Arch. Med. Vet. 39, Nº 3, 2007

ARTICULO ORIGINAL

Effect of a feed supplementation during the mid-lactating period on body condition, milk yield, metabolic profile and pregnancy rate of grazing dual-purpose cows in the Mexican humid tropic

Efecto de la suplementación alimenticia en el período medio de lactancia sobre la condición corporal, producción láctea, perfil metabólico y tasa de gestación de vacas de doble propósito en pastoreo en el trópico húmedo mexicano

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RESUMEN

Se determinó el efecto de la suplementación alimenticia (FS) sobre condición corporal (BCS), producción láctea, perfil metabólico y tasa de gestación en 48 vacas de doble propósito anéstricas en pastoreo en lactancia media en época de secas (DS, n = 24) y lluvias (RS, n = 24) en México. La mitad de las vacas recibió FS con 19% PC del día 0 al 45. Los días 0 y 45 se evaluó la BCS en todas las vacas y se tomaron muestras sanguíneas para determinar concentraciones séricas de ciertos metabolitos. La producción láctea se registró individualmente los días –7 a 45. El día 10 todas las vacas recibieron norgestomet para inducir el estro y después fueron inseminadas. La BCS, la albúmina sérica y la tasa de gestación fueron mayores (P < 0,05) en DS. La producción láctea y el fósforo inorgánico sérico no difirieron (P > 0,05) por FS o época del año. La proteína total sérica fue mayor (P < 0,05) el día 0 en vacas con FS en DS. La urea sérica fue menor y mayor (P < 0,05) el día 45 en vacas con y sin FS en DS y RS, respectivamente. Las concentraciones séricas de cobre y zinc fueron mayores (P < 0,05) en RS, y las de zinc fueron mayores (P < 0,05) también el día 45 en vacas con y sin FS en DS. En conclusión, la FS afectó las concentraciones séricas de proteína total, urea y zinc, y la época del año afectó la BCS, las concentraciones de albúmina, cobre y zinc y la tasa de gestación.

Palabras clave: metabolitos, vacas, *Bos taurus/Bos indicus.*

Key words: metabolites, *Bos taurus/Bos indicus,* cows.

INTRODUCTION

In tropical regions, cattle industry is based on crosses of Zebu and European breeds managed in dual-purpose systems of milk and beef, that are sustained mainly on grazing of tropical grasses. During the dry season, when sufficient amounts of forage are not available, feeding of grazing cattle with feed supplementation (FS) is practiced to maintain productivity (Leaver 1986). However, FS of grazing cows remains not fully understood (Peyraud *et al* 1997).

Insufficient energy supply in the diet may result in a higher risk for metabolic disorders (Andersson 1988) and poor reproductive performance (Butler 2000, Reist *et al* 2000). Estimation of energy status under field conditions is difficult, because energy content of the feed depends on environmental factors, processing, and storage (Reist *et al* 2002). Moreover, estimation of feed intake is inaccurate due to physiological variations in individual cows, ambient temperature, feeding strategy and forage quality (Allen 2000, Ingvartsen and Andersen 2000).

Evaluation of body condition score (BCS) is widely used to assess the energy balance of cows and provides information on feeding and health status of herds (Roche *et al* 2000). In beef (Rae *et al* 1996) and dairy (Gillund *et al* 2001) cows, this technique is recommended as a method for evaluating their nutritional management. Evaluation of BCS measures the amount of metabolic energy stored as subcutaneous fat and muscle in an animal (Houghton *et al* 1990). It reflects the body reserves available for metabolism, growth, lactation and activity (Wright *et al* 1987). Changes in BCS of cows can be used as an indicator of their nutritional status; cows with low BCS are prone to suffer from metabolic disorders, reproductive failure and lowered milk yield (Edmonson *et al* 1989). A decrease in BCS during early lactation affects reproductive performance and milk production (Aeberhard *et al* 2001, Dechow *et al* 2002).

Aceptado: 07.03.2007.

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Usually, in tropical regions milk production is increased in the rainy season, and this great amount of milk produced is positively correlated with the length of postpartum anoestrous (Aluja and McDowell 1984). When milk yield is greater than 8 kg/day/cow FS is required, since forage will satisfy the nutritional demands only for a short time (Iturbide 1989).

The metabolic profile test (MPT) was first established by Payne *et al* (1970) for assessing metabolic status and diagnosing metabolic disorders in dairy cows. It has been applied to improve feeding management, detect subclinical health problems and prevent production diseases (Dyk *et al* 1995, Butler 1998). The MPT indicates the balance of some metabolic pathways, and together with animal, diet and BCS assessment, is a useful tool for nutritional evaluation in dairy herds (Van Saun and Wustenberg 1997, Whitaker 2000). In the MPT reference values are defined as mean values and ranges of standard deviation. Thus, values from blood analysis are compared with the population average or ranges of reference values (Herdt 2000). In dairy cattle, concentrations of some individual blood metabolites have been related to fertility (Ruegg *et al* 1992). The influences of metabolic changes during early lactation on reproductive performance have been reviewed (Jorritsma *et al* 2003).

In cattle, there is a relationship between reproduction and nutritional status and in tropical regions, under-nutrition is the main hindering factor in bovine production systems (Galina and Arthur 1989[b], Randel 1990). Under-nutrition, or the inadequate intake of nutrients relative to metabolic demands, is a great contributor to prolonged postpartum anoestrous, particularly among cows dependent upon natural forages for most or all of their feed requirements (Jolly *et al* 1995). In dairy cows, a converse relationship between energy balance and time elapsed until resumption of postpartum ovarian activity has been reported (De Vries *et al* 1999).

The objective of the present study was to determine the effect of a FS during the mid-lactating period on BCS, milk yield, metabolic profile and pregnancy rate in grazing anoestrous *Bos taurus*/*Bos indicus* cows during the dry and rainy seasons, in the Mexican humid tropic.

MATERIAL AND METHODS

Location and study characteristics. The present study was conducted during the dry (January to March) and rainy (July to September) seasons in Veracruz, Mexico, at latitude 19º 03’ N, longitude 96º 09’ W, at 10 m altitude, with a humid tropical climate, a mean daily temperature of 23.4ºC, and a mean annual rainfall of 1677 mm.

Experimental animals and management. Forty-eight multiparous *Bos taurus*/*Bos indicus* crossbred cows (24 for each season) that were anoestrous, lactating and with > 90 days postpartum, were selected for the study from a commercial herd of 200 cows. Cows averaged 136 ± 38 days postpartum, 48 ± 7 months of age and 410 ± 57.9 kg of weight. Cows grazed in 100 ha of *Cynodon plectostachyus*, *Hyparrhenia rufa*, *Panicum maximum*, *Brachiaria brizantha*, *Paspalum spp*. and *Axonopus spp*., and were milked once a day in the morning. Calves were reared under a restricted suckling scheme, being allowed to suckle only for 1 to 2 min immediately prior to morning milking to facilitate milk let-down, and for 30 min of *ad libitum* suckling at midday.

Feed supplementation and BCS evaluation. From days 0 to 45, half of the cows in each season received individually FS with 1% of their live weight (DM) of a commercial concentrate (Purina, Mexico) with 19% crude protein and 3.84 Mcal/kg digestible energy (table 1). The remainder of cows received no FS (control group). On days 0 and 45 (start and end of the FS period), BCS was assessed using a five-points scale (1 = thin, to 5 = obese, Edmonson *et al* 1989), and as a result for selection of anoestrous cows BCS of those included in the study ranged from 1.5 to 2.5 at the first BCS evaluation (day 0).

Determination of the anoestrous status and induction of oestrous. Every 10 days, from day -30 until day 0 (day 0 = start of the FS period), the anoestrous status of each cow was confirmed by palpation per rectum (absence of a corpus luteum at each evaluation) and determination of milk progesterone concentrations (values below 2.5 nmol/L at each sampling).

To allow the artificial insemination (AI) of all the cows, on day 10 of the study all the cows were induced to oestrous with a subcutaneous ear implant (*in situ* nine days) containing 6 mg of norgestomet, together with a 2 mL intramuscular injection of 5 mg of oestradiol valerate and 3 mg of norgestomet. At implant removal (day 19), cows were weaned for 48 h and oestrous detection was started, being continuous for three days (days 19 to

Table 1. Nutritional composition of the concentrate offered to the cows during the feed supplementation period.

Composición nutricional del concentrado ofrecido a las vacas durante el período de suplementación alimenticia.

Component	Content
Crude protein	19%
Digestible energy	3.84 Mcal/kg
Moisture (Min)	12%
Crude fat (Min)	1.5%
Crude fiber (Max)	25%

Main ingredients of the concentrate: ground cereals, mixture of oleaginous pastes, cereal by-products, feeding agricultural and industry by-products, dehydrated alfalfa, fodder by-products, molasses, bovine fat, vegetal oil.

21), with the aid of a teaser bull. Oestrous was defined as standing to be mounted by the bull or by another cow. Cows detected in oestrous were bred by AI 12 h later (days 21 and 22). On days 42 and 43, a second AI service was given to the repeat breeder cows. In all cows AI was performed by the same technician. In both AI services, all cows were bred with frozen-thawed semen from the same bull. Pregnancy was diagnosed 30 days after AI by transrectal ultrasonography using a portable Pie Medical Scanner ultrasound model Vet Scan 480 with a 7.5/5.0 MHz transrectal transducer, and the diagnosis was confirmed 15 days later by palpation per rectum.

Milk yield and determination of the metabolic profile. From days -7 to 45, milk yield was daily recorded after milking in each of all cows, using a scale. On days 0 and 45, concentrations of blood metabolites were determined in each of all cows through blood samples collected from the coccygeal vein into vacutainers with no preservatives. The samples were kept at 5ºC until carried to the laboratory where they were centrifuged at 2000 x g for 10 min to separate the serum, which was stored at – 20ºC until analysis for the metabolic profile that included albumin, total protein, urea, copper, zinc and inorganic phosporus. Serum metabolite concentrations were determined by atomic absorption spectrophotometry (Perkin Elmer, Mod. 3110, Connecticut, USA), using commercial kits from Diagnostic Chemicals Limited (USA), except the one for total protein that was from Ciba-Corning (USA). Albumin was quantified using a modification of the bromocresol green procedure that shows a greater linearity; the spectrophotometer had a minimum and maximum sensitivity of 0.001 and 100 g/L, respectively. Total protein was determined using a reagent based on the Biuret reaction; the minimum and maximum sensitivity were 0.001 and 83 g/L. Urea was measured by an enzymatic assay, with minimum and maximum sensitivity of 0.001 and 30 mmol/L. Copper was quantified by atomic absorption spectrophotometry with minimum and maximum sensitivity of 0.077 and 24.0 mg/L, respectively. Zinc was determined by atomic absorption spectrophotometry with minimum and maximum sensitivity of 0.018 and 79 mg/L. Inorganic phosphorus was quantified using a modification of the non-reduced phosphorus-molybdate complex, with minimum and maximum sensitivity of 0.001 and 8.07 mmol/L, respectively.

Statistical analysis. Continuous variables were analyzed according to a completely random design in a factorial arrangement of 2 x 2, being factor A the two seasons of the year (dry and rainy), and factor B the two levels of FS (with and without FS), resulting in 4 treatments with 12 repetitions. For the analysis of the continuous variables, the PROC TTEST was used for the comparison of paired means before and after FS for BCS, milk yield and blood metabolites. For the analysis of the nominal or ordinal variables (pregnant and non-pregnant for the first and second AI service), the PROC CATMOD was used. Both statistical procedures were from SAS version 6.08 for Windows (SAS Inst Inc, Cary NC, USA 1988).

Statistical model (factorial linear model)

Yij	=	m + Ei + Sj + ESij + Eij
Yij	=	Dependent observation
m	=	Overall mean of the dependent observation
Ei	=	Effect of season of the year i, i = 1, 2
Sj	=	Effect of feed supplementation j, j = 1, 2
ESij	=	Season of the year x feed supplementation interaction
Eij	=	Residual error

RESULTS

Body condition score was not different (P > 0.05) by FS. At the beginning (day 0) and end (day 45) of the FS period BCS averaged 1.85 ± 0.26 and 1.99 ± 0.23 (P > 0.05), respectively, in the dry season, and 1.47 ± 0.35 and 1.43 ± 0.23 (P > 0.05), respectively, in the rainy season. Body condition score was different (P < 0.05) by season of the year (SY), being higher in the dry season (table 2). Milk yield was not different (P > 0.05) by FS or SY. Serum albumin concentration was not different (P > 0.05) by FS, but by SY (P < 0.05; table 2). Serum total protein concentration differed (P < 0.05) by FS in the dry season (table 3), but was not different (P > 0.05) by SY. Serum urea concentration was different (P < 0.05) by FS in the rainy season (table 4), but did not differ (P > 0.05) by SY. Serum copper concentration was not different (P > 0.05) by FS, but by SY (P < 0.05; table 2). Serum zinc concentration was different (P < 0.05) by FS in the dry season (table 3), and by SY (P < 0.05; table 2). Serum inorganic phosphorus concentration did not differ (P > 0.05) by FS or SY. Pregnancy rate was not affected (P > 0.05) by FS, but by SY (P < 0.05; table 2).

DISCUSSION

Evaluation of BCS is recommended because it reflects the nutritional status of cattle (Edmonson *et al* 1989, Rae *et al* 1996). In the present study, BCS of the cows was low. Cows with low BCS are very common among grazing crossbred cattle raised in tropical regions, since they receive no FS (Jolly *et al* 1996, Montiel 2001). The absence of changes in BCS before and after the FS period might suggest that dietary energy shortages were not great. In cattle receiving FS, the supplement intake has a substitution effect on forage intake (Mayne *et al* 1991). Thus, cows might have reduced their forage intake during the FS period, which could explain that they did not gain BCS. In addition, in cattle raised in tropical areas, heat stress during the summer months reduces feed and energy intakes and activity, and increases respiratory rate

Table 2. Seasonal mean (± SD) values of body condition score and milk yield, seasonal mean (± SE) values of blood metabolites, and seasonal pregnancy rate in dual-purpose cows in the Mexican humid tropic.

Valores promedio (± DE) de condición corporal y producción láctea por época, valores promedio (± EE) de metabolitos sanguíneos por época, y tasa de gestación por época en vacas de doble propósito en el trópico húmedo mexicano.

Variable	Dry season (n = 24)	Rainy season (n = 24)
Body condition score (points)	1.92 ± 0.24[a]	1.45 ± 0.28 [b]
Milk yield (kg)	4.0 ± 0.4[a]	3.8 ± 0.1[a]
Blood metabolite		
Albumin (g/L)	30.1 ± .0.6[a]	26.6 ± 0.5[b]
Total protein (g/L)	78.1 ± 1.4[a]	76.4 ± 1.1[a]
Urea (mmol/L)	3.4 ± 0.15[a]	2.9 ± 0.2[a]
Copper (mmol/L)	6.2 ± 0.2[a]	12.5 ± 0.3[b]
Zinc (mmol/L)	17.7 ± 0.1[a]	32.8 ± 0.9[b]
Inorganic phosphorus (mmol/L)	1.5 ± 0.07[a]	1.6 ± 0.16[a]
Pregnancy rate		
First AI service (%)	33[a]	12[b]
Second AI service (%)	25[a]	17[b]
Overall pregnancy rate (%)	58[a]	29[b]

[a,b] Row means with different superscripts differ (P < 0.05)

Table 3. Mean (± SE) concentrations of blood metabolites at the beginning and end (days 0 and 45) of the feed supplementation period during the dry season in dual-purpose cows in the Mexican humid tropic.

Concentraciones promedio (± EE) de metabolitos sanguíneos al inicio y final (días 0 y 45) del período de suplementación alimenticia durante la época de secas en vacas de doble propósito en el trópico húmedo mexicano.

Blood metabolite	Dry season (n = 24)			
	With feed supplementation (n = 12)		Without feed supplementation (n = 12)	
	Day 0	Day 45	Day 0	Day 45
Albumin (g/L)	31.1 ± 0.9[a]	30.1 ± 0.9[a]	30.8 ± 0.8[a]	28.5 ± .0.8[b]
Total protein (g/L)	82.3 ± 2.1[a]	75.6 ± 2.1[b]	79.8 ± 2[a]	74.4 ± 2[a]
Urea (mmol/L)	3.7 ± 0.2[a]	3.2 ± 0.2[a]	3.6 ± 0.2[a]	2.9 ± 0.2[b]
Copper (mmol/L)	6.2 ± 0.2[a]	6.5 ± 0.2[a]	6.3 ± 0.2[a]	5.7 ± 0.2[a]
Zinc (mmol/L)	15.5 ± 0.1[a]	21.1 ± 0.1[b]	14.5 ± 0.1[a]	19.7 ± 0.1[b]
Inorganic phosphorus (mmol/L)	1.63 ± 0.1[a]	1.32 ± 0.1[a]	1.47 ± 0.1[a]	1.43 ± 0.1[a]

[a,b] Row means with different superscripts differ (P < 0.05)

Table 4. Mean (± SE) concentrations of blood metabolites at the beginning and end (days 0 and 45) of the feed supplementation period during the rainy season in dual-purpose cows in the Mexican humid tropic.

Concentraciones promedio (± EE) de metabolitos sanguíneos al inicio y final (días 0 y 45) del período de suplementación alimenticia durante la época de lluvias en vacas de doble propósito en el trópico húmedo mexicano.

Blood metabolite	Rainy season (n = 24)			
	With feed supplementation (n = 12)		Without feed supplementation (n = 12)	
	Day 0	Day 45	Day 0	Day 45
Albumin (g/L)	28 ± 0.7[a]	26.8 ± 0.7[a]	26.4 ± 0.7[a]	25.3 ± 0.7[a]
Total protein (g/L)	74.2 ± 1.5[a]	77.6 ± 1.5[a]	76.9 ± 1.7[a]	76.7 ± 1.7[a]
Urea (mmol/L)	2.6 ± 0.2[a]	3.3 ± 0.2[b]	2.1 ± 0.4[a]	3.4 ± 0.4[b]
Copper (mmol/L)	12.5 ± 0.3[a]	12.7 ± 0.3[a]	12.5 ± 0.3[a]	12.4 ± 0.3[a]
Zinc (mmol/L)	32.5 ± 0.9[a]	32.9 ± .9[a]	32.1 ± 0.9[a]	33.9 ± 0.9[a]
Inorganic phosphorus (mmol/L)	1.57 ± 0.2[a]	1.74 ± 0.2[a]	1.41 ± 0.2[a]	1.82 ± 0.2[a]

[a,b] Row means with different superscripts differ (P < 0.05)

and sweating, resulting in a detrimental effect on production and physiologic status of the cow (West 2003). This could also explain why cows did not gain BCS during the dry season, when ambient temperatures were higher than usual because of the climatological phenomenon "El Niño", that was present throughout our study. Moreover, in grazing cattle the effect of dominance for food availability is present (Grant and Albright 2001), and in our study cows might have had to compete for the scarce available forage. However, during the rainy season when cows were supposed to gain BCS due to the greater amount of available food, BCS was lower. One of the reasons for this might be that during the rainy season, a great amount of rain fell because of "El Niño", and as a consequence the grazing fields were flooded, provoking stress to the cows. To this respect, physiological and metabolic effects of environmental stress and associated changes in feed intake, performance, and maintenance energy requirements of cattle have been indicated (Fox *et al* 1988).

In dairy cows, BCS at calving and loss of BCS in early lactation have been related to fertility and milk yield (Markusfeld *et al* 1997), but in this study these relationships were not proven. Milk yield was comparable to that obtained by Romero (1999) in dual-purpose cows in the dry (4.45 kg/cow/day) and rainy (4.25 kg/cow/day) seasons, but was lower than other reports in dual-purpose cows receiving FS, such as 5.0 ± 1.5 kg/cow/day (Corro *et al* 1999), and 6.5 kg/cow/day (Parra *et al* 1999). In dual-purpose cows, greater milk production was obtained in the rainy season (Aluja and McDowell 1984, Corro *et al* 1999), contrary to the results of our study. The low milk yield obtained could have been due to "El Niño", which caused very high ambient temperatures and drought, with the consequent shortage in forage availability during the dry season, and great amounts of rainfall during the rainy season, resulting in a stressful situation for the cows. Some of the negative effects of heat stress on milk production could be explained by decreased nutrient intake and decreased nutrient uptake by the portal drained viscera of the cow. Blood flow shifted to peripheral tissues for cooling purposes may alter nutrient metabolism and contribute to lower milk yield during hot weather (West 2003). Furthermore, similar to what might have happened with BCS, the low response in milk production in cows receiving FS might have been due to a substitution effect of concentrate on forage intake, resulting in a low increment in the total feed intake (Mayne *et al* 1991).

The MPT looks at metabolite levels in small representative groups of cows within each herd together with information on BCS, milk yield, and feeding. Comparison with optimum values, the degree of variation from them and comparisons between groups within herds have provided information about nutritional constraints on productivity (Whitaker *et al* 1999). In our study, serum albumin concentration was comparable to those obtained in previous studies in dairy cows (31 ± 4.4 and 34 ± 3.3 g/L, Contreras *et al* 1996, 28.7 ± 0.5 g/L, Rajora *et al* 1997) and dual-purpose (29.8 ± 0.6 to 36.8 ± 6 g/L, Corro *et al* 1999, 33.6 ± 4.4 g/L, Parra *et al* 1999). However, albumin concentration was lower in the rainy season. This might have been due to an inadequate protein metabolic balance, caused by the effects of stress and reduced feed intake mentioned above. Serum total protein concentration was comparable to values reported for dairy herds (77 ± 7.7 and 78 ± 6.7 g/L, Contreras *et al* 1996, 65.3 ± 1.2 g/L, Rajora *et al* 1997), and was higher at the beginning of the FS period and then decreased. As with BCS and milk yield, this might have been because of a reduced feed intake as a consequence of the FS. Serum urea concentration was lower than some reports in dairy (5.31 ± 1.48 and 5.39 ± 1.83 mmol/L, Contreras *et al* 1996) and dual-purpose (5.4 ± 1.5 to 7.9 ± 0.4 mmol/L, Corro *et al* 1999; 5.4 ± 1.6 mmol/L, Parra *et al* 1999) cows. Urea concentration was higher at the end of the FS period in both groups, with and without FS, which might indicate no effect of FS. However, changes in urea value before and after the FS period may suggest an influence of the protein supply. The trend for low urea concentration suggests that improving protein supply had no effect on this metabolite. Serum copper level was lower than the values reported by Wittwer (1995) in dairy herds (10 to 20 mmol/L), and was higher in the rainy season. Serum zinc value was comparable to those indicated by Wittwer (1995) in dairy herds (10 to 30 mmol/L). Zinc concentration was higher at the end of the FS period in both cows that did and did not receive it, as well as in the rainy season. The higher concentrations of serum copper and zinc in the rainy season might indicate an effect of the rain on the soil composition and consequently in the forage mineral content, although this was not analyzed in our study. Serum inorganic phosphorus level was not different by FS or SY; however, it was comparable to some reports in dairy cows (1.51 ± 0.4 and 1.55 ± 0.4 mmol/L, Contreras *et al* 1996, 1.56 ± 0.03 mmol/L, Rajora *et al* 1997), and was lower than the values reported in other studies in dual-purpose cows (1.99 ± 0.3 mmol/L, Parra *et al* 1999). Blood metabolite levels are influenced by nutritional status of the animal, feed intake and nutrients requirements, which fluctuate largely throughout the parturition and lactation periods (Sato *et al* 1999). In addition, each animal has different patterns of the metabolic profile that can change with age (Lee *et al* 1978). Although our results were generally coincident with those reported in other countries, it is difficult to compare them because of differences in genotype, and environmental and management conditions of the cows. Thus, differences found in some metabolites would be rather due to environmental than genetic factors, determined by the management and feeding systems of each herd. It must be considered that cows were in their mid-lactating period, which tends to limit metabolic changes and the productive response following FS with a concentrate.

One of the main factors affecting the duration of postpartum anoestrous in cattle is nutritional status, measured by BCS (Randel 1990). Pregnancy rate obtained for the first AI service was modest, particularly in the rainy season. A reason for this might have been the low BCS of the cows. In tropical regions, cows with acceptable BCS at and after calving have greater reproductive rates than cows calving in poor BCS (Galina and Arthur 1989a). Basurto *et al* (1998) obtained greater first service conception rates in dual-purpose cows with BCS > 2.5 rather than with BCS < 2.5 (scale 1 to 5). Ahuja *et al* (2005) obtained low pregnancy rates for *Bos taurus*/*Bos indicus* cows with BCS < 2.5 (scale 1 to 5). Another reason for the low pregnancy rate obtained could be the high ambient temperature during the dry season. There is evidence that 0.5 ºC of increment in the uterine temperature above the normal at the day of AI can decrease pregnancy rate in 12.8% (Gwazdauskas *et al* 1973). During the hot months, heat stress reduces pregnancy rates after AI in dairy cows (Cordoba and Fricke 2001). Heat stress is more harmful to the establishment of pregnancy if it occurs at oestrous or immediately after (Aréchiga *et al* 1998). Heat stress may also affect the maintenance of the corpus luteum, since at day 17 of pregnancy the PGF_{α} production increases in response to oxytocin (Wolfenson *et al* 1993). This could have happened during the dry season. Moreover, heat stress affects the oocyte quality during the periovulatory period and increases early embryonic loss (Hansen *et al* 1992). When small follicles damaged by heat stress during summer develop, ovulation of an infertile ovum or development of a subfunctional CL may prevail at the end of summer or during autumn (Howell *et al* 1994). This could have contributed to the low pregnancy rate obtained in the rainy season, as well as the stressful conditions the cows were subjected to because of the great amount of rainfall, as previously mentioned. Although the existence of a relationship between reproduction and nutritional status has been established (Galina and Arthur 1989[b], Randel 1990), the curve of response of BCS - postpartum interval has not been determined in *Bos taurus*/*Bos indicus* crossbred cattle. In spite of that, frequent evaluation of BCS of anoestrous females might help to shorten the calving intervals within the herds, and to know the optimum BCS required by crossbred cows from tropical regions in order to improve their reproductive performance.

Finally, in the present study, FS with 1% the live weight (DM) of a commercial concentrate during the mid-lactating period in grazing anoestrous dual purpose (*Bos taurus*/*Bos indicus*) cows had no effect on BCS, milk yield, serum concentrations of albumin, copper and inorganic phosphorus, and pregnancy rate. However, FS affected serum values of total protein, urea and zinc. On the other hand, SY did not affect milk yield and serum levels of total protein, urea and inorganic phosphorus, but it did have an effect on BCS, serum concentrations of albumin, copper and zinc and pregnancy rate.

SUMMARY

Forty-eight grazing mid-lactating anoestrous dual-purpose cows were used to determine the effect of feed supplementation (FS) on body condition score (BCS), milk yield, metabolic profile and pregnancy rate in the dry (DS, n= 24) and rainy (RS, n= 24) seasons in Mexico. Half of the cows received FS with 19% crude protein from days 0 to 45. On days 0 and 45 BCS was assessed in all cows, and blood samples were collected to determine the serum concentrations of some metabolites. Milk yield was individually recorded from days-7 to 45 (day 0 = start of the FS period). On day 10 all cows were induced to oestrous with norgestomet and then artificially inseminated. BCS, serum albumin concentration and pregnancy rate were higher ($P < 0.05$) in DS. Milk yield and serum inorganic phosphorus concentration were not affected ($P > 0.05$) by FS or season of the year. Serum total protein was higher ($P < 0.05$) on day 0 in cows receiving FS in DS. Serum urea was lower ($P < 0.05$) on day 45 in cows without FS in DS, but was higher on day 45 in cows with and without FS in RS ($P < 0.05$). Serum copper and zinc were higher ($P < 0.05$) in RS, and serum zinc was also higher ($P < 0.05$) on day 45 in cows with and without FS in DS. In conclusion, FS affected serum concentrations of total protein, urea and zinc, whereas season of the year affected BCS, serum concentrations of albumin, copper and zinc and pregnancy rate.

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