Scrotal circumference, body weight and serum testosterone concentration of Red Sokoto weaner bucks as influenced by dry season crop -residue supplementation

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Abstract

The effect of dry season supplementation with crop residue based rations on body weight, scrotal circumference and serum testosterone concentrations in Red Sokoto weaner bucks at 5, 6 and 7 months of age was investigated in this study. There were 7 treatment groups which comprised of a positive control ration (conventional concentrate) fed at 1 and 2% of the bucks' body weights (rations 1A and 2A), two crop residue based test rations each fed at 1 and 2% of body weight (1B, 2B, 1C and 2C) and a negative control that was unsupplemented (ration D). All treatment groups had ad libitum access to natural pastures and Digitaria smutsii hay as basal diet. Body weight and scrotal circumference of the bucks significantly increased ($P<0.05$) with age from 5.9 Kg at 5 months to 10.2 Kg at 7 months of age and 4.40 cm to 6.95 cm, respectively. Bucks on ration D (unsupplemented group) had the lowest body weight and scrotal circumference. Bucks on ration 2A showed a significant increase in basal testosterone concentration from 0.32 ng/mL at 5 months of age to 0.65 ng/mL at 7 months of age. Peak testosterone concentration also increased from 1.0 ng/mL at 5 months to 2.8 ng/mL at 7 months of age. Bucks on test ration 2C had higher body weights (6.75, 8.00 and 10.00 kg at 5, 6 and 7 months of age, respectively) than bucks on the other test ration B (6.20, 7.20 and 8.50 kg, respectively). There were no significant differences between the two test rations with regards to scrotal circumferences of the bucks at all ages. However, at 7 months of age, bucks on test ration 2C had significantly higher peak testosterone concentration (1.80 ng/mL) than their counterparts on test ration 2B (1.30 ng/mL). The secretory patterns of testosterone were episodic and pulsatile in nature. It was concluded that crop-residue supplementation in pre-pubertal Red Sokoto bucks has a significant influence on their body weight, scrotal circumference and testosterone production. Test ration C was a cheap, affordable and better crop-residue based ration for optimal reproductive performance than test ration B.

Keywords: Body weight, crop-residue, Red Sokoto bucks, scrotal circumference, testosterone.

Introduction

The Red Sokoto goat is found throughout the subhumid and semi -arid zones of Nigeria. It is a medium-sized breed with reddish-brown coat colour with a mature average liveweight of 30 Kg kept for its milk, meat and skin. Detailed descriptions of its herd size (G efu & Adu 1982), production (Otchere et al. 1987; Mathewman 1980), lactation (Ehoche & Buvanendran 1983) and reproductive performance (Adu et al. 1979) have been documented. The dry season is a critical period for small ruminant farmers in the subhumid zon e of Nigeria due to feed scarcity. Smallholder goat farmers resort to crop-residues from post-harvest farm operations to feed their animals. However, these crop residues are limiting in nutrients necessary for maintenance and production. Therefore, supplementary feeding to boost the nutritional status of the animals has been recommended (Alawa & Umunna 1993). However, feed supplementation packages for improv ing reproductive performance of small ruminants during the long dry periods of the year are currently not available in Nigeria.

The purpose of proper management of a young male animal is to improve growth rate and to enable it to produce optimum levels of good quality semen at the earliest possible age. However, the onset of puberty is more closely relat ed to body weight than to age (Setchell et al. 1965). The effect of improving protein intake on age at onset of puberty in Zebu bulls under range conditions has been reported (Oyedipe et al. 1981; Rekwot et al. 1987). The concentrations of serum testosterone have been shown to increase linearly with advancing age in bulls (Lunstra et al. 1978). Furthermore, Bos indicus bulls have been reported to have lower fertility than Bos taurus bulls (Fields et al. 1982) and this is attributed to smaller testis size (O yedipe et al. 1981). Strategic intervention with supplementary feeding in the dry season of the year is likely to have a great impact on the nutritional deficiencies observed in tropical animals during this period. Vital information on testosterone profiles for monitoring reproductive performance in Red Sokoto bucks is lacking. Therefore, this study was designed to investigate the influence of dry season crop-residue supplementation on body weight, scrotal circumference and testosterone concentrations of Red Sokoto weaner bucks and to recommend to smallholder goat farmers as a cheap, affordable and better crop–residue based ration for optimal reproductive performance.

Materials and Methods

Location and climatic conditions: The experiment was conducted in the Goat Experimental Unit of the Small Ruminant Research Programme at the National Animal Production Research Institute, Shika, Zaria, Nigeria. Shika falls between latitudes 11 and 12°N and between longitudes 7 and 8°E, with an altitude of 640m above sea level. Shika is located within the Northern Guinea Savannah Zone and an average annual rainfall and temperature are 1,107 mm and 24.4°C respectively. The seasonal distribution of the annual rainfall is approximately 0.1% (11.0 mm) in the late-dry season (January-March), 25.8% (285.6 mm) in the early-wet season (April-June), 69.6% (770.4 mm) in the late-wet season (July-September) and 4.5 % (40.0 mm) in the early dry season (October-December). The experiments were conducted during the dry seasons (from October to March). The animals were routinely dewormed with anthelmintic drugs and dipped in an acaricide (Asuntol , Bayer Nigeria Limited) solution against ectoparasites. The animals were housed in well-ventilated pens during the night after grazing during the day.

Experimental animals: Twenty-eight Red Sokoto weaner bucks approximately 4 months of age were balanced for weight and blocked into seven treatment groups of four animals per group (Table 1). They were group-fed for two hours each day between 08.00h and 1000h with the appropriate ration. Thereafter, they were released into a specified paddock to graze natural pastures and Digitaria smutsii hay (ad libitum) under the supervision of a herdsman until 18.00 hrs. An initial adjustment period of three weeks was allowed so that the animals could get used to their respective feeds and pens before measurements. The study lasted for three months. Just before the commencement of the study (i.e. at 4 months of age), measurements of body weight and scrotal circumference for all the treatment groups were taken. Subsequently, these parameters were taken at 5, 6 and 7 months of age in the experimental animals. The component ingredients and chemical composition of the experimental rations are shown in Tables 2 and 3, respectively.

Hormonal assay: Blood samples from the bucks in each treatment group were collected every 30 minutes for 6 hours (from 06.00 hrs to 12.00 hrs) at 5, 6 and 7 months of age by jugular venipuncture. Serum samples were harvested and stored at –20°C until analysed. Thus, a total of 273 blood samples were collected and the serum analysed for testosterone concentration. Serum testosterone concentrations were determined using a non-extraction, "Coat-A-Count" solid phase testosterone radio-immunoassay kit (Diagnostic Products Corporation 1987). Human serum-based standards with testosterone concentrations ranging from 0, 0.3, 1.0, 3.0, 10.0 and 30.0 ng/mL were used. The assay procedure was as follows:

To anti-body coated tubes, 25 μL of standard (0, 0.3, 1.0, 3.0, 10.0 and 30.0 ng/mL) or serum sample and 1 mL buffered [^{125}I]–labelled testosterone solution were added. The mixture was vortexed, incubated for 3 hrs at 37°C and decanted to remove all visible moisture and separate bound from free testosterone. The tubes were placed in a gamma counter (Beckmann 4000, Beckmann Instruments Inc. Manchester, UK) and the potencies of the samples estimated using a linear logit log dose response curve. The anti-sera were highly specific for testosterone, the cross reactivities with androsteredione and dihydrotestosterone were 3.0 and 8.1% respectively, while the cross reactivity with other C19 steroids was <3%. The sensitivity of the assay was 0.081 ng/m L, while intra and inter-assay coefficients of variation were 8.5 and 9.5% respectively. Mean basal testosterone levels were defined as the mean of the 6 lowest values observed during the 6 -hour sampling, while peak testosterone concentrations were defined as each single or series of values two-fold above mean basal concentration (Renaville et al. 1983).

Digestibility trial: Each buck was individually offered its appropriate corresponding ration to evaluate the digestibility of the diets. The animals used for the digestibility trial were 5 months old on the average. The study comprised a two-week preliminary period of realimentation and adjustment, and one week of sample collection. The animals were housed in individual metabolism cages with facilities for separate collection of faeces and urine. The animals were weighed at the beginning and end of the study. Feces were collected each morning just before feeding. 10% of each daily fecal output was collected for chemical analyses. Samples of the different rations fed were taken daily and bulked, from which sub-samples were taken for laboratory analysis. Also, samples of the individual feed ingredients were analysed in the laboratory. Water was made available to the animals ad libitum. The inventory, abundance and palatability of the plant species in the grazed paddock was conducted as described by Lakpini et al. (1997).

Proximate analyses: Proximate analyses of feed and faecal samples were carried out by the AOAC (1980) methods. Dry matter of samples was determined in an oven at 105 °C for 48 hours. Nitrogen determination was by the Micro Kjedahl method, while the Soxhlet extraction procedure was used for ether extraction. Crude fibre was determined by alternate refluxing with weak solutions of H_2SO_4 and KOH. The detergent fibre fractions (Neutral detergent fibre, acid detergent fibre and lignin) were determined according to Goering and Van Soest (1970).

Statistical analysis: Statistical analysis was carried out using the general linear model procedure of SAS (1987) in a 3 x 2 factorial analysis of variance to test the effects of ration and feeding level on body weight, scrotal circumference and testosterone concentrations. Duncan's multiple range test was utilised in separating differences between significant means.

Results

Experimental rations: The chemical composition of the individual feed ingredients and the experimental diets are shown in Tables 2 and 3 respectively. Table 3 shows that all the rations had high dry matter (DM) contents with a mean value of about 95%. Ration A had the highest crude protein (CP) value of 17.19% followed by Rations B and C with 9.54 and 10.38%, respectively. The CP value of the grazed pastures (dry season) was the lowest (2.76%), while that of Digitaria hay was 4.75%. The least ash content value was obtained in Ration D with the hay having 8.47% and the grazed pasture having 7.02%. The highest ash content value of 13.85% was obtained in Ration A. Ration A also had the highest ether extract (EE) value of 14.08% and Ration D, the least (0.78 and 2.40% for grazed pasture and Digitaria hay, respectively). Acid detergent fibre (ADF), neutral detergent fibre (NDF) and lignin contents were least in Ration A with values of 20.00%, 40.01% and 4.64% respectively. Ration D on the other hand, contained the highest ADF, NDF and lignin values of 49.14%, 74.73% and 9.49% for hay and 50.29, 80.27 and 11.5% for grazed pasture respectively. The calculated chemical analysis of the experimental rations (Table 3) reveals that Ration A had a CP content of 17.05% while the test rations B and C had 9.82 and 10.85%, respectively. Ration A also had a metabolisable energy (ME) of 11.17 MJ/Kg DM, while Rations B and C had 10.29 and 10.17 MJ/Kg DM respectively. Table 4 shows the DM and CP intakes and digestibilities of the nutrients. The Table shows that generally, the supplemented groups had significantly higher ($P<0.05$) DM and CP intakes and digestibilities than the unsupplemented group except animals on Ration B that had similar values to the unsupplemented group. It was also evident that increasing the level of supplementation also resulted in increased DM and CP intakes of all the experimental rations, with these increases being significant ($P<0.05$) and similar for Rations A and C. It was also observed that supplementation increased the digestibility of all the nutrients. However, animals on Ration B recorded very poor digestibility values and their counterparts in the unsupplemented group had the least. Even though the digestibility of nutrients decreased with increasing levels of supplementation, these decreases were not significant ($P>0.05$). Ration 1A (the conventional concentrate at 1% of body weight) gave the highest digestibility values. A comparison of the unsupplemented animals with all the other treatment groups reveals that DM digestibility improved by a range of 4.1 to 27.9 points and CP digestibility by 17.1 to 42.2 points, the highest being in animals on Ration A at 1% level. Similar improvement trends were also noticeable for neutral detergent fibre (NDF) and acid detergent fibre (ADF). A simple economic analysis (Table 4) revealed that the conventional concentrate feed was the most expensive for supplementation particularly, at the 2% level (4.42 naira per animal per day). Of the two tested crop-residue rations, Ration 1B was significantly cheaper ($P<0.05$) than Rations 2B and 2C, but similar to Ration 1C.

Body weight, scrotal circumference and testosterone concentration : The means ($\pm$ se) of pre-study measurements of body weight and scrotal circumference of the experimental animals were 5.8 ± 0.3 Kg and 4.0 ± 0.2 cm respectively. The results of the study showed that there were significant ($P<0.05$) body weight differences among bucks fed different rations and at the different ages (Table 5). At 5 months of age, bucks on rations 2A and 2C were significantly heavier than bucks on all other rations (6.80 and 6.75 Kg, respectively), except for Ration 1A (6.50 Kg). Bucks on ration D had the least weight (5.90 Kg) but it was not significantly different from rations 1A, 1B, 1C and 2B. At 6 and 7 months of age, the trends were similar with bucks on rations 2A and 2C weighing more than the others and those on ration D ranking the least in weight (Table 5). Within treatments, there were significant age effects in that all the bucks increased in weight as their ages increased from 5 to 7 months. At 5 and 6 months of age, there were no significant differences between bucks on different rations in terms of scrotal circumference, but at 7 months of age, bucks on ration 2A had significantly higher scrotal circumferences (6.95 cm) than all the other groups.

Table 6 shows the episodic peaks of the experimental animals. The trend was similar for both the basal and peak testosterone concentrations. In this regard, there were no significant differences in all the treatment groups at 5 and 6 months of age, but at 7 months, bucks on ration 2A recorded significantly higher values than all the others. The fluctuations in testosterone concentrations in bucks at 7 months of age during a 6-hour period at 30 minutes' intervals are presented in Fig. 1. Bucks on ration 2A had significantly ($P<0.05$) higher peak testosterone concentrations (2.8 ng/mL) than the other bucks (1.3-1.8 ng/mL).

Discussion

The quantity and type of ingredients used in formulating the rations influenced their chemical compositions. In Ration A, the inclusion of wheat offal and cottonseed cake boosted the protein level of the ration giving it a value of 17.19%. This value is higher than the recommended CP level of 15% for optimum maintenance of production by Nuru (1985) and 8.9 – 16.0% by NRC (1975). The metabolisable energy (ME) value of Ration A (11.17 MJ/Kg DM) is also higher than the 9.5 MJ/Kg DM recommended for maintenance by INRA (1988). Rations B and C had similar CP and ME values indicating that they are isocaloric and isonitrogenous rations. The preponderance of crop residues in Rations B and C was responsible for their high crude fibre and lignin levels. The current study showed that inspite of Rations B and C being isocaloric and isonitrogenous, animals on Ration C had better intakes and digestibilities than those on Ration B, possibly due to the low palatability, hence low voluntary intake, and poor digestibility of Ration B.

The observed higher digestibilities of DM, CP, NDF and ADF at 1% level in comparison to 2% level can be attributed to the higher feed intake at the 2% level of inclusion. It has been established that higher feed intake results in a faster rate of passage of digesta f rom the reticulo-rumen (Swan & Lamming, 1967). This does not allow for effective degra dation, hence lowering the digestibility of feed. Increasing the level of crop residue inclusion in the diet also increases the amount of lignin, which depresses the digestibility of the ration (McDonald et al. 1988), because the rate of microbial colonisation of a feed with high fibre content is comparatively lower (Silva & Orskov 1988). The poor intake and digestibility values obtained for the unsupplemented animals is due to the fact that Ration D had crude protein levels that are below the recommended m inimum values for maintenance. This shows that there is the need for dry season supplementation in goats because the available feeds at that time are limiting in crude protein.

Of the two tested rations, Ration C seemed to have produced better intakes and digestibilities in the animals, possibly due to the composition of the rations. It contained maize offal which has very low fibre content (Alawa & Umunna 1993), groundnut haulms which have been demonstrated to be better quality roughages than Digitaria smutsii hay and contain adequate protein to maintain ruminants without any form of supplementation during the perio ds of feed scarcity (Ikhatua & Adu 1984). The groundnut shells fed to the animals were also crushed before inclusion into the ration as suggest ed by Alawa and Umunna (1993). This must have aided to improve their consumption and digestibility. Even though Ration B contained groundnut haulms, the combination of Guinea corn bran and cowpea husk which had low crude protein percentages, must have reduced the intake and digestibility of the ration. Alhassan et al. (1984) observed lower digestibility values in sheep and goats (48.8 and 56.3% respectively) compared with cattle (73.6%)

when they fed them cowpea vines. This might imply that cattle do better on cowpea residues than small ruminants. From the economic analysis, the high cost of the conventional concentrate ration shows that it is beyond the reach of a typical smallholder goat farmer, whereas the crop-residue based rations seem quite affordable. Even though Ration B had the least cost, it was glaring that it had lower intake and digestibility compared to Ration C, indicating in essence, that Ration C had a better efficiency of utilisation

The results from this study have shown the significance of supplementation on body weight gain, scrotal circumference and testosterone concentration. Drymundsson (1973) reported that supplementation enhanced the ability of lambs to reach puberty and the results from the present study substantiate his observations. Body weight, scrotal circumference and testosterone concentrations have all been observed to increase with age in bulls (Karg et al. 1976; Lunstra et al. 1978; Rekwot et al. 1987). The observation in the present study that testosterone concentrations increased gradually as the bucks approached puberty supports the hypothalamic desensitisation theory of sexual maturation (Odell & Swedloff 1974; Lacroix & Pelletier 1979). Nutritional imbalances may primarily affect the anterior pituitary or hypothalamus, thus interfering with normal luteinising hormone and follicle-stimulating hormone production (Gerioff 1986).

The peak and basal testosterone concentrations reported in this study are lower in value than those reported by Rekwot et al. (1997) in Bunaji bulls. This may be due to species differences and also the duration of this study (3 months) being lesser than their study (7 months). However, the testosterone concentrations of the bucks showed fluctuations with one to three distinct episodic peaks in agreement with the findings of Sanwal et al. (1974), Agarwal et al. (1983) and Rekwot et al. (1987) in bulls. The exact significance of these episodic peaks is not clear but may be related to the sexual and behavioural states of the animals or adjustments to pho toperiodicity, temperature and postural states of the animals (Sanwal et al. 1974). The testosterone profiles observed were episodic, pulsatile or temporal in nature and this agrees with the reports obtain ed in bulls (Agarwal et al. 1983; Rekwot et al. 1987).

In conclusion, this study demonstrates that supplementation aids body weight gain and peak testosterone concentration with bucks on ration 2A recording the highest body weights and testosterone concentrations (especially at 7 months of age) in agreeme nt with studies in sheep by Orji (1976) and Osinowo and Abubakar (1988). Furthermore, ration C also recorded some positive results compared to the other test ration (ration B) in that bucks fed on ration 2C had heavier body weights and higher peak testoste rone concentrations. From the economic and biological analyses reported herein, it can be recommended to smallholder goat farmers that test ration C is a cheap, affordable and better crop-residue based ration for optimal reproductive performance than test ration B, and a good alternative to the expensive, conventional concentrate ration A.

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Table 1 Component ingredients in the experimental rations

Ration	Ingredients	% inclusion (DM)	Remarks
1A + Basal diet	Maize Wheat offal Cottonseed cake Bone meal Salt	40.00 35.00 20.00 3.00 2.00	Positive control (conventional concentrate) offered at 1% of body weight
2A + Basal diet	✔	✔	Positive control (conventional concentrate) offered at 2% of body weight
1B + Basal diet	Guinea-corn bran Cowpea husk G/Nut haulms Salt	39.50 30.00 30.00 0.50	Test Ration 1 offered at 1% of body weight
2B + Basal diet	✔	✔	Test Ration 1 offered at 2% of body weight
1C + Basal diet	Maize offal G/Nut shells G/Nut haulms Salt	49.50 20.00 30.00 0.50	Test Ration 2 offered at 1% of body weight
2C + Basal diet	✔	✔	Test Ration 2 offered at 2% of body weight
D (Basal Diet)	Digitaria hay and natural grazed pasture	Ad libitum	Negative control (unsupplemented)

Table 2 Chemical composition of the major feed ingredients (DM basis) (%)

Feedstuff	DM	CP	CF	Ash	EE	NFE
Maize	90.73	9.56	2.20	9.67	4.05	74.52
Wheat offal	87.60	16.90	11.30	6.40	3.80	61.60
Cottonseed cake	93.60	29.94	23.50	5.16	5.76	35.64
Bone meal	75.00	36.00	3.00	49.00	4.00	8.00
Guinea corn bran	93.33	7.60	24.80	6.95	3.01	59.90
Cowpea husks	91.41	7.10	33.40	7.14	0.65	58.91
Groundnut haulms	93.65	15.63	23.26	8.00	2.43	51.00
Maize offal	89.07	10.08	1.50	0.80	1.70	60.30
Groundnut shells	96.05	5.90	31.80	8.50	1.31	50.30

Table 3 Chemical composition of the experimental diets (DM basis) (%)

Ration	DM	CP	Ash	EE	ADF	NDF	LIGNIN
Ration A	93.87	17.19	13.85	14.08	20.00	40.01	4.64
Ration B	94.97	9.54	10.55	10.43	38.10	68.42	8.94
Ration C	95.94	10.38	11.97	12.45	36.65	54.74	8.23
Ration D Hay	94.78	4.75	8.47	2.40	49.14	74.73	9.49
Ration D Natural pastures	96.26	2.76	7.02	0.78	50.29	80.27	11.50

Calculated analysis of the experimental rations

	Ration A	Ration B	Ration C
CP (%)	17.05	9.82	10.85
ME (MJ /kg DM)	11.17	10.29	10.17

The ME values of the experimental rations were calculated as per Alderman (1985) as follows:

$$ME\ (MJ/kg\ DM) = 11.78 + 0.00654CP + (0.000665EE)^2 - CF(0.00414EE) - 0.0118A$$

where CP = Crude Protein, EE = Ether Extract, CF = Crude Fibre, A = Ash .

Table 4 Mean nutrient intake, apparent digestibility coefficients and cost of the experimental diets

Ration	1A	2A	1B	2B	1C	2C	D	SEM
<u>Nutrient intake (kg/day)</u>								
DMI	0.24^{b}	0.47^{a}	0.21^{bc}	0.30^{ab}	0.23^{b}	0.42^{a}	0.15^{c}	± 0.02
CPI	0.044^{a}	0.087^{a}	0.012^{b}	0.017^{b}	0.032^{a}	0.072^{a}	0.009^{b}	± 0.01
<u>Apparent digestibility of nutrients (%)</u>								
DM	84.3^{a}	83.0^{a}	62.5^{d}	60.5^{e}	75.8^{b}	67.8^{c}	56.4^{f}	± 2.84
CP	90.6^{a}	89.2^{a}	69.5^{d}	65.5^{e}	82.7^{b}	78.1^{c}	48.4^{f}	± 3.07
NDF	69.5^{a}	66.6^{b}	62.1c^{d}	61.9^{d}	65.9^{b}	63.7^{c}	60.1^{e}	± 3.23
ADF	51.7^{a}	49.8^{a}	43.9^{bc}	42.8^{c}	46.1^{b}	44.4^{bc}	42.3^{bc}	± 5.01
<u>Economic analysis of the feeds (Naira)*</u>								
Cost of feed consumed per animal per day	2.19^{b}	4.42^{a}	0.50^{e}	1.06^{d}	0.83d^{e}	1.55^{c}	-	± 0.15

a,b,c,d,e,f means within the same row bearing different superscript letters differ significantly ($P<0.05$)
Naira = Nigerian currency (100 kobo make 1 naira and current exchange rate is 1US$ = 140 Naira) .

Table 5 Effect of ration supplementation on body weight and scrotal circumference at 5, 6 and 7 months of age

Ration	1A	2A	1B	2B	1C	2C	D
Body weight (Kg) at:							
5 months	6.50^{ab}	6.80^{a}	6.00^{b}	6.20^{b}	6.20^{b}	6.75^{a}	5.90^{b}
6 months	7.80^{a}	8.00^{a}	6.70^{c}	7.20^{bc}	7.75^{ab}	8.00^{a}	6.20^{d}
7 months	9.50^{b}	10.20^{a}	8.20^{c}	8.50^{c}	9.50^{b}	10.00^{ab}	7.50^{d}
Scrotal circumference (cm) at:							
5 months	4.60	4.40	4.40	4.70	4.60	4.50	4.40
6 months	4.90	4.70	4.65	4.90	4.85	4.85	4.75
7 months	6.20^{b}	6.95^{a}	6.35^{b}	6.20^{b}	6.30^{b}	6.30^{b}	6.25^{b}

Means within rows bearing different superscripts are significantly different (P<0.05).

Table 6 Effect of ration supplementation on basal and peak testosterone concentrations a t 5,6 and 7 months of age

Ration	1A	2A	1B	2B	1C	2C	D
Basal testosterone concentration (ng/ml) at:							
5 months	0.30	0.32	0.30	0.33	0.30	0.32	0.31
6 months	0.30	0.33	0.31	0.34	0.31	0.32	0.33
7 months	0.32^{b}	0.65^{a}	0.31^{b}	0.34^{b}	0.33^{b}	0.34^{b}	0.34^{b}
Peak testosterone concentration (ng/ml) at:							
5 months	1.00	1.00	1.10	1.00	1.20	1.20	1.10
6 months	1.00	1.10	1.20	1.20	1.20	1.30	1.10
7 months	1.30^{b}	2.80^{a}	1.30^{b}	1.30^{b}	1.50^{b}	1.80^{b}	1.30^{b}

Means within rows bearing different superscripts are significantly different ($P<0.05$).

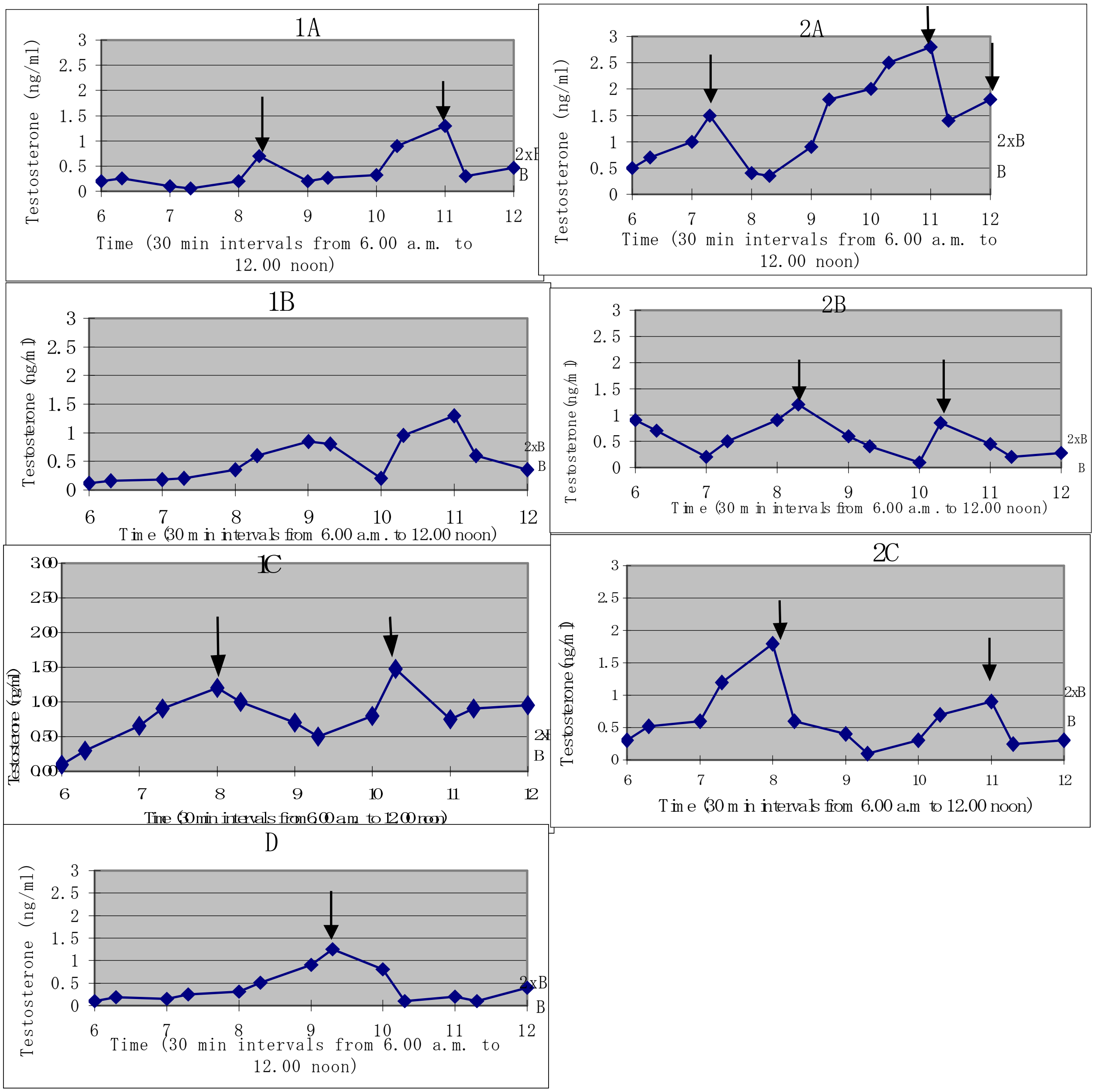

Fig. 1. Testosterone profiles of Red Sokoto weaner bucks at 7 months of age showing basal (B) and episodic peaks (arrows) in different treatment groups.