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*Full Length Research Paper*

# Effect of season and supplementation during late pregnancy and early lactation on the performance of Zebu cows and calves

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**The effect of supplementation 8 weeks before and/or 5 weeks after calving in the wet and dry seasons on cow and calf performance was studied using 24 pregnant Zebu cows in each season. During pregnancy the cows were randomly allocated to two treatment groups of 12 cows each and after calving six cows within each pregnancy group were allocated to two post-partum treatments. All cows grazed natural pastures for 8 h /day and the treatments both pre- and post-partum was: grazing only, or grazing and supplementation with cottonseed cake and molasses. The cows were milked twice a day and the calves were allowed to suckle after each milking. The average body weight of the cows after parturition were similar among treatments, but were significantly higher in the wet season. All cows, except the unsupplemented cows during the wet season, gained weight during the first 5 weeks of lactation. Pre-partum supplementation of the cows significantly ($P<0.05$) increased the birth weights of the calves during both the dry and wet seasons. Calves from pre- and post-partum supplemented cows gained 350 and 307 g/day and calves from unsupplemented cows gained 271 and 185 g/day in the wet and dry season, respectively. The total milk yields for pre- and post-partum supplemented cows were 5.02 and 4.24 kg/d and for unsupplemented cows 2.65 and 2.18 kg/d in wet and dry season, respectively. The cows supplemented either pre- or post-partum generally showed intermediate production results. There were no significant differences in milk composition due to treatment. The best performance of cows and calves was obtained with supplementation both before and after calving, but supplementing during lactation only may give a better return than supplementing during pregnancy.**

**Key words:** Milked yield, suckled yield, milk composition, growth, weight change.

## INTRODUCTION

Improving nutritional status during lactation coupled with suckling strategies generally enhances the performance of both cows and calves under tropical conditions (Nyambati et al., 2003; Mahecha et al., 2004; Diack et al., 2004; Sidibe-Anago et al., 2006; Fröberg et al., 2007). Several nutritional approaches have been proposed for the transition period from late pregnancy to the first weeks of lactation. The strategies support the concept of additional feeding to dairy cows during the late pregnancy period, since late pregnancy and early lactation have been indicated as the two critical and most traumatic periods of the reproductive cycle (Murphy, 1999; Keady et al., 2001; Park et al., 2002). Late pregnancy is a physiologically and nutritionally stressful period, as feed intake is reduced while nutrient demands for the support of foetal growth and initiation of milk synthesis are increased. During this period the cow has to alter her metabolic priorities from net tissue deposition to reserve tissue mobilization and the foetus grows rapidly, increasing energy and protein requirements of the cow by as much as 20% (Bauman and Currie, 1989; Andersen et al., 2005). The effects of feeding strategy during late pre-

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pregnancy appear to be dependant on the initial live weight and body condition of the animal. Feeding pre-partum diets with high energy and protein levels seemed to result in higher dry matter intake (DMI) after calving, improved energy balance, decreased loss of body weight (BW) and increased calf birth weight, but had varying effects on milk yield (Bennison et al., 1999; Doepel et al., 2002; McNamara et al., 2003). Contreras et al. (2004) reported that the best results of pre-partum feeding were achieved with the thinnest cows, which consumed substantially more feed, maintained normal body condition and increased milk yield post-partum. According to Freetly et al. (2000) feed-restriction during the last trimester of pregnancy significantly decreased calf birth weights and growth rates of the calf during the first 28 days of lactation, and negatively altered the DMI of the dam. According to Rukkwamsuk et al. (1999) overfeeding of high producing dairy cows during pre-partum can also depress appetite and reduce DMI during early lactation, resulting in a decrease in milk production.

Improvement of late pregnancy feeding is seldom practiced in the production systems in subtropical Africa and the response may be different in different seasons. The aim of this study was to determine the effect of different pre- and post-partum nutritional levels on milk production during the first five weeks of lactation, birth weight and growth of the calf and BW changes of the cows during both dry and wet seasons.

## MATERIALS AND METHODS

The study was conducted at the research centre of INERA Farako-Bâ in Burkina Faso from June to October 2005 (wet season) and from November 2006 to March 2007 (dry season). The area has a unimodal rainfall that lasts from June to September and the precipitation varies from 900 to 1100 mm per year with the highest amount recorded in July and August. The daily mean temperature is lowest in January and highest in April, 32 and 40°C, respectively (Sawadogo et al., 2005).

The study was carried out in two different seasons, from eight weeks before calving to five weeks after calving, and for each part of the experiment 24 multiparous, confirmed pregnant Zebu cows were randomly selected. Calving date was estimated from day of mating/insemination. The actual pre-partum feeding period was 67 ± 3 days in average. For the duration of the study all cows grazed natural pastures for 8 hours/day (from 07h30 to 13h00 and from 14h30 to 17h00). The cows were housed separately from their calves overnight. The animals had free access to water before and after grazing. During the pre- and post-partum periods the cows were supplemented according to treatment. The calving period was spread over 6 weeks both in dry and wet seasons. From the 2$^{nd}$ day after parturition, calves were kept in a fenced enclosure and provided Mucuna legume hay *ad libitum* while the dams were grazed. From parturition to the 5$^{th}$ day of lactation, the entire milk production, including the colostrum of the dam, was suckled by the calves.

Milking started on the 6$^{th}$ day and milked yield was determined by adding the production recorded in the evening with the production recorded the following morning. The cows were hand-milked twice a day, at 07h00 and 17h30. The calves suckled at every milking, first to stimulate milk ejection prior to milking and then again after milking.

The cows were dosed against trypanosomiasis with Survidim® (5 ml/100 kg BW) and against parasites and ticks with Ivermectin® (1 ml/50 kg BW) at the onset and the end of the experiment. In addition, the cows were inoculated with a long action oxytetracycline (1 ml /20 kg BW) immediately after calving to prevent calving microbial infection.

The natural pastures consisted of a mixture of species dominated by *Andropogon gayanus, A. ascinodis* and *Pennisetum pedicellatum* in the rainy season and in addition *Loudetia togoensis* in the dry season. A mineral lick containing 6% P, 12% Ca, 65% NaCl, 2% Mg and 15% binder (oligo-elements 1.5 mg Cu, 7.5 mg Mn, 30 mg Co, 9 mg Zn, 100 mg I per kg) was available at all times in the barn. During the pre-partum part of the experiment, the supplemented cows were offered 1 kg of cottonseed cake mixed with 0.5 kg molasses individually once daily at 7h30. The cottonseed cake was provided to post-partum supplemented cows in two equal portions at 07h30 and 17h30, after the morning and evening milking, respectively. The daily ration was increased from 1 kg cottonseed cake the first two days after parturition to 1.3 kg/d from day 3 and to 1.5 kg/d from day 6. Molasses was provided at 0.5 kg/d throughout the experimental period.

During the pre-calving period in both wet and dry seasons the cows were randomly allocated to two groups of 12 cows each. The treatments were grazing only (GP) during pregnancy or grazing with supplementation containing cottonseed cake and molasses (SP). After calving six cows from each pregnancy treatment group were randomly allocated to two treatments. The treatments were grazing only (GL) during lactation or grazing with supplementation with cottonseed cake and molasses (SL). The four treatment combinations during the lactation period were consequently: GPGL: Grazing only both during pregnancy and lactation; GPSL: Grazing only during pregnancy, grazing and supplementation in lactation; SPGL: Grazing and supplementation during pregnancy, grazing only during lactation; SPSL: Grazing and supplementation during both pregnancy and lactation.

The cows were weighed at the beginning of the experiment and then every second week, prior to feeding in the morning. Cows and calves were weighed on the day of calving and BW losses due to calving were calculated as the difference between the most recent pre-partum BW minus parturition BW. Thereafter the weights of cows and calves were recorded once a week after morning milking and before feeding

Milk consumption of the calves was recorded once a week by weighing before and after suckling at the evening and the morning milking. Milk samples were taken twice a week and were analysed for protein, fat and lactose content in the milk. Total milk yields were calculated by adding the milked and suckled amount. The milk samples from the evening and morning milk were analysed separately by automatic infra-red analysis using a Farm Milk Analyzer (FMA/DMA 2001 *Miris AB* Uppsala, Sweden) for fat, protein and lactose.

Cottonseed cakes were sampled every 2 weeks. Ten randomly selected forage plots of 1m$^2$ were also harvested and pooled to one sample every 2 weeks. Molasses was sampled only once at the end of the experiment. The feed samples were analysed for DM, ash and N according to AOAC (1990), Crude protein (CP) was calculated as N*6.25. Cottonseed cake and grass was also analysed for acid detergent fibre (ADF) and neutral detergent fibre (NDF), according to Van Soest et al. (1991).

The data were subjected to ANOVA using the GLM procedure of Minitab (Minitab, 2003). The treatment means which showed significant difference at the probability level of P<0.05 were compared using Tukey's pairwise comparison procedures. The variables used in the models were season (wet or dry) and treatment

**Table 1.** Chemical composition of the experimental feeds (means and standard deviations (SD).

| | Pasture | | | |
|---|---|---|---|---|
| | Wet season | Dry season | Cottonseed cake | Molasses |
| n | 7 | 7 | 8 | 1 |
| DM (g/kg) | 418 (76.3) | 721 (90.6) | 930 (2.4) | 810 |
| **In g/kg DM** | | | | |
| Ash | 110 (8.9) | 99 (19.4) | 89 (7.6) | 120 |
| CP | 71 (4.3) | 45 (13.9) | 413 (25.0) | 64 |
| NDF | 722 (13.8) | 849 (22.1) | 340 (41.8) | NA[a] |
| ADF | 451 (9.6) | 538 (38.2) | 122 (2.1) | NA |

[a]NA = Not analysed.

**Table 2.** Effect of pre-partum supplementation and season on weight changes of the cows and the birth weight of the calves (least squares means and standard error (SE).

| | Wet season | | Dry season | | Level of sign. | | | |
|---|---|---|---|---|---|---|---|---|
| | GP | SP | GP | SP | SE | T | S | T*S |
| **Weight and weight changes of the cows (kg)** | | | | | | | | |
| Weight 8 weeks pre-partum | 276 | 275 | 267 | 271 | 3.1 | NS | * | NS |
| Weight before calving | 282 | 282 | 269 | 279 | 3.2 | NS | * | NS |
| Weight after calving | 253 | 254 | 242 | 251 | 3.0 | NS | * | NS |
| Weight loss at calving | 28 | 27 | 27 | 28 | 0.6 | NS | NS | NS |
| Weight loss (% of BW) | 11 | 10 | 10 | 11 | 0.2 | NS | NS | NS |
| Birth weight of the calves (kg) | 20.5 | 21.7 | 19.4[b] | 22.0[a] | 0.5 | ** | NS | NS |

[ab]Means in the same row within season with different superscripts are significantly different (P<0.05); GP=Grazing only during pregnancy; SP = Grazing and supplementation during pregnancy; T = Treatment; S = Season; NS = non significant; *P<0.05;**P<0.01. n = 12.

treatment (GP and SP) during the pre-partum period, and season (wet or dry) and treatment (GPGL; GPSL; SPGL; SPSL) during the post-partum period. All interactions were tested and included if significant and initial BW was used as a covariate in the pre-partum period.

## RESULTS

The chemical composition of the pasture during the dry and wet season is presented in Table 1. . The pasture had low crude protein (CP) content and a high concentration of fibre. Whatever the season, concentrate offered to the supplemented cows was completely consumed and provided approximately 439 g CP and 340 g NDF in late pregnancy and 645 g CP and 510 g NDF in early lactation.

### Effect of pre-partum supplementation and season on weight changes of the cows, and birth weight and growth rate of the calves

The BW of the cows was similar at the start of the experiment (Table 2), but the mean BW was higher (P<0.05) in the wet season (275.5 kg) than in the dry season (268.8 kg). During the two months prior to calving, GP cows gained on average 2 to 5 kg while SP cows increased their BW on average by 7 to 8 kg (P> 0.05). Neither pre-partum nutrition nor season had any significant effect on weight loss at parturition. All cows lost about 27 kg, corresponding to around 10% of BW, at parturition. Weight after parturition was similar among treatments, but higher (P<0.05) in the wet season.

All cows, except GPGL cows during the wet season, gained weight during the first 5 weeks of lactation (Table 3). Cows that were supplemented during lactation gained more weight than the unsupplemented cows during the wet season. GPGL cows lost approximately twice as much BW (-26.2 and -31.5 kg) as SPSL cows (-14.7 and -12.8 kg) in the wet and dry season, respectively (Table 3). The weight loss of cows that were supplemented only pre-partum or post-partum was significantly lower than for GPGL cows. The weight loss of GPSL cows was less than for SPGL cows (P>0.05), and there was no interaction between treatment and season.

**Table 3** Effects of treatments and season on body weight of the cows and calf growth rate at 35 days post-partum (least squares means and standard error (SE).

| | Wet season | | | | Dry season | | | | Level of sign. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GPGL | GPSL | SPGL | SPSL | GPGL | GPSL | SPGL | SPSL | SE | T | S | T*S |
| **Cows (kg)** | | | | | | | | | | | | |
| Weight after Calving | 253 | 252 | 253 | 256 | 241 | 242 | 254 | 248 | 4.4 | NS | * | NS |
| 35 d post–partum | 252 | 259 | 255 | 262 | 243 | 248 | 257 | 253 | 4.6 | NS | * | NS |
| **Weight** | | | | | | | | | | | | |
| Weight change 0-35d | -1[b] | 6[a] | 3[ab] | 6[a] | 2 | 5 | 3 | 5 | 4.2 | * | NS | NS |
| Weight Change during the experiment | -26[b] | -15[a] | -18[a] | -15[a] | -32[c] | -18[ab] | -20[b] | -13[a] | 1.6 | *** | NS | NS |
| **Calves** | | | | | | | | | | | | |
| Weight at 35 d (kg) | 30.9[b] | 33.2[a] | 31.8[a] | 35.3[a] | 25.3[c] | 28.0[b] | 28.5[b] | 32.2[a] | 0.9 | *** | *** | NS |
| ADG (g/d) | 307.1[c] | 347.6[ab] | 328.6[b] | 350.0[a] | 185.7[c] | 229.5[ab] | 204.8[b] | 271.4[a] | 16.7 | *** | *** | NS |

[abc]Means in the same row within season with different superscripts are significantly different (P<0.05); GPGL= Grazing only both during pregnancy and lactation; GPSL= Grazing only during pregnancy, grazing and supplement during lactation; SPGL= Grazing and supplementation during pregnancy, grazing only during lactation; SPSL= Grazing and supplementation during both pregnancy and lactation; T = Treatment; S = Season; NS= non significant;* P<0.05;***P<0.001. n = 6.

**Table 4** Effects of treatments and season on milk production and milk composition (least squares means and standard error (SE).

| | | Wet season | | | | Dry season | | | | Level of sign. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | GPGL | GPSL | SPGL | SPSL | GPGL | GPSL | SPGL | SPSL | SE | T | S | T*S |
| **Milked yield (kg/d)** | | 1.4[c] | 2.4[b] | 2.1[bc] | 3.3[a] | 0.8[c] | 1.6[b] | 1.6[b] | 2.5[a] | 0.2 | *** | *** | NS |
| **Suckled yield (kg/d)** | | 1.3[c] | 1.5[b] | 1.7[ba] | 1.7[a] | 1.4[b] | 1.4[b] | 1.5[b] | 1.7[a] | 0.1 | *** | NS | * |
| **Total yield (kg/d)** | | 2.7[c] | 3.9[b] | 3.8[b] | 5.0[a] | 2.2[c] | 3.0[b] | 3.1[b] | 4.2[a] | 1.0 | *** | *** | NS |
| **Milk composition (g/kg)** | | | | | | | | | | | | | |
| Fat | Morning | 42.9 | 40.8 | 43.0 | 40.7 | 34.6 | 34.4 | 37.2 | 33.7 | 1.7 | NS | ** | NS |
| | Evening | 55.1 | 53.1 | 49.7 | 54.1 | 55.3 | 50.2 | 57.7 | 53.3 | 3.1 | NS | NS | NS |
| Lactose | Morning | 46.1 | 47.1 | 45.1 | 42.6 | 48.3[a] | 47.5[a] | 45.1[b] | 47.0[ab] | 0.6 | *** | *** | * |
| | Evening | 42.8[a] | 44.7[a] | 38.0[b] | 42.4[a] | 46.6[ab] | 47.6[a] | 44.3[b] | 46.3[ab] | 1.0 | *** | *** | NS |
| Protein | Morning | 35.6 | 35.3 | 36.3 | 38.6 | 32.3 | 32.7 | 31.3 | 33.5 | 0.9 | NS | *** | NS |
| | Evening | 35.4 | 33.3 | 35.6 | 35.8 | 32.2 | 33.2 | 31.2 | 33.7 | 1.1 | NS | *** | NS |

[abc]Means in the same row within season with different superscripts are significantly different (P<0.05); GPGL=Grazing only both during pregnancy and lactation; GPSL=Grazing only during pregnancy, grazing and supplement during lactation; SPGL=Grazing and supplementation during pregnancy, grazing only during lactation; SPSL=Grazing and supplementation during both pregnancy and lactation; T=Treatment; S=Season; NS=non significant;* P<0.05;***P<0.001. n=6.

The birth weight and growth rate of the calves are summarized in Tables 2 and 3. Pre-partum supplementation of the cows increased the birth weights of the calves by 12% (P<0.01) during the dry season and 6% during the wet season (P>0.05). There was no significant difference due to season and no interaction between treatment and season.

In both dry and wet seasons, calves from SPSL cows had the highest weight gains, and those from GPGL cows the lowest weight gains (P<0.001) (350 and 307 g/day in the wet season and 271 and 185 g/day in the dry season, respectively). Calves suckling cows supplemented post-partum had a higher growth rate than calves suckling cows that were not supplemented in both seasons (P<0.001).

### Effects of treatments and season on milk production and milk composition

Milk yields and milk composition are presented in Table 4 Supplementation pre- or post-partum increased milk yields in both seasons (P<0.001), but total yield was significantly higher in the wet season than in the dry season. The cows provided with supplementation both pre- and post-partum, had the highest (P<0.001) milk production. The total milk yields for SPSL were 5.02 and

4.24 kg/day and for GPGL were 2.65 and 2.18 kg/day in the wet and dry season, respectively.

There were no significant differences in milk composition between treatments, but there was a tendency for the milk of SPSL cows to contain less fat, less lactose and more protein than that of GPGL cows. Milk fat and protein contents were lower, but lactose was higher in the dry season compared to the wet season (P<0.001).

## DISCUSSION

The BW changes of the cows during the pre-partum period were similar among the treatments groups, but differed significantly between seasons. An increase in BW due to pre-partum supplementation has been reported by Soto et al. (2001) and Mpairwe et al. (2003). The moderate weight gains of the cows in the pregnancy period may be attributed to the increasing weight of foetal tissues and fluid over the last 8 weeks of pregnancy (Agenäs et al., 2003) and probably represented an actual decrease in BW. Supplementation with CP in marginal pre-calving conditions did not result in any weight changes in mature cows, but priority would have been given to the protein requirements of the foetus, which would have been met at the expense of the maternal tissue reserves (Ingvartsen et al., 2001; Bell et al., 2000; Knight, 2001). The fact that BW did not differ significantly between treatments suggests that the level of supplementation may not have been enough to cause any marked changes in BW in late pregnancy. As expected, the cows were heavier in the wet season than in the dry season due to better availability and quality of pasture.

All cows lost around 10% of their BW at parturition, but since the cows were significantly heavier at the start of the experiment in the wet season than in the dry season they were still heavier after calving in the wet season. After calving, all cows except GPGL cows increased their BW. This was probably due to the fact that requirements for milk production were lower than the amount of nutrients consumed. SPGL cows lost more weight during lactation than GPSL cows (P>0.05) but the milk yield was not significantly different, which indicates that SPGL cows used some of their body reserves for milk production.

GPGL cows that were supplemented, neither before nor after calving, represented the traditional rearing practice. Since GPGL cows in the wet season had access to pasture with higher CP and lower fibre content than in the dry season, they had higher body reserves after calving than the same group in the dry season. During the first part of lactation in the wet season these body reserves could have been used for milk production, since the pasture still had a moderate CP content, and GPGL cows produced about 0.5 kg more milk per day than the corresponding group in the dry season.

The post-partum increase in BW was higher when the cows were supplemented during lactation and especially during the wet season. The unsupplemented cows either lost weight or only gained slowly, and even if milk production decreased with time it would have been a long process to regain any major weight losses. Increasing BW when supplementing during lactation was also noted by Sidibe-Anago et al. (2006) and according to Kanuya et al. (2006) this is partly due to the adaptive physiological mechanics of the breed to gain weight in early lactation when supplemented.

At parturition the calves from cows supplemented during late pregnancy were heavier than calves from the unsupplemented cows in both wet and dry seasons. The mean birth weights of calves from SP cows were 21.7 and 22.0 kg, in wet and dry season respectively, which were higher than the 19.4 and 17.8 kg of Sahiwal Mpwapwa calves (Das et al., 1999), but lower than the 28 to 32 kg for Brahman Tuli (Chase et al., 2004) and Gudali calves (Marichatou et al., 2005). The growth of the calves was significantly influenced by both supplementation and season. The amount of milk suckled was, however, only affected by treatment and not by season. The proportion of the milk used for the calves was subsequently higher and for off-take lower in the dry season than in the wet season. Since the consumption of milk was similar among the calves in the wet and the dry season, the lower growth rate in the dry season is difficult to explain. At least part of the difference in growth rate may have been due to the composition of the milk, since the milk in the wet season had a higher fat and protein content than during the dry season.

The growth rates of the calves recorded in the present study were higher than values of 149 to 178 g/day reported by Sidibe-Anago et al. (2008) with suckling up to 3 months of age, due to the fact that the calves were getting more milk in the present study.

Zebu cows supplemented in the pre- and post-partum period may increase milk production regardless of season according to Marston et al. (1995) and McNamara et al. (2003) and this was confirmed in the present study. Milked yields and total milk production were significantly affected by supplementation. These effects were greatest for total milk yield of cows supplied both pre-and post-partum, and their total mean milk production either during the dry season (4.24 kg) or wet season (5.02 kg) was higher than the average of 3 kg/day reported by Jenet et al. (2006) with Boran. Daily milked amount ranged from 2.5 to 3.3 kg in this study and was comparable to the average of 2.8 kg reported with purebred Boran Zebu (Demeke et al., 2004), but lower than the 6.1 kg reported by Das et al. (1999) with Boran cows under similar conditions in Tanzania. Because of the generally low yield, Zebu cows have a lower demand for mobilization of body reserves, contrarily to high producing cows that are often in a negative energy balance during early lactation (Lanyasunya et al., 2005). Most studies with high yielding cows have reported that improving pre-partum nutrition increased milk yield (Holcomb et al., 2001; Keady et al., 2001; Doepel et al., 2002; Agenäs et al., 2003). Improvement of post-partum nutrition only results in higher production if the cows have not reached their genetic capacity for milk production or do not have any body reserves to mobilize (Komaragiri and Erdman, 1997; Soto et al., 2001; McNamara et al., 2003; Kanuya et al., 2006). Supplementation during pregnancy and/or lactation resulted in an increase in the daily offtake of milk of 0.8 to 1 kg for GPSL, 0.7 to 0.8 kg for SPGL and 1.7 to 2 kg for SPSL in the dry and wet season, respecttively. The ratio in price between cottonseed cake and milk is at present about 1:2.5 in Burkina Faso. For an additional 0.8 kg milk per day, the cost of the cottonseed cake and molasses during the last eight weeks of pregnancy was covered already at day 35 of lactation even if the benefit of increased birth weights and presumed lower mortality of the calves are not included. An increased milk yield during lactation due to supplementation similarly increased the profit and probably also prolonged the period of lactation (Sidibe-Anago et al., 2008).

Since the supplementation resulted in higher milk yield in both wet and dry seasons there was no significant interaction between supplementation and season for milk production. However, the milk production of non supplemented cows was higher in the wet season than in the dry season which suggests that the somewhat better quality of the pasture during the wet season resulted in a better nutrient intake in the wet season than in the dry season. This improvement in nutrient intake was, however, not sufficient to cover the requirements for milk production at the same level as for the supplemented cows.

Milk protein content is often used as an indicator of energy balance, and higher concentrations of milk fat and protein are typical for cows in early lactation (Garnsworthy et al., 2006). According to Kadzere et al. (2002) and Bonfoh et al. (2005) the relatively high fat and protein concentration in the milk from Zebu cows is related to the breed and the low milk production. The milk protein content in the dry season was lower than reported in a recent study under similar conditions (Sidibe-Anago et al., 2006), but higher than data presented by Mpairwe et al. (2003) with *Bos indicus* ×*Bos taurus* cows. The higher levels of milk fat content in the wet season could possibly be attributed to the better utilization of dietary fibre from which the precursors for mammary lipid synthesis are derived (Bell et al., 2000).

## Conclusion

Supplementation during pregnancy and/or lactation resulted in an increase in milk production, which was higher in the wet season than in the dry season. To achieve better results in the dry season supplementation probably has to be at a higher level. The best performance of cows and calves was obtained with supplementation both before and after calving, but if the cost of the feed is a limiting factor, supplementing during lactation, that is, after calving, may give a better return than supplementing during pregnancy, even if it is difficult to put an economical value on higher birth weights and presumably lower mortalities compared to the economical value of a longer lactation period.

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