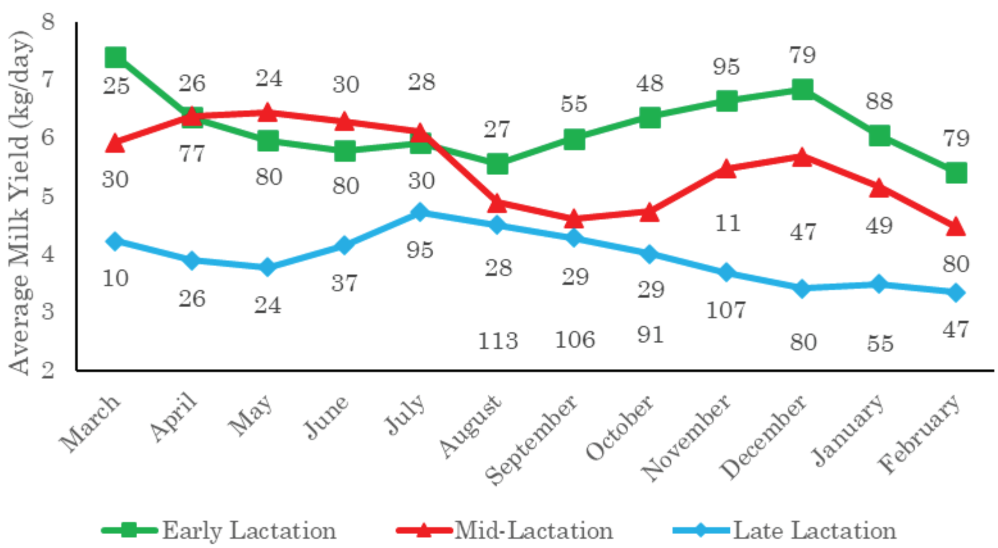


Figure 5. Monthly Average Milk Yield of Dairy Buffaloes in the Early, Mid, and Late Lactation Stage. The number denotes the number of animals averaged per month.

Results show that in Figures. 4 and 5, purebreds, crossbreds, and buffaloes in the early lactation stage attained their peak milk yield in March where temperature was slightly cooler at 27.75°C compared to the temperatures in April (28.79°C) to September (28.20°C). The decline in milk yield from April to September can probably be attributed to high average temperature of 28.75°C during these months. West *et al* (2003) pointed out in their study that dry matter intake and milk yield declined linearly with respective increases in air temperature during the hot period. One of the early works on the effects of ambient temperature and relative humidity on dairy production by Nevens (1951) stated that hot weather is likely to depress appetite while cool weather stimulates it. With extremely high temperatures and humidity, cows have difficulty in disposing the surplus heat from their bodies and their body temperature may rise above the normal. This may cause them to eat less causing rapid fall in milk production. However, mid and late-lactating buffaloes in the present study attained peak milk yield in May (29.41°C) and July (28.71°C), respectively. This can probably be supported by Zicarelli *et al.*, (2005) who reported that buffaloes can acclimatize more to hot than cold environments. Buffaloes, through natural selection, acquire morphological features that allowed them to adapt to warmer environments. A few of these are their melanin-pigmented skin that protect them against harmful ultraviolet rays as well as their low hair density that facilitate better heat dissipation. Notable also in Figures 3 and 4 is the purebred, early, mid, and late lactating buffaloes having the lowest average milk yield in February. Rainfall curve will show that in both January and February, the amount was less than 1mm. Growth of forage is affected by the amount of rainfall. Extremely low amount of rainfall would mean less quantity of good quality forage that lactating dairy buffaloes consume daily this in turn, will affect the volume and quality of milk production. Pairwise mean comparisons demonstrated that dairy buffalo milk yield in March is significantly different from January, February and August to December.

Monthly Climatic Parameters

Figure 6 shows the average monthly temperature, relative humidity, and rainfall observed and recorded during the study period. This study began in March with a temperature of 27.75°C and has increased for two months, with the highest recorded temperature in May (29.4° C). From this point, it declined steadily for nine months until the lowest recorded temperature in February (26.3C°). Relative humidity in March was 81% and went down for two months until May (74.84%). After which, it steadily increased for seven months until the peak of high humidity in December (87.75%). Here onwards, relative humidity declined to 84.89% in March. The study began in March with an average rainfall of 4.39mm. The following month recorded the lowest rainfall at 0.54mm. Starting May (2.89mm), there was a sustained increase for four months until August (8.03mm). From here onwards, it declined until November (3.55mm). A vastly abrupt and high rise in December recorded the highest amount of rainfall in the duration of this study.

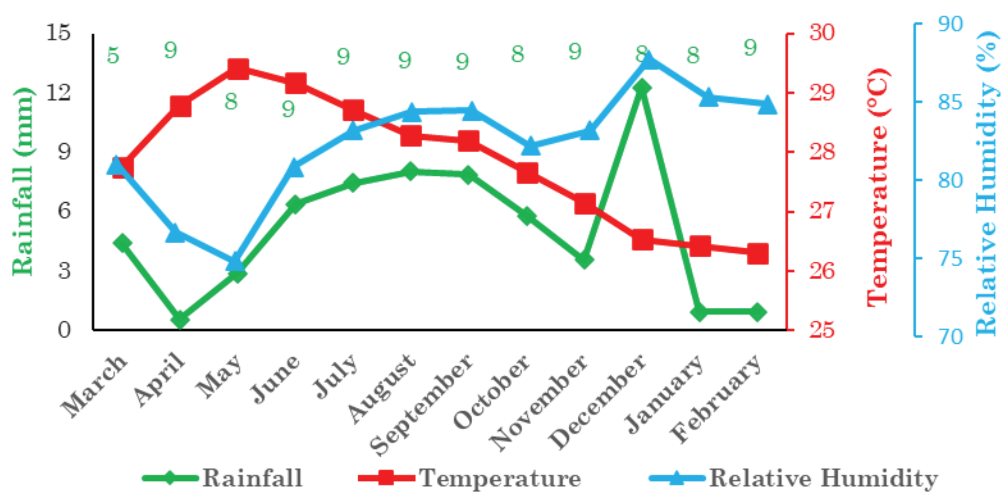


Figure 6. Average Monthly Rainfall, Temperature, and Relative Humidity. The number denotes the number of animals averaged per month.

Correlation (R) and Regression Slopes (b) of Milk Yield, BCS, Lactation Stage, Breed, and Climatic Parameters

Correlation of BCS to Milk Yield

The correlation (r) and regression slopes (b) of milk yield, BCS, lactation stage, breed, and climatic conditions is presented in Table 2. The results show that there is a weak, monotonic, and significant ($P < 0.01$) negative correlation ($r = 0.23$) found between BCS and milk yield. As BCS approaches a score of 3.0, the average daily milk yield increases. A unit increase in BCS can reduce milk yield by as much as 0.86 kg/day. The increase or decrease in milk yield can be attributed to BCS by only 5% since there are other factors affecting the production of milk in dairy animals. Milk yield of cows correlates with their body condition which is a wide and effective method to evaluate the nutritional management of dairy cows (Jilek *et al.*, 2008). BCS plays a vital role in critical moments of the lactation cycle. At the peak of lactation, the energy needs exceed the energy supply and generates a negative energy balance (NEB) (Agenas *et al.*,2003). In order to correct this deficit, the cow mobilizes its own body reserve and loses weight. This is in agreement with the outcome of Anitha *et al.*, (2011) where buffaloes having BCS 3.5-3.99 displayed higher milk production traits. Milk production increased with BCS up to a score of 3.99, but declined beyond this. This study developed a new body condition scoring system specific for Murrah buffaloes. It is also supported by Bayram *et al*., (2012) who reported that actual milk yield and 305-day milk yield of thin cows were significantly higher than those of moderate cows (P<0.01). In accordance to this is a study by Hossain *et al*., (2008) on crossbred cattle which indicated that the highest milk yield (13.45±1.80 kg/day) was recorded with moderate BCS (3.00) followed by lower (2.75 to 2.25) and higher (3.25 to 4.00). Contrary are the results obtained by Patel *et al* (2018) where the highest predicted lactation milk yield was obtained in lactating Murrah buffaloes with BCS 4.0 and above and the lowest predicted lactation milk yield from animals with BCS 2.5 - 3.0. In addition to these, Ishaq *et al*. (2011) generated results that buffaloes having high BCS (4, 5) have significantly (P>0.05) higher milk production compared to low BCS (1, 2) and reproductive disorders were significantly higher (P>0.05) in low BCS (1, 2) compared to high BCS (4, 5).

In the study conducted by Mirza *et al* (2013) on genetic factors affecting BCS and milk yield, results revealed that a negative phenotypic correlation of -0.156±0.35 with 305 days milk yield and -0.216±0.03 with score day milk yield was observed and low genetic correlations (0.051±0.0001 and 0.117±0.017) of BCS with 305 days milk yield and score day milk yield was estimated.

Correlation of Breed to BCS and Milk Yield

Breed has effect on body condition score and milk yield. The purebred buffalo was found to have a significant (P<0.01) negative, extremely weak, monotonic correlation to BCS (r= -0.14) and positive correlation with milk yield (r=0.12). Purebred Murrah BCS tend to decrease by 0.14 units with a corresponding daily milk yield increase of 0.42 kg/day. It is the other way around for the crossbred. A significant (P<0.01) positive, very weak, monotonic correlation to BCS (r=0.14) and has greatly weak, monotonic, negative correlation to milk yield (r= -0.12) were observed. A crossbred buffalo has a tendency to increase BCS by 0.14 in BCS with a decrease of 0.42 kg in daily milk yield. Specifically, for Murrah buffalos, Anitha *et al*. (2011) revealed that a BCS of 3.5-3.99 was ideal for better reproductive and productive performance and feeding management should be monitored so that the buffalos maintain this BCS at the time of calving.

Correlation of Stages of Lactation to BCS and Milk Yield

The stages of lactation have effects on body condition scores and daily milk yield. The early lactation stage of dairy buffaloes has a significant (P<0.01) negative, moderate, monotonic correlation to BCS (r = -0.27) and a positive correlation to milk yield (r = 0.39). Dairy buffaloes in the early and mid-phase of lactation are more likely to have greater milk yield but lower BCS while cows in the late stage of lactation tend to produce less milk but have higher BCS. It is also during the early lactation stage when BCS can decrease by as much as 0.27 unit with a concomitant increase in milk yield by 1.52 kg/day. To optimize milk production, it is necessary to maximize milk production in early lactation but not automatically during late lactation (Souissi and Bouraoui, 2019). Cows in early lactation utilize tissue reserves to support milk yield (Mishra *et al*., 2016). During this phase, cows experience negative energy balance with mobilization of body reserves and loss of BCS since high-producing cows cannot meet their energy needs through feed intake at early lactation. Cows with BCS lower than 3.5 in the first month of lactation have the highest milk yield during the first five months of lactation which can be explained by high mobilization of body reserves in high-yielding cows (Jilek *et al*., 2008). Cows having high BCS before parturition retained high BCS level in the first five months of lactation but opposite for lowest BCS cows (Souissi and Bouraoui, 2019). Cows should not lose more than one point of body condition in early lactation because it results to breeding and milk production inefficiencies. Mid-lactating cows have significant (P<0.01) negative correlation to BCS (r = -0.15) and positive correlation to milk yield (r = 0.18). The change in BCS from early lactation can again be seen with only a 0.16 unit decrease in BCS, however, the rate of increase in milk yield was estimated to be 0.71 kg/day. In dairy cattle, recommended BCS (Ohnstad, 2013; Jones *et al*., 2017) between 200 days of lactation and the date of dry-off should be between 2.75 and 3.50 but animals should be dried off when BCS has reached 3.25–3.5 thus, the increase in BCS must happen in the late lactation phase (Souissi and Bouraoui, 2019). In this period, the aim of the nutrition program is to completely fulfill body fat reserves without reaching an over-conditioning (Mishra *et al*., 2016). A significant (P<0.01) positive correlation to BCS (r = 0.39) and negative correlation to milk yield (r = -0.54) was found during late lactation of dairy buffaloes. This is the reverse of the results in early and mid-lactation. Dairy buffaloes in late lactation will have the tendency to increase in BCS by a score of 0.37 units and milk yield to decrease by 1.96 kg/day. Cows should be designed a nutrition program that supports persistency of lactation without gaining excessive weight (Souissi and Bouraoui, 2019).

Correlation of Climatic Parameters to BCS and Milk Yield

There is a very weak but significant (P<0.01) and positive correlation between temperature and relative humidity to BCS and milk yield. Temperature and humidity have effect on body condition scores and milk yield. Results of correlation also indicate that although the relationship is very weak, temperature is monotonically and positively correlated to the dairy buffalo BCS (r = 0.09) and daily milk yield (r = 0.12). A unit increase in temperature, can increase BCS by 0.04 and the daily milk yield by 0.20 kg/day. Meanwhile, humidity was found to be negatively correlated to BCS (r = -0.06) and milk yield (r = -0.12). As the day of body condition scoring becomes more humid, the BCS and daily milk yield also seem to decrease. Nonetheless, the relationship between the variables is very weak. The amount of rainfall was found to have no effect on BCS and milk yield.

The present study suggests that BCS negatively affected milk yield by 0.858 kg/day per unit change in BCS. Breed has effect on body condition scores and milk yield. BCS of purebred Murrahs tend to decrease by 0.14 units with a corresponding daily milk yield increase of 0.42 kg/day while crossbred buffaloes have a tendency to increase BCS by 0.14 in BCS with a decrease of 0.42 kg in daily milk yield. The stages of lactation have effects on body condition scores and daily milk yield. Dairy buffaloes in the early and mid-phase of lactation are more likely to have greater milk yield but lower BCS while cows in the late stage of lactation tend to produce less milk but have higher BCS. Purebreds produced more milk than crossbreds. The highest milk yield was observed both in March for purebreds and crossbreds while the lowest in August and October for purebreds and crossbreds, respectively. Temperature and humidity have effects on body condition scores and milk yield. In conclusion, BCS, breed, stages of lactation, temperature, and relative humidity have significant effects to milk production. A practical recommendation would be to look at BCS during specific periods such as breeding, calving, 60- and 90-days post-calving, and drying-off. The information obtained would be beneficial to transfer to client farmers for better animal management and milk productivity.

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STATEMENT ON COMPETING INTEREST

There is no conflict of interest between the authors and other people and organization.

AUTHOR'S CONTRIBUTION

Author TAS designed the study, wrote the protocol, collected data, reviewed literature, and wrote the manuscript. Author HT reviewed manuscript, extensively managed literature research, performed statistical analyses, finalized and approved the manuscript. Author AGT and PMB collected the primary and secondary data. Author JANB extensively managed literature research, reviewed and approved the manuscript.

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