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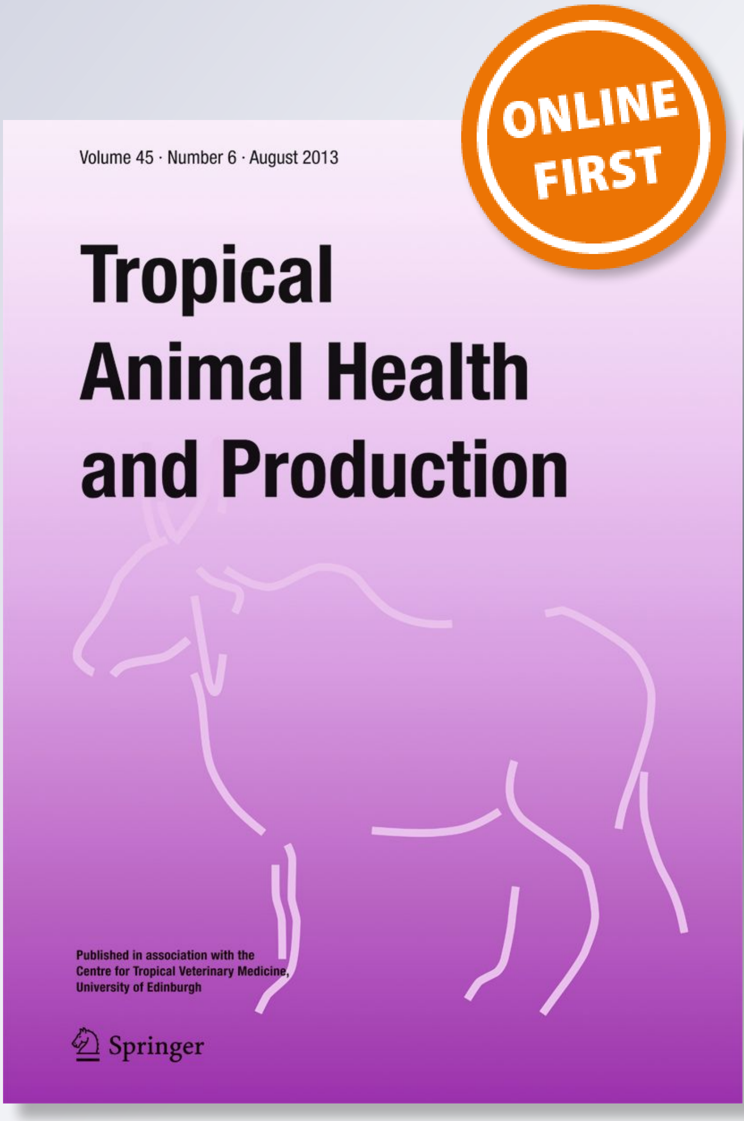

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REGULAR ARTICLES

Effects of feed supplementation on growth, blood parameters and reproductive performance in Sanga and Friesian-Sanga cows grazing natural pasture

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Abstract

This study determined the effects of feed supplementation during the postpartum period on the weight gain, milk yield, blood profiles and reproductive performance of Sanga and Friesian-Sanga cows grazing on natural pasture. 20 Sanga and 20 Friesian-Sanga cows were randomly allocated either to serve as a control on grazing only or to be supplemented with 2.5 kg of concentrate a day for 10 weeks during the dry season. Each week, all cows were weighed and scored for body condition. Partial milk yield of cows was determined daily. Plasma concentrations of blood metabolites were assessed fortnightly from weeks 1 to 10 postpartum. Resumption of postpartum ovarian activity was determined by measuring progesterone concentration in the plasma from weeks 1 to 10. Supplemented cows had a better body condition score (6.2 versus 5.8; $P < 0.05$) and higher partial milk yield (1.94 versus 1.55 L/day; $P < 0.01$) than non-supplemented cows. Sanga cows had a better body condition score (6.2 versus 5.8; $P <$ 0.05) but lower milk yield (1.58 versus 1.92 L/day; $P < 0.01$) than the Friesian-Sanga crossbreds. Total protein ($P < 0.05$) and albumin ($P < 0.01$) concentrations were higher in the supplemented than in the non-supplemented cows. Sanga cows recorded higher globulin ($P < 0.05$) and total cholesterol ($P < 0.01$) but lower albumin ($P < 0.01$) concentrations than Friesian-Sanga crossbred cows. Feed supplementation did not affect ($P < 0.05$) the interval from calving to resumption of ovarian activity, and the days to resumption of ovarian activity in the Sanga and Friesian-Sanga cows were also similar ($P > 0.05$). The results demonstrate the beneficial effects of feed supplementation in terms of improved body condition and metabolic status and increased milk yield.

Keywords Accra Plains · Blood metabolite · Dry season · Nutrition · Ovarian activity

Introduction

Cattle production in the Accra Plains of Ghana is carried out mainly by smallholder farmers using mostly indigenous breeds (Sanga, N'Dama, West African Shorthorn, White Fulani and Sokoto Gudali) which mature inherently slow, produce low milk and have poor reproductive performance (Obese et al. 2015a). Also, some farmers raise exotic breeds (Jerseys) and crossbreds (Friesian-Sanga) in small holdings, mainly for dairy. Generally, cattle are grazed extensively on natural pasture with little or no feed supplementation coupled with minimal health care. A major limitation in this production system is the scarcity of good-quality feed especially during the dry season, with available forage characterized with deficiencies of protein, energy and minerals. Livestock grazing tropical pastures without feed supplementation may not meet their production requirements mostly due to insufficient nitrogen supply to rumen microbes for microbial protein synthesis and intestinal amino acid absorption which tend to limit forage intake (Osafo et al. 2013; Detmann et al. 2014). Under such conditions, loss of body weight and body

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condition and poor milk yield and reproductive performance occur leading to economic loss to farmers (Obese et al. 2013).

Adequate nutrition is the key to meeting the nutritional and metabolic needs of cattle for enhanced productivity. The provision of appropriate supplementary feedstuffs which can supply substantial amounts of livestock energy, protein and other nutritional needs would therefore be an important step to enhance the productivity of cattle under the extensive grazing systems in Ghana. Improvements in the productivity of cattle grazing tropical natural pastures have been achieved through the use of concentrate supplementation in some studies (Karikari et al. 2008; Idris et al. 2011; Selemani and Eik 2016).

The Sanga and Friesian-Sanga cattle are among the popular breeds raised for meat and milk production in the extensive production system in the Accra Plains. However, only few studies have evaluated the nutritional and metabolic status of these cows with respect to growth rate, milk production and resumption of ovarian function postpartum. An earlier study by Obese et al. (2015a) suggested that Sanga cattle may be better adapted to the negative effects of energy deficiencies and are able to maintain hormonal balance than the Friesian-Sanga crossbred probably due to their lower milk-producing ability when grazed solely on pasture.

In this study, therefore, the effects of feed supplementation on daily weight gain, body condition score (BCS), milk yield, concentrations of blood metabolites and resumption of ovarian activity in Sanga and Friesian-Sanga cows grazing on natural pasture during the postpartum period were evaluated. It was hypothesized that feed supplementation of lactating grazing Sanga and Friesian-Sanga cows would improve cow weight gain, BCS, milk yield and metabolic and reproductive performance. Such information will guide the development of management strategies for improved productivity in these breeds of cattle.

Materials and methods

Location of study

The study was conducted at the Animal Research Institute's (CSIR-ARI) Katamanso station located in the Accra Plains on latitude 05° 44′ N and longitude 00° 08′ W. The area was about 63 m above sea level. The vegetation is grassland with sparsely distributed shrubs. The area has a bimodal rainfall pattern with a major wet season occurring from April to July and a minor season from September to November. The remaining months constitute the dry period. Annual rainfall and temperatures range between 600 and 1000 mm and 21 and 33 °C respectively, and relative humidity ranges from 69 to 94% (https://en.climatedata.org/location/777295/).

Management of Animals

Multiparous cows in their second to fifth lactation were used in the study. They calved between January and May (mostly in the dry season). At the start of the experiment, the Sanga cows (n = 20) had a mean (± SEM) bodyweight (BW) of 289.6 ± 4.9 kg and BCS of 7.1 ± 0.28 (scale 1–9; Nicholson and Butterworth 1986). The Friesian-Sanga crossbreds (n = 20) had an average BW of 291.2 ± 9.8 and BCS of 6.9 ± 0.26. Ten cows of each breed were supplemented before grazing, while the other ten which served as controls were not supplemented. The two herds were housed separately in open kraals and were also grazed separately, but on plots within the same field of natural pasture with similar nutritive value. The grazing period was from 08.00 to 16.00 h daily. Water was provided twice daily: morning and evening. Cows were milked once daily in the morning between 05.00 and 06.30 h. Partial milking was practiced: calves were separated from their dams in the evening and brought to suckle for a few minutes to stimulate milk let-down before milking. Milk was collected from two quarters of the udder, and the other two quarters were reserved for the calves. Mating was natural with service bulls running freely with females all year round. Calves were weaned at about 6 months of age. Cows and their calves were treated against ectoparasites, mainly ticks, fleas and mange mites, using a pour-on acaricide (flumethrin 1% m/v) once a month during the dry season and fortnightly in the wet season. Treatment against endoparasites was done using an anti-helminth, albendazole (10%), once a month during the dry season and fortnightly in the wet season. They were treated against diseases as the need arose and vaccinated against contagious bovine pleuropneumonia once a year as has been reported in earlier studies (Obese et al. 2015a, b). Cows and their calves were weighed weekly, and BCS of cows determined weekly using a nine-point score (1 = very thin to 9 = obese; Nicholson and Butterworth 1986).

Feeding of animals

The cows were grazed on natural pasture comprising a mixture of grasses and broad-leaved plants. *Panicum insularis*, *Sporobolus pyramidalis* and *Brachiaria deflexa* constituted the dominant grass species. *Millettia thonningii*, *Griffonia simplicifolia* and *Grewia carpinifolia* were among the common browses, while *Stylosanthes hamata* and *Stylosanthes guianensis* formed the dominant forbs found in the grazing area. The supplementary diet was a concentrate with composition presented in Table 1. It was fed at 2.5 kg per cow/day to cows before grazing for a period of 10 weeks.

Feed analysis

Samples of the forages dominant in the study area were collected and bulked, oven-dried at 65 °C for 48 h and then

Table 1 Composition of supplement (concentrate)

Ingredient	Composition (%)
Maize	40.0
Wheat bran	42.0
Soya bean meal	10.0
Dicalcium phosphate	2.0
Oyster shell meal	5.0
Salt	0.5
Premix*	0.5
Total	100

* The premix provided the following per kilogram of concentrate: VA 30,000 IU, VD 35,000 IU, VK 33.75 Mg, VB_2 10 Mg, Se 0.375 Mg, Mn 150 Mg, iodate 5 Mg, Zn 125 Mg, Cu 15 Mg, choline chloride 300 Mg and antioxidant 62.5 Mg

ground to pass through a 1 mm sieve in a hammer mill. Samples of the bulked forages and concentrate (supplement) were weighed after milling and bagged pending further analysis. Dry matter, ash and crude protein were determined using standard methods (AOAC 2012). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined according to the method of Van Soest et al. (1991). A rumen fluid sample from a fistulated ewe was used to determine the in vitro digestibility of the bulked forages and supplementary diet. The energy content of the forage and feed supplement was determined using a bomb calorimeter (PARRG 100, Mettler and Toledo Co., UK).

Blood sampling

Blood samples were collected from cows once every week, from weeks 1 to 10 postpartum after morning milking at 08.30 h by jugular venipuncture into 7.5 mL EDTA-coated vacutainer tubes (BD Vacutainer Systems, Plymouth, UK), for analysis of progesterone, total protein, albumin, triglyceride, cholesterol, non-esterified fatty acid (NEFA), beta-hydroxybutyrate (BHB) and urea. Blood samples for determining concentrations of glucose were collected into evacuated tubes containing fluoride oxalate. All samples collected were then placed on ice immediately after collection, and plasma was separated by centrifugation at $1800 \times g$ for 15 min at 4 °C. Plasma was stored at −20 °C, until assayed for the hormones and metabolites.

Blood metabolite analyses

The concentrations of the blood metabolites (glucose, total protein, albumin, triglyceride, cholesterol and urea) in the plasma were measured at weeks 1, 3, 5, 7, and 9 using the VITROS® 5,1 FS Chemistry System auto-analyzer (Ortho Clinical Diagnostics, USA). Globulin concentration was computed as the difference between the total protein and albumin concentrations. The concentration of NEFA in the plasma was determined by enzymatic calorimetric techniques using an assay kit (DiaSys Diagnostic Systems, Germany). Also, plasma BHB concentration was measured using a BHB assay kit (Randox Laboratories, UK).

Progesterone assay

Resumption of postpartum ovarian activity was determined by measuring the progesterone concentrations in plasma samples from cows from weeks 1 to week 10 postpartum using a commercial ELISA kit (DiaMetra Immunodiagnostic Systems, Boldon, UK) according to the manufacturer's instructions. The progesterone ELISA assay had a sensitivity of 0.05 ng/mL. Cows were classified as having resumed ovarian activity when plasma progesterone concentration of ≥ 1 ng/mL was recorded in two consecutive samples (Tamadon et al. 2011). Cows were classified as non-cycling if the progesterone concentration remained below 1 ng/mL throughout the study period. Oestrous cycles (first and second) were classified as short when the duration was < 17 days or prolonged when > 27 days (Pires et al. 2015).

Statistical analyses

The effects feed supplementation had on daily weight gain, BCS, milk yield and plasma concentration of blood metabolites (total protein, albumin, globulin cholesterol, triglycerides, NEFA and BHB) in the Sanga and Friesian-Sanga cows were determined using repeated measures analysis of variance procedure of GenStat Release 12th Edition (GenStat 2009). The model included the fixed effects of breed (Sanga versus Friesian-Sanga), feeding regime (supplementation versus non-supplementation) and time, as well as all two-way and three-way interactions. The chi-square test was used to determine the association between resumption of ovarian cycle and breed or feeding regime.

Values reported are least square means and SEM, unless otherwise stated. The significance level was predefined at $P \leq 0.05$, and the trend moves towards significance when $0.05 < P \leq 0.10$.

Results and discussion

Chemical composition of basal diet and supplement

The chemical composition of the forages being grazed (basal diet) and supplement is shown in Table 2. Generally, the basal diet and supplement had high dry matter content, but the supplement had higher energy and crude protein and lower NDF, ADF and lignin contents compared to the basal diet. The in

Table 2 Chemical composition of forage (basal diet) and supplement diet (concentrate) on dry matter basis fed to Sanga and Friesian-Sanga cows

Item	Forage (%)	Supplement (%)
Dry matter	90.2	88.0
Crude protein	5.40	16.0
NDF	77.5	49.7
ADF	49.0	13.8
Hemicellulose	28.5	35.9
Cellulose	31.9	3.97
Lignin	11.0	5.00
Silica	3.71	3.71
Digestible energy (MJ/kg)	11.2	13.9

vitro dry matter digestibility of the supplement was higher than that of the forage (76.3 versus 62.4%). The high energy and crude protein and low fibre and lignin contents of the supplementary diet coupled with its high dry matter digestibility suggest its potential in providing the necessary nutrients limiting the basal diet to improve rumen fermentation and productivity of the cattle.

Weight gain, body condition and milk yield

Average daily weight gain (ADG), BCS and milk yield data are presented in Table 3. The daily weight gains of supplemented and non-supplemented cows or calves were similar. This may be attributable to the fact that the multiparous cows used in this study have passed the active growth phase and had not lost weight during the gestation period which fell within the rainy season (April to January). Supplemented cows had better body condition score than non-supplemented cows (6.23 versus 5.75; $P < 0.01$), and this may be accounted for by the provision of extra nutrients by the supplement to meet nutrient demands by the cows thus enhancing microbial synthesis for improved growth and development. Sanga cows had better BCS (6.16 versus 5.80; $P < 0.05$) than the Friesian-Sanga crossbreds due probably to the Sanga's (indigenous breed) ability to withstand adverse environmental conditions such as inadequate feed and higher temperatures coupled with its low nutritional requirement compared to the Friesian-Sanga crossbred.

Partial milk yield increased from week 1 to week 10 postpartum in both supplemented and non-supplemented cows (Fig. 1), with supplemented cows having higher partial milk yield than non-supplemented counterparts at the end of the study (1.94 versus 1.55 L/day; $P < 0.01$) implying the benefits of feed supplementation in meeting maintenance and production requirements of cows. This suggests the need for improved feeding in the extensive system of production in the Accra Plains especially during periods of scarcity and also when quality of pasture is poor. The benefits of feed supplementation on improving milk yield of cattle grazing on tropical natural pastures have been reported in some studies (Karikari et al. 2008; Idris et al. 2014). The average daily milk yield of the Friesian-Sanga crossbred cows was higher ($P < 0.05$) than that produced by the Sanga cows (1.92 versus 1.58 L/day; Fig. 2). The Friesian-Sanga crossbred cows may have partitioned more of their energy for milk production. The values obtained were higher than the 1.04 L/day and 1.39 L/day reported for the Sanga and Friesian-Sanga breed at the same station (Darfour-Oduro et al. 2010). Coffie et al. (2015) had reported a higher value of 1.9 L/day for the Sanga in the humid forest zone of Ghana. These differences might be due to differences in management practices, availability of feed and nutritional requirements of animals. The higher milk yield of the Friesian-Sanga cows may have provided a better advantage for the growth of their calves over those of the Sanga cows. This may explain the trend towards significance ($P = 0.07$) observed in this study since calves at an early stage in life depend on their mother's milk.

Blood metabolite concentrations

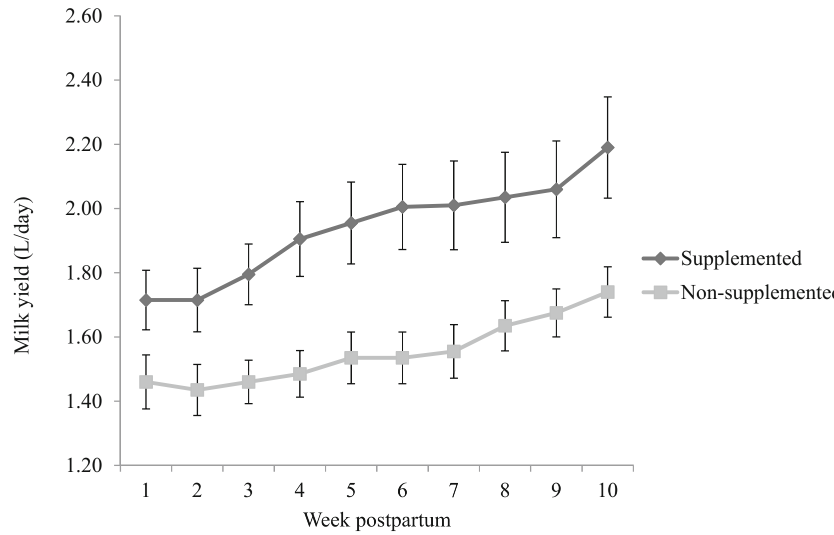
Details of plasma metabolite concentrations are outlined in Table 4. The blood glucose concentrations recorded in the

Table 3 Daily weight gain, body condition score and milk yield in Sanga and Friesian-Sanga cows. All values are least square mean ± SEM ($n = 20$)

	Feeding regime		Breed			*P* value						
	Sup	Non-sup	S	F-S	SEM	Feeding regime	Breed	Time	B × F	B × T	F × T	B × F × T
ADG cow (g)	270	259	261	266	0.38	0.610	0.597	0.040	0.264	0.017	0.001	0.130
ADG calves (g)	747	587	554	781	0.47	0.795	0.070	< 0.001	0.973	0.001	0.093	0.811
BCS	6.23	5.75	6.16	5.80	0.11	0.004	0.023	0.277	0.830	0.839	0.852	0.628
Milk yield (L/day)	1.94	1.55	1.58	1.92	0.09	0.004	0.011	< 0.001	0.058	< 0.001	0.149	0.004

ADG average gain in weight, *BCS* body condition score, *Sup* supplementation, *Non-sup* non-supplementation, *S* Sanga, *F-S* Friesian-Sanga, *B × F* breed × feeding regime interaction, *B × T* breed × time interaction, *F × T* feeding regime × time interaction, *B × F × T* breed × feeding regime × time interaction

Fig. 1 Changes in milk yield in supplemented and non-supplemented Sanga and Friesian-Sanga cows during the first 10 weeks postpartum. All values are least square mean ± SEM ($n = 20$)



Sanga (4.40 mmol/L) and Friesian-Sanga crossbred (4.34 mmol/L) cows were similar and fell within the normal physiological range of 2.2–5.6 mmol/L for cattle (The Merck Veterinary Manual 2010) suggesting adequate energy supply to the cows. The higher concentrations of total protein (76.8 versus 73.3 g/L; $P < 0.05$) and albumin (30.1 versus 29.1 g/L; $P < 0.05$) in the blood of supplemented than non-supplemented cows could be attributed to additional nitrogen provided by the supplement for improved microbial protein synthesis. Feed supplementation of cows during lactation thus assisted in meeting nutrient requirements for maintenance and maximum production.

Higher albumin concentrations in the Friesian-Sanga crossbred than in the Sanga cows ($P < 0.05$) suggest that the Friesian-Sanga crossbred cows may have better protein status, as albumin concentration in the blood is known to reflect protein status. The albumin concentrations obtained in the present study were 28.8 g/L for the Sanga breed and 30.4 g/L for the Friesian-Sanga crossbred and were within the normal range of 25.0–38.0 g/L reported for cows (The Merck Veterinary Manual 2010). This implies that the cows used in this study were not malnourished since albumin concentrations in the blood are reported to significantly correlate with nutritional status in cattle (Coppo 2004). The albumin values obtained in the present study were comparable to the values of 29.9 g/L reported for Sanga by Damptey et al. (2014) and the 36.3 g/L obtained by Obese et al. (2015b) for Friesian-Sanga crossbred cows grazing mainly on natural pastures in the Accra Plains. The higher globulin concentrations in the Sanga cows compared to the Friesian-Sanga crossbred (46.7 versus 43.6 g/L; $P < 0.05$) may be attributed to the better ability of the Sanga cows to resist infections or diseases and their high adaptability to the environment than the Friesian-Sanga crossbred cows. According to Kapale et al. (2008), circulating concentrations of globulin provide an indication of an animal's health status and its response in fighting infections and

Fig. 2 Changes in milk yield in Sanga and Friesian-Sanga cows postpartum during the first 10 weeks postpartum. All values are least square mean ± SEM ($n = 20$)

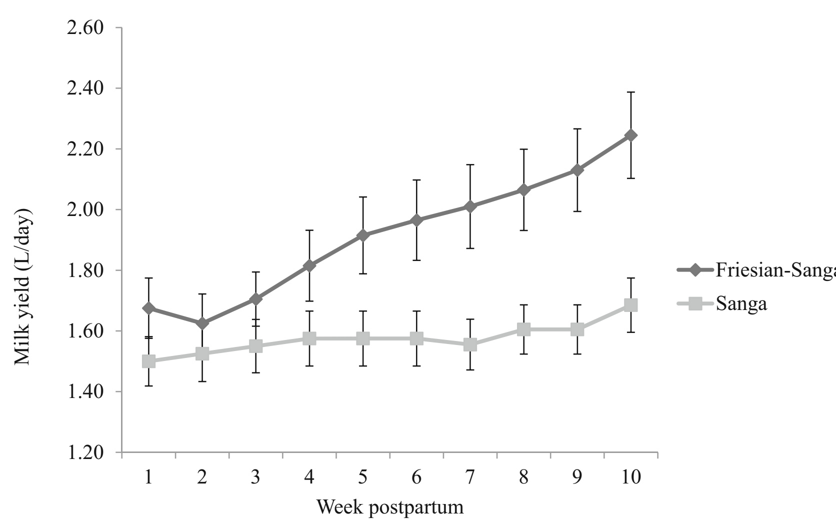


Table 4 Blood metabolite concentrations in Sanga and Friesian-Sanga cows. All values are least-squares mean ± SEM ($n = 20$)

	Feeding regime		Breed			*P* value						
	Sup	Non-sup	S	F-S	SEM	Feeding regime	Breed	Time	B × F	B × T	F × T	B × F × T
Glucose (mmol/L)	4.29	4.46	4.40	4.34	0.12	0.334	0.734	< 0.001	0.275	< 0.001	0.063	0.130
Total protein (g/L)	76.8	73.3	76.0	74.0	1.07	0.028	0.197	0.335	0.896	0.636	0.942	0.667
Albumin (g/L)	30.1	29.1	28.8	30.4	0.27	0.008	< 0.001	0.009	0.744	0.148	0.758	0.201
Globulin (g/L)	45.5	44.8	46.7	43.6	1.05	0.612	0.039	0.495	0.977	0.387	0.832	0.698
Cholesterol (mmol/L)	2.17	2.15	2.34	1.98	0.05	0.737	< 0.001	0.129	0.629	0.096	0.589	0.141
Triglycerides (mmol/L)	0.23	0.22	0.23	0.22	0.00	0.819	0.817	< 0.001	0.133	0.866	0.667	0.929
Urea (mmol/L)	5.17	5.16	5.20	5.13	0.09	0.876	0.561	0.029	0.163	0.433	0.250	0.064
NEFA (mmol/L)	0.17	0.20	0.18	0.19	0.01	0.094	0.901	< 0.001	0.941	0.232	0.872	0.814
BHB (mmol/L)	0.41	0.36	0.35	0.41	0.02	0.165	0.087	< 0.001	0.986	0.728	0.784	0.818

NEFA non-esterified fatty acid, *BHB* beta-hydroxybutyrate, *Sup* supplemented, *Non-sup* non-supplemented, *S* Sanga, *F-S* Friesian-Sanga, *B × F* breed × feeding regime interaction, *B × T* breed × time interaction, *F × T* feeding regime × time interaction, *B × F × T* breed × feeding regime × time interaction

diseases. High levels of low-density lipoprotein (LDL) in cows have been indicated to promote increased levels of cholesterol synthesis (Saleh et al. 2011), and this may account for the higher levels in Sanga than in Friesian-Sanga cows. The cholesterol values of 2.34 and 1.98 mmol/L recorded for the Sanga and Friesian-Sanga crossbred cows respectively were within the normal physiological range of 1.6–5.0 mmol/L for cows (The Merck Veterinary Manual 2010) and comparable to the 2.47 mmol/L and 2.23 mmol/L reported for the Sanga (Damptey et al. 2014) and Friesian-Sanga cows (Obese et al. 2015b) respectively in the extensive cattle production system in the Accra Plains. Triglycerides, urea, NEFA and BHB concentrations were not significantly ($P < 0.05$) different in supplemented and non-supplemented cows and also between the Sanga breed and Friesian-Sanga crossbred.

Resumption of ovarian cycle

There was no significant difference ($P > 0.05$) in the number of days to resumption of ovarian activity in Sanga cows and Friesian-Sanga crossbred cows (Table 5). The limited numbers of animals used in the present study or the rate of supplementation (2.5 kg per day) was probably not adequate to elicit significant differences. However, the beneficial effects of feed supplementation in enhancing the onset of ovarian cyclicity after calving have been reported in some cattle on range under tropical conditions (Rekwot et al. 2004; Msangi et al. 2004; da Silva et al. 2017). The days to resumption of ovarian activity in the Sanga and Friesian-Sanga cows were not significantly ($P > 0.05$) different (Table 5). The Friesian-Sanga crossbred cows (26.3%), however, tended ($P = 0.065$) to have more abnormal ovarian cycles than the Sanga cows (5%). The prioritization of milk secretion by the Friesian-Sanga crossbred cows could account for this as Friesian-Sanga crossbred cows produced more milk and lost more body condition in the present study. Higher nutrient demands for milk production especially during early lactation could induce negative energy balance in cows leading to delays in ovulation and abnormal resumption of ovarian cycles as has been observed in some studies (Esposito et al. 2014; Pires et al. 2015).

In conclusion, supplementation of Sanga and Friesian-Sanga cows with a concentrate at 2.5 kg per cow per day improved body condition score, milk yield and protein

Table 5 Resumption of luteal activity and frequency of ovarian cycle abnormalities in Sanga ($n = 20$) and Friesian-Sanga cows ($n = 20$) postpartum

	Feeding regime		Breed		*P* value	
	Sup	Non-sup	Sanga	Friesian-Sanga	Feeding regime	Breed
Resumption of ovarian activity (day)[a]	61.8 ± 2.8	63.4 ± 2.7	61.9 ± 2.8	63.6 ± 2.2	0.960	0.710
Non-cycling[b]	1/20	2/19	1/20	2/19	0.095	0.065
Non-cycling and abnormal 1st or 2nd cycling[c]	3/20	3/19	1/20	5/19	0.095	0.065

[a] Number of days to resumption of ovarian cyclicity

[b] Non-cycling at the end of the progesterone monitoring period (> 70 days postpartum)

[c] Proportion of cows with cyclicity problems (non-cycling and first or second cycling)

status of cows. However, failure of the Friesian-Sanga cows to show their genetic superiority for milk yield, relative to the Sanga, suggests that the level of supplementation was below the level required by these crossbreds. Both supplemented cows and their non-supplemented counterparts resumed ovarian activity at about the same time postpartum probably due to the small numbers of animals used in the study or it may be that nutrients obtained by cows in pastures as at the time of study were adequate for the resumption of ovarian cyclicity postpartum. Sanga cows had higher levels of globulin than Friesian-Sanga cows indicating that they are better suited for infectious challenges in their environment than the Friesian-Sanga crossbred.

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Compliance with ethical standards

All procedures used followed approved guidelines for the ethical treatment of animals.

Conflict of interest The authors declare that they have no conflict of interest.

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