ABSTRACT

Two experiments were conducted to measure response to prepartum feeding using 101 Nili-Ravi buffaloes of mixed ages and lactation numbers. Nutritional treatment was initiated approximately 75 d before calving and stopped at parturition. Levels of prepartum feeding were moderate and high in Experiment 1 and high and very high in Experiment 2. Estimated daily intakes of metabolizable energy by buffaloes on moderate, high, and very high intake treatments were 31.9, 45.8, and 50.6 Mcal, respectively. Prepartum feeding affected the BW gain by buffaloes in both experiments. Yields of milk and milk fat for first 75 d were greater for buffaloes on higher prepartum feeding treatments. In Experiment 2, buffaloes suckled for a limited time produced more milk than nonsuckled buffaloes, but the difference was small. Calf birth weight increased with increasing prepartum feeding in both experiments. Gain in BW of buffalo calves from birth to 75 d of age had no relationship with birth weight. In Experiment 2, calf weight gain was influenced by the interaction of dam’s prepartum feeding and suckling. In conclusion, improvement in prepartum feeding can be used to increase milk yield and birth weight of Nili-Ravi buffaloes.

INTRODUCTION

Water buffaloes (Bubalus bubalis) of the Nili-Ravi breed are the primary dairy animals in Pakistan, contributing more than 70% of the national milk production (3, 5). The breed is among the highest milk-producing water buffalo in the world (5, 15). During the last trimester of gestation, a female needs nutrients not only for maintenance but also for growth of the fetus. Studies in dairy and beef cows indicate significant correlations of milk yield with both prepartum plane of nutrition (4, 9, 11, 14) and peripartum changes in BW (2, 7, 11, 17). Farmers in Pakistan generally do not feed dry buffaloes in advanced pregnancy with particular care.

Common practice in Pakistan is to allow buffalo calves to suckle their dams before each milking. Suckling is considered the best method to initiate milk let-down in buffaloes. Calves are, however, kept separate during times other than milking. Knowledge regarding the effects of limited suckling on milk production and postpartum reproductive efficiency of dairy buffaloes is limited (8, 16).

No information is available regarding the peripartum profile of body weight of Nili-Ravi buffaloes relative to feeding practices, calf nursing, and milk yield. The objective of these studies was to characterize the peripartum changes in BW of Nili-Ravi buffaloes in relation to different amounts of prepartum feeding and to examine their relationship with milk production and calf growth of buffaloes either not suckled or suckled for a limited time.

MATERIALS AND METHODS

Two experiments were conducted, each using a 2 x 2 factorial arrangement of treatments. In Experiment 1, Nili-Ravi buffaloes maintained at the Animal Sciences Institute of the National Agricultural Research Center (Islamabad, Pakistan) and calving during September through December of 1985 and 1986 were utilized. The lactation numbers and ages of the 58 buffaloes involved ranged from 1 to 9 (mean =
TABLE 1. Composition of green fodder and concentrate mixture fed to experimental buffaloes.

<table>
<thead>
<tr>
<th>Nutrient component</th>
<th>Experiment 1</th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fodder¹</td>
<td>Concentrates²</td>
</tr>
<tr>
<td>DM, %</td>
<td>27.0</td>
<td>89.0</td>
</tr>
<tr>
<td>CP, % DM</td>
<td>5.5</td>
<td>15.2</td>
</tr>
<tr>
<td>TDN, % DM</td>
<td>54.5</td>
<td>70.9</td>
</tr>
<tr>
<td>EME, Mcal/kg DM</td>
<td>2.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>

¹Mixture of corn, sorghum, and alfalfa (Experiment 1). Samples were collected twice a month.
²Ingredients: cotton seed cake = 20%, wheat-bran = 30%, rice polishings = 25%, corn gluten feed = 9.5%, molasses = 15%, and mineral supplement = 2.5%. Samples were collected once a month.
³Mixture of corn, sorghum, and cow-peas (Experiment 2).
⁴Ingredients: cotton seed cake = 40%, rape seed cake = 29%, rice polishings = 15%, molasses = 15%, and mineral supplement = 1%. Samples were collected once a month.
⁵Estimated metabolizable energy calculated from TDN values (12).

3.7) and 3 to 14 yr (mean = 8.4), respectively. Experiment 2 was undertaken at the Livestock Experiment Station, Bahadarnagar (Pakistan), which has a herd of about 500 Nili-Ravi buffaloes. The 43 buffaloes studied calved during May through August 1986 and were 5 to 13 yr of age (mean = 8.8) with parities of 2 to 7 (mean = 4.1) at initiation of experimental feeding.

Prepartum Nutritional Treatment

Approximately 75 d prior to calving, buffaloes were weighed. They were paired by age (± 1 yr), BW (± 20 kg), and expected calving date (± 10 d) and randomly assigned to moderate or high feeding (Experiment 1) or to high or very high feeding (Experiment 2). All buffaloes were dry at the time of initiation of prepartum feeding. Buffaloes in each nutritional group were managed in adjacent barns, identical in facilities for feeding and watering the animals. Throughout the observation period, animals were weighed weekly, in the morning before offering feed.

Daily feed allowance for buffaloes on moderate feeding (Experiment 1) consisted of 60 to 70 kg of chopped green fodder per animal, offered at about 1000 h. Buffaloes assigned to high (both experiments) or very high feeding (Experiment 2) received 5.0 or 7.5 kg of TDN, respectively, from a concentrate mixture in addition to a similar daily allowance of green fodder. A weighed amount of the concentrate mixture was offered to buffaloes in individual stalls at about 0800 h.

Depending upon availability, the green fodder contained different proportions of corn (Zea mays), sorghum (Sorghum vulgare), and alfalfa (Medicago sativa) in Experiment 1 and corn, sorghum, and cow-peas (Vigna sinensis) in Experiment 2. Refused green fodder was weighed the next morning, and amount of daily fodder consumption per buffalo was calculated. Samples of green fodder (every 15 d) and concentrate mixture (every 30 d) were collected throughout the feeding periods. Chemical composition of feed samples was determined by proximate analysis (12) conducted at the Animal Nutrition Laboratories at Islamabad and Bahadarnagar (Table 1).

Estimated metabolizable energy (EME) contents were 2.0 and 2.7 Mcal/kg DM of fodder and concentrate mixtures, respectively, in both experiments. Daily intakes of DM, TDN, CP, and EME by buffaloes assigned to different prepartum feeding levels are presented in Table 2. Daily intake of EME increased by 43% from moderate to high feeding (Experiment 1) and by 10% from high to very high feeding (Experiment 2).

Postpartum Suckling Treatment

Suckling treatment was similar in both experiments. Beginning on the day of calving, half the buffaloes in each nutritional group was allowed to nurse their calves twice daily for 2
TABLE 2. Some measures of daily feed intake by experimental buffaloes during prepartum period.

<table>
<thead>
<tr>
<th>Feeding</th>
<th>DM</th>
<th>TDN</th>
<th>CP</th>
<th>EME1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(kg)</td>
<td>(Mcal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green fodder</td>
<td>16.2</td>
<td>8.8</td>
<td>.9</td>
<td>31.9</td>
</tr>
<tr>
<td>Concentrates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16.2</td>
<td>8.8</td>
<td>.9</td>
<td>31.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green fodder</td>
<td>13.5</td>
<td>7.3</td>
<td>.7</td>
<td>26.6</td>
</tr>
<tr>
<td>Concentrates</td>
<td>7.1</td>
<td>5.0</td>
<td>1.1</td>
<td>19.2</td>
</tr>
<tr>
<td>Total</td>
<td>20.6</td>
<td>12.3</td>
<td>1.8</td>
<td>45.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very high</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green fodder</td>
<td>10.4</td>
<td>6.0</td>
<td>1.2</td>
<td>22.0</td>
</tr>
<tr>
<td>Concentrates</td>
<td>10.6</td>
<td>7.5</td>
<td>1.9</td>
<td>28.6</td>
</tr>
<tr>
<td>Total</td>
<td>21.0</td>
<td>13.5</td>
<td>3.1</td>
<td>50.6</td>
</tr>
</tbody>
</table>

1EME = Estimated metabolizable energy.

min before milking (limited-suckled buffaloes). Calves from buffaloes in the remaining half of each nutritional group were weaned within 72 h after birth (nonsuckled buffaloes).

All buffaloes were hand-milked twice daily at 0300 and 1400 h. Daily milk production was recorded every 2 wk for each buffalo during the first 75 d of lactation. On each recording day, milk samples collected at evening milking were assayed for milk fat by the Babcock method. The calves of limited-suckled buffaloes were weighed before and after suckling. Difference in calf's weight was considered to be the amount of milk consumed by the calf. This amount was added to the daily milk yield of the dam. Limited-suckled buffaloes were milked in the presence of their calves.

Calves were weighed within 12 h of birth and every 2 wk to 75 d of age. Calves were raised in individual pens, fed whole milk at the rate of 10% of BW, and weaned gradually with weaning completed by the age of 12 wk.

Postpartum Feeding

In both experiments, nutritional treatment was stopped at parturition. However, weekly weighing was continued until d 75 postpartum. The postpartum feeding program consisted of 50 to 60 kg of available green fodder per head per day plus an allowance of concentrates calculated on the basis of daily milk produced by each buffalo. Buffaloes received 1.0 kg of concentrates for each 2.5 kg of milk above 3.0 kg. The same concentrate mixture as used for prepartum feeding was offered to individual buffaloes twice daily before each milking.

Statistical Analyses

Data were examined by analysis of variance using General Linear Models procedures of SAS (1). The model used for each experiment was:

\[ Y_{ijkl} = \bar{\mu} + f_i + s_j + m_k + f_{si} + f_{mk} + s_{mj} + f_{smj} + \beta_{1aijkl} + \beta_{2pijkl} + \epsilon_{ijkl} \]

where:

\[ Y_{ijkl} \] is peripartum body weight changes, birth weight, growth rate off calf, or 75-d milk yield
\[ \bar{\mu} = \text{overall mean}, \]
\[ f_i = \text{effect of feeding}, \]

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\[ s_j = \text{effect of suckling}, \]
\[ m_k = \text{effect of month of calving}, \]
\[ \beta_{1ijkl} = \text{covariate effect of age of buffalo}, \]
\[ \beta_{2ijkl} = \text{covariate effect of parity}. \]

For the data of Experiment 1, replicate (year) was included in the model. When F-tests were significant, means were compared by Duncan's multiple range tests. Because the analyses indicated that BW at the initiation of prepartum feeding and at calving affected 75-d milk yield, linear regression equations were derived to examine the relationships between milk yield and BW.

### RESULTS

#### Changes in Body Weight Around Calving

Changes in weight of buffaloes from the initiation of prepartum nutritional treatment to d 75 postpartum are presented in Figure 1. At the start of Experiment 1, BW of buffaloes assigned to moderate and high feeding (672 ± 11.5 (mean ± SE) and 654.6 ± 10.0 kg, respectively) did not differ (P>.10). Prepartum gain was higher (P<.01) for buffaloes on high feeding (42.8 ± 2.4 kg) than for those on moderate feeding (16.5 ± 1.7 kg). In Experiment 2 mean BW at onset of prepartum feeding were 720.0 ± 18.7 and 701.1 ± 15.1 kg for buffaloes on high and very high feeding, respectively. Prepartum gain was greater (P<.01) on very high (49.9 ± 6.3 kg) than on high feeding (31.9 ± 6.4 kg). Month of calving, age, and parity of buffaloes did not influence prepartum gain in either experiment.

Buffaloes in both experiments lost BW during the first 75 d of lactation. The loss (excluding that due to parturition) averaged 15.6 ± 2.0 kg and did not differ with prepartum feeding in Experiment 1. In Experiment 2 however, buffaloes on very high feeding prepartum lost more BW after calving (44.4 ± 3.7 kg) than those maintained on high feeding (34.5 ± 3.8 kg/ P<.01). Moreover, the interaction between month of calving and prepartum feeding was significant (P<.05) for postpartum BW loss in Experiment 2. Loss was maximum (47.2 ± 5.2 kg) for buffaloes on very high feeding that calved during May and June and minimum (32.6 ± 5.3 kg) for buffaloes on high feeding that calved during July and August. Age and parity of buffaloes and suckling by calves did not affect postpartum BW loss in either experiment.

#### Seventy-Five-Day Milk Yield

In both experiments, higher amounts of feeding prepartum increased the amounts of

<table>
<thead>
<tr>
<th>Variable</th>
<th>Prepartum nutrition</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moderate</td>
<td>High</td>
<td></td>
<td>High</td>
<td>Very high</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>SE</td>
<td>n</td>
<td>X</td>
<td>SE</td>
</tr>
<tr>
<td>Milk yield, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No sucking</td>
<td>485±b</td>
<td>12</td>
<td>13</td>
<td>596a</td>
<td>10</td>
</tr>
<tr>
<td>Limited suckling</td>
<td>536±a</td>
<td>16</td>
<td>16</td>
<td>627b</td>
<td>21</td>
</tr>
<tr>
<td>Overall</td>
<td>513±a</td>
<td>12</td>
<td>29</td>
<td>610b</td>
<td>11</td>
</tr>
<tr>
<td>Milk fat yield, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No suckling</td>
<td>33.1b</td>
<td>1.2</td>
<td>.9</td>
<td>41b</td>
<td>.9</td>
</tr>
<tr>
<td>Limited suckling</td>
<td>38.1a</td>
<td>1.5</td>
<td>1.6</td>
<td>45b</td>
<td>1.6</td>
</tr>
<tr>
<td>Overall</td>
<td>36.1a</td>
<td>1.0</td>
<td>1.3</td>
<td>43b</td>
<td>1.3</td>
</tr>
</tbody>
</table>

| a,b,c,dMeans within same row, column, and experiment with different superscripts differ. ab or cd: P<.0001; ac or bd: P<.05. |
| 1Calculated from 2-wk fat tests. Fat percentage did not differ due to prepartum feeding and averaged 6.95 over both experiments. |
milk and milk fat produced by the buffaloes during the first 75 d of lactation \( P<.01 \); Table 3). In Experiment 1, suckling by the calf did not alter milk or milk fat production \( P \equiv .07 \). In Experiment 2, limited-suckled buffaloes produced more milk and milk fat \( P<.05 \) than nonsuckled buffaloes at both levels of prepartum feeding. Replicate, month of calving, age, and lactation number of buffaloes did not cause significant variations in 75-d yields of milk or milk fat.

Regression analyses revealed that 75-d milk production increased by .24 kg and .71 kg for each kilogram increase in the initial BW of buffaloes in Experiments 1 \( P<.1 \) and 2 \( P<.01 \), respectively. Similarly, for each kilogram increase in BW at parturition, 75-d milk yield increased by .35 and .81 kg in Experiments 1 \( P<.01 \) and 2 \( P<.01 \), respectively. Slopes did not differ with prepartum feeding within experiment \( P>.05 \). Prepartum gain and postpartum loss in weight of buffaloes did not
influence the 75-d milk yield in either experiment. Likewise interactions of prepartum feeding with prepartum BW gain, weight at parturition, and postpartum BW loss were nonsignificant for effects on 75-d milk production.

Birth Weight and Growth Rate of Calf

Effects of prepartum feeding of buffaloes on birth weight and growth rate of calves are presented in Figure 2. In Experiment 1, buffaloes on high feeding gave birth to heavier calves (41.3 ± 1.1 kg) than buffaloes on moderate feeding (35.9 ± 1.2 kg; P<.05); this difference was maintained at 75 d (86.4 ± 1.6 vs. 75.2 ± 1.7 kg; P<.01).

In Experiment 2, mean birth weights of calves produced by buffaloes on high and very high feeding were 41.7 ± .5 and 45.8 ± .5 kg, respectively (P<.05). Weight gain by the calf from birth to 75 d of age was influenced by the interaction of dam's feeding prepartum with suckling (P<.05). Calves suckling dams that had been maintained on very high feeding showed minimum gain (35.9 ± 1.8 kg), whereas those weaned from such dams at birth made maximum gain (44.6 ± 1.9 kg). As a result, the overall average BW of buffalo calves at 75 d of age did not differ with prepartum feeding of dams.

Month of calving, age or parity of dam, and suckling did not influence birth weight or growth rate of calves in either experiment. In
Experiment 1, calves born during 1986 grew faster during the first 75 d than those born during 1985 \((P<.05)\), but there were no interactions between replicate and prepartum feeding.

**DISCUSSION**

Designations of prepartum feeding of buffaloes as moderate, high, or very high were based upon the daily intake of EME. These designations were arbitrary, because the nutrient and energy requirements have not been standardized for dairy buffaloes during growth, pregnancy, or lactation (6). Because all buffaloes gained BW during experimental feeding and gain increased with increasing intake of metabolizable energy, such designations seem appropriate. Positive correlations between prepartum energy intake and BW gains have been documented for dairy (7, 9, 14) and beef cows (2, 7, 10). The higher prepartum BW gains by buffaloes fed on high or very high nutrition proved that they were getting more dietary nutrients than required for body maintenance and fetal growth.

All buffaloes lost BW during the first 75 d of lactation. The postpartum feeding strategy was similar for all buffaloes and was based on amount of daily milk produced, thus high producing buffaloes received more concentrates than low producing buffaloes. In dairy cows, postpartum loss in BW is dependent on feeding in late pregnancy (9), body condition at calving (7, 9), postpartum feeding strategy (7, 9, 14), and milk production (7, 9, 14). Results of the present study indicate that dairy buffaloes behave like dairy cows in terms of postpartum changes in BW. During the first 75 d of lactation, buffaloes on very high feeding prepartum (Experiment 2) produced more milk and lost more BW than those on high feeding. Moreover, an interaction between BW at parturition and month of calving influenced the postpartum loss in BW. This suggests that environmental factors such as seasonal variation in forage quality might alter changes in weight during early lactation.

Seventy-five-day milk yield increased with increasing amounts of prepartum feeding. Similar relationships of feeding during the dry period with early lactation yield have been reported for dairy cows (4, 9, 14). Haresign (9) suggested that improvement in early lactation yield from supplementary feeding during the preceding dry period depended on the amount of feed before initiation of supplementation. Response was minimal when supplements were added to generous rations and maximal when added to poor rations. He further suggested that these responses may reflect the buildup of body stores, which can be mobilized to meet the energy deficit in the early lactation period. Thus, it is not surprising that 75-d milk yield was positively related to BW at the start of prepartum feeding and at parturition. This relationship was consistent in both experiments and at each prepartum level of feeding.

Milk fat averaged 6.9% and did not differ with prepartum feeding, milk production, age, or parity of buffaloes. These findings are in agreement with other reports for Nili-Ravi buffaloes (5, 13). Buffalo milk generally exceeds cow milk in fat by 1 to 3 percentage units and the difference depends upon the breed or type of buffalo (13).

Birth weight of the calf increased with increasing prepartum feeding of buffaloes. We have recently reported (15) that birth weight of calf is related quadratically to BW of Nili-Ravi buffaloes at calving. At lower BW of dams at calving (350 to 573 kg) calf birth weight increased by 18 g for each kg increase in weight of dam. At higher BW of dams at calving (576 to 815 kg), the calf birth weight increased by only 5.5 g for each kilogram increase in BW of dam. Buffaloes in the present study fell into the category of higher BW at calving. Year of birth, age of dam, and sex of calf were reported to affect birth weights (15), but such effects were not observed in the present study.

Effects of prepartum feeding of dam and suckling on growth rates of buffalo calves were not consistent in the two experiments. In Experiment 1, growth rate of calves did not differ due to dam's feeding prepartum or suckling. As a result, the calves that were born heavier remained heavier up to 75 d of age. In Experiment 2, the interaction between dam's feeding prepartum and suckling had a significant effect on growth rate; calves that were weaned at birth from buffaloes that had received very high feeding prepartum showed maximum weight gain. The inconsistency might be due to the variations in season of year, location of herd, nature of calf starter, and quality of available forages.
green fodder between Experiments 1 and 2.

In conclusion, improvement in feeding of buffaloes during late gestation increased the weight at parturition and milk yield during subsequent lactation. Higher BW of buffaloes at calving resulted in heavier birth weights and possibly higher growth rates of buffalo calves. Weaning of calves at birth had limited effects on milk yield in two experiments. Further studies regarding economic impacts of these findings are needed before making any recommendation about the feeding strategy of buffaloes.

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