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Original article

Effects of bull exposure and body growth on onset of puberty in Bunaji and Friesian × Bunaji heifers

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Abstract — A total of ninety seven pre-pubertal Bunaji (BJ) and Friesian-Bunaji (FR × BJ) heifers were allotted randomly to two treatments groups for a period of 15 months. The treatment groups consisted of the followings: Mature Bull Exposure (MBE) and No Bull Exposure (NBE). Heifers were body condition scored and their live weights recorded on 28 days consecutive intervals. A heifer tactile stimulation in bull bio-stimulation. was considered to have attained puberty if she displayed oestrus, had a palpable corpus luteum with an associated P4 concentration > $1 ng \cdot mL^{-1}$. The onset of puberty was significantly earlier in MBE heifers (23.1 ± 0.4 months) than NBE heifers (26.4 ± 0.4 months). The mean ages at puberty for MBE-BJ, NBE-BJ, MBE-FR × BJ, NBE-FR × BJ were 24.3, 27.8, 22.1 and 25.0 months respectively. More MBE heifers (70.8%) attained puberty between 17 and 24 months of age than NBE heifers (18.3%) and on the same ages, more FR × BJ heifers (62.0%) than BJ heifers (25.5%). The mean live weight of MBE heifers at puberty (224.4 ± 4.2 kg) was significantly lower than that of the NBE heifers (255.8 ± 4.2 kg). The FR × BJ heifers attained puberty at a significantly higher live weight (270.2 ± 4.2 kg) than the BJ heifers (228.6 ± 4.2 kg). The use of a vasectomised bull especially in some elite farms that rely on artificial insemination services may be an effective management tool that can decrease age at puberty. More work is required to determine the relative contribution of visual, auditory, olfactory, pheromonal and tactile stimulation in bull biostimulation.

bull-exposure / body growth / puberty / tropical climate

Résumé — **Effets de l'exposition au taureau et de la croissance corporelle sur le début de la puberté des génisses de races Bunaji et Frisonne × Bunaji.** Quatre-vingt-dix-sept génisses prépubères de races Bunaji (BJ) et Frisonne-Bunaji (FR × BJ) ont été réparties en deux lots, un où elles ont été mises en présence d'un taureau (MBE), l'autre sans cette présence (NBE). Elles ont été

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pesées et suivies pour leur condition corporelle tous les 28 jours pendant 15 mois. Une génisse a été considérée pubère après la manifestation d'un oestrus associé à un corps jaune palpable et une concentration de progestérone > 1 ng·mL^{-1}. Les génisses du lot MBE ont atteint la puberté significativement plus tôt (23,1 ± 0,4 mois) que les génisses NBE (26,4 ± 0,4 mois). Les âges moyens à la puberté des génisses MBE-BJ, NBE-BJ, MBE-FR × BJ et NBE-FR × BJ ont été respectivement de 24,3, 27,8, 22,1 et 25,0 mois. Les génisses du lot MBE ont été plus nombreuses à être pubères entre 17 et 24 mois (70,8 %) que les génisses du lot NBE (18,3 %) et aux mêmes âges, les génisses FR × BJ ont été plus nombreuses (62,0 %) à être pubères que les génisses BJ (25,5 %). Le poids vif à la puberté des génisses du lot MBE, égal à 224,4 ± 4,2 kg a été significativement plus faible que celui des génisses NBE égal alors à 255,8 ± 4,2 kg. Les génisses FR × BJ ont atteint la puberté à un poids (270,2 ± 4,2 kg) plus élevé que les génisses BJ (228,6 ± 4,2 kg). L'emploi d'un taureau vasectomisé peut donc être un moyen de diminuer l'âge à la puberté. Des études supplémentaires sont nécessaires pour déterminer les contributions relatives des stimulations visuelles, auditives, tactiles ou impliquant les phéromones pour expliquer cet effet.

bovins / climat tropical / croissance corporelle / puberté

1. INTRODUCTION

Age at puberty is an important determinant of reproductive efficiency and early attainment of puberty is an important trait to achieve optimum reproductive performance of cattle [3, 22]. General body growth and development are pre-requisites for the initiation of sexual function in male and female animals [22]. The control of the transition to puberty in the heifer appears to depend on endocrine components which become potentially functional in young heifers immediately after birth and this hypothesis is described as the gonadostat theory [5]. Ovarian steroids inhibit gonadotropin secretion in prepubertal animals via a negative feedback action on the hypothalamo-pituitary axis [17]. The classical gonadostat theory suggests that first ovulation then results when sensitivity to steroid feedback diminishes allowing sufficient gonadotropin output to bring about follicular maturation [5].

Factors affecting the onset of puberty in heifers include age and breed [1], nutrition and growth rate [6, 14, 15], photoperiod, environmental temperature and season [6], and bull and biostimulation [8, 9, 20]. Biostimulation is described as the stimulatory effects of a male on estrus and ovulation through genital stimulation, pheromones or other less well defined external cues [4]. Pheromones are substances secreted externally by an animal and cause a specific reaction in a receiving individual of the same species; the reaction involves either a specific behaviour, or physiological change in the recipients endocrine or reproductive system [7]. Primimg pheromones exert their effects through olfactory or accessory olfactory pathways (vomeronasal system) which can detect chemical signals [10, 28]. The bovine species has a well developed vomeronasal organ and it has been hypothesised that the accessory olfactory system mediates the effect of priming pheromones that influence ovarian function including reproductive maturation [10, 28]. Bull and cow biostimulation has been shown to advance puberty in heifers [8, 9, 20]. The results of Roberson, Wolfe, Stumpt, Werth, Cupp, Kojima, Wolfe, Kittok and Kinder [20] are corroborated with the observation of Izard and Vandenbergh [9] and further support the hypothesis that social interaction between bulls and prepubertal heifers can result in a decreased age at puberty.

There has been little or no documented information on the biostimulatory influences of bulls on the onset of puberty in heifers in Nigeria. Therefore, the purpose of the present study was to determine the influence of bull biostimulation and body growth on the onset of puberty in Bunaji and Friesian × Bunaji heifers.

2. MATERIALS AND METHODS

2.1. Location

This work was carried out using ninety-seven prepubertal heifers of National Animal Production Research Institute, Shika, Ahmadu Bello University Zaria. Shika is in Giwa District, situated in the northern Guinea Savannah between latitudes 11° and 12° N and between longitudes 7° and 8° E at an altitude of 650 m above sea level. Shika has two distinct seasons: the dry season (November to April) and rainy season (May-October). Daily temperatures range from 13 to 30 °C with a relative humidity of 23% during the dry season. In the study area, the harmattan period, which is the initial part of the dry season is from November to February and is usually characterised by cold weather and dry dusty winds. The average monthly rainfall for the rainy season was 153.2 mm with a range of 32.4 to 300.8 mm, while the dry season was characterised by total lack of rainfall.

2.2. Experimental heifers

A total of ninety-seven pre-pubertal heifers (n = 47 and n = 50 for Bunaji and Friesian × Bunaji respectively) of approximately 14.8 ± 1.6 months of age (13–15 months) were allotted randomly to one of two treatment groups for a period of 15 months. The treatment groups consisted of (i) heifers exposed to two mature teaser (vasectomised) bulls; Mature Bull Exposure (MBE, n = 48) and (ii) heifers isolated from bulls; No Bull Exposure (NBE, n = 49). The 48 MBE heifers consisted of 23 Bunaji (BJ) and 25 Friesian × Bunaji (FR × BJ) heifers; while the 49 NBE heifers consisted of 24 Bunaji heifers and 25 Fresian × Bunaji heifers. The heifers were introduced into the study at the beginning of the dry season (November) for a period of 15 months that is one rainy season and two dry seasons.

2.3. Management of the heifers

Heifers in the MBE and NBE treatments were maintained in improved pasture paddocks separated by a distance of 1 km to minimise the influence of exteroceptive stimuli associated with each other. Therefore isolation from stimulatory influence was assumed for the NBE treatment group. Heifers in addition to grazing improved sown pasture fields (Stylosanthes, Brachiaria and Digitaria) were given supplementary concentrates consisting of wheat bran, maize and cotton seedcake at about 1–2 kg per head per day. The supplementary ration was formulated to contain 2.40 ME Mcal·kg^{-1} DM and 13.5% crude protein serving as a normal plane of nutrition. They were also given baled hay, free access to salt lick and water ad-libitum throughout the experimental period. The above management practice eliminated the seasonal influences of nutrient availability, which is a serious constraint during the dry season in the tropics. All experimental heifers were ear-tagged with large plastic ear tags (Ritchey Europe Ltd., Yorkshire, England) in order to enable the identification of heifers from a distance during heat detection. Before commencement of study, the young heifers were screened for blood and helminth parasites and appropriate treatments and vaccination against endemic diseases were carried out. Regular treatments with anthelmintics, acaricides and antibiotics for control of helminthiasis, ticks and tick-borne diseases respectively were implemented throughout the study period.

2.4. Body measurements

Heifers were body condition scored and their liveweights were recorded on 28-d consecutive intervals throughout the study period. The heifers were scored as recommended by Pullan [16], using a score of 0–5 from the most emaciated to the fattest. Condition scoring provides a quick, inexpensive and easy method for the comparison of herds of cattle or individual animals under different management systems, experimental treatments, seasons or environments. Only heifers with a body condition score of 2.5 and above were involved in the study. The mean (± s.e.m.) liveweights of the treatment groups at the start of the experiments were as follows: (i) NBE heifers = 146.9 ± 2.5 kg; (ii) MBE heifers = 144.8 ± 2.5 kg.

2.5. Estrus detection and blood sampling

Two weeks before the commencement of the experiments, the heifers were observed visually for signs of estrus by herdsmen and the inseminators, twice daily between 07.30 and 08.30 and 17.30 and 18.30 h. The ovaries of all the heifers were examined by the rectum for the presence of functional ovarian structures to make sure that they were non-pubertal. A 10 mL jugular blood sample was collected by venipuncture from each heifer 10 days before and at the start of the experiment, to ensure that the heifers were non-pubertal. Progesterone concentrations below 1 $ng \cdot mL^{-1}$ of serum in blood samples from heifers receiving both treatments within this period were indicative of prepuberty. In the MBE group of heifers, heat detection was accomplished by herdsmen, inseminators and two vasectomised mature bulls, whereas estrus detection in the NBE group was carried out by herdsmen and inseminators only. In both groups, heifers were observed visually for signs of estrus by herdsmen and inseminators twice daily between 07.30 and 08.30 and 17.30 and 18.30 h. The two vasectomised bulls harnessed with a chin-ball mating device containing red paint (The Great Outdoor Co. Ltd., New Zealand) were used in the MBE group to effect bull biostimulation and also aid in heat detection.

Estrus was defined and recorded when a heifer stood to allow herdmates or vasectomised bulls to mount her. The ovaries of such a heifer were palpated daily per rectum for the presence of functional corpus luteum from day 7 to day 15 after the standing estrus. To still confirm the above, corresponding 10 mL blood samples via jugular venipuncture from each estrus heifer were harvested on day 7, 9, 11, 13 and 15 after standing estrus. Blood samples were placed immediately on ice and allowed to clot at 4 °C for 24 h. Serum was separated immediately by centrifugation at 3 000 rpm for 15 min and stored at –20 °C until concentrations of progesterone (P_4) were determined by radioimmunoassay.

2.6. Radioimmunoassay

Serum progesterone concentrations were determined using a no-extraction, Coat-A-Count solid phase, progesterone RIA Kit. The method is a rapid, simple and direct (no-extraction) assay and depends on the competition between progesterone in serum and ^{125}I-labelled progesterone (tracer) for a limited number of binding sites on a progesterone specific antibody immobilised (coated) on the internal walls of test-tubes (solid phase). In this study, the sensitivity (detection limit or least detectable dose) of the assays was defined as the apparent progesterone concentration at twice the standard deviation away the from zero standard (B_o) and was determined as 0.09 $ng \cdot mL^{-1}$. The B maximum is a measure of how well the assay is functioning, that is, how well progesterone binds to the antibody coated tubes. The B maximum values of all the assays ranged between 35 and 50%. Measure of the variation of samples, that is precision and reliability of the assay procedures were taken into account. The intra-assay and inter-assay coefficients of variations were 8.8% and 9.4% respectively.

2.7. Criteria for attainment of puberty

In this study, a heifer was considered to have attained puberty if she displayed estrus; had a palpable corpus luteum between day 7 and day 15 after estrus and had associated progesterone concentrations of 1 ng·mL^{-1} within the specified period [19]. Liveweights and body condition scores at puberty were interpolated between the two measurements nearest the first estrus. All of the 97 heifers in the study met the above criteria for puberty and were used in the statistical analysis.

2.8. Statistical analysis

Age, liveweight, body condition score and progesterone concentrations were analysed by least square analysis of variance using the general linear model procedure of SAS [23]. A proportion of heifers in the different treatment groups reaching puberty between 18 and 30 months of age were analysed by contingency chi-square analysis.

3. RESULTS

3.1. Age at puberty

The results of this study show that bull biostimulation reduces the age at the onset of puberty (Tabs. I and II). Age at the onset of puberty of MBE heifers (23.1 ± 0.4 months), was significantly lower than the age (26.4 ± 0.4 months) at the onset of puberty for the NBE heifers ($P < 0.05$; Tab. I). The MBE.BJ heifers attained puberty at a mean age of 24.3 ± 0.7 months which was significantly ($P < 0.05$) earlier than the mean age of 27.8 ± 0.7 months of the NBE.BJ heifers. Age at the onset of puberty of MBE.FR × BJ heifers (22.1 ± 0.7 months) was significantly ($P < 0.05$) lower than the mean age of 25.0 ± 0.7 months for the NBE.FR × BJ heifers. The breed of the heifers had a significant influence on the age at the onset of puberty (Tabs. I and II). The FR × BJ heifers attained puberty at 23.6 ± 0.4 months which was significantly ($P < 0.05$) earlier than the BJ heifers (26.1 ± 0.4 months). Age at the onset of puberty for

Table I. The effects of biostimulation and breed on liveweight, body condition score and progesterone concentrations of heifers at puberty.

Pubertal traits	Bull exposure			Breed		
	MBE *n* = 48	NBE *n* = 49	s.e.m.	BJ *n* = 47	FR × BJ *n* = 50	s.e.m.
Age at puberty, months	23.1[a]	26.4[b]	0.4	26.1[b]	23.6[a]	0.4
Liveweight at puberty, kg	224.4[a]	225.8[b]	4.2	228.6[a]	270.2[b]	4.2
Body condition score	2.9	2.8	0.1	2.81	2.9	0.1
P_4 conc. Ng·mL^{-1}	3.4	3.0	0.4	3.2	3.2	0.4
Average daily gain, kg	0.34	0.32	0.06	0.24	0.42	0.08

[a, b] Data in rows within treatment groups with different letter superscripts are significantly different ($P < 0.05$).

Table II. The interaction between biostimulation and breed on age, liveweight, body condition score and progesterone concentrations of heifers at puberty.

Pubertal traits	Treatment groups				
	MBE.BJ n = 23	MBE.FR × BJ n = 25	NBE.BJ n = 24	NBE.FR × BJ n = 25	s.e.m.
Age at puberty, months	24.3^{b}	22.1^{a}	27.	25.0^{b}	0.7
Liveweight at puberty, kg	228.3^{a}	259.8^{b}	228.9^{a}	280.6^{c}	8.4
Body condition score	2.9	3.1	2.7	2.9	0.2
P_4 conc. Ng·mL^{-1}	3.4	3.4	3.0	3.0	0.3
Average daily gain, kg	0.25^{a}	0.43^{b}	0.22^{a}	0.42	0.1

[a, b, c] Data in rows with different letter superscripts are significantly different (P < 0.05).

MBE.FR × BJ heifers (22.1 ± 0.7 months) was significantly (P < 0.05) lower than age at puberty for MBE.BJ heifers (24.3 ± 0.7 months). Age at the onset of puberty for NBE.BJ heifers (27.8 ± 0.7 months) was significantly (P < 0.05) higher than the age at puberty for NBE.FR × BJ heifers (25.0 ± 0.7 months).

3.2. Proportion of heifers at puberty

The results of this study indicate that bull biostimulation has significant effects on proportion of heifers at puberty (Tab. II). More MBE heifers attained puberty at earlier ages than the NBE heifers (Tab. III). Bull biostimulatory effect was found to be significant among BJ heifers at puberty, with more MBE.BJ heifers attaining puberty earlier than NBE.BJ heifers. Similarly, more MBE.FR × BJ heifers attained puberty earlier than NBE.FR × BJ heifers (Tab. II). The results of this study also show that more FR × BJ heifers attained puberty between the ages of 17–24 months, than Bunaji heifers (Tab. III).

Table III. Percentage of heifers reaching puberty at varying ages.

Treatment group	n	Age at puberty, months			
		17–20	21–24	25–28	29–30
		Percentage (%)			
MBE (pooled)	48	12.5 (6)	58.3 (28)	29.2 (14)	0 (0)
NBE (pooled)	49	2.0 (1)	16.3 (8)	65.3 (32)	16.3 (8)
BJ.MBE	23	0 (0)	52.2 (12)	47.8 (11)	0 (0)
BJ.NBE	24	0 (0)	0 (0)	66.6 (16)	33.3 (8)
FR × BJ.MBE	25	24.0 (6)	64.0 (16)	12.0 (3)	0 (0)
FR × BJ.NBE	25	4.0 (1)	32.0 (8)	64.0 (16)	0 (0)
BJ (pooled)	47	0 (0)	25.5 (12)	57.5 (27)	17.0 (8)
FR × BJ (pooled)	50	14.0 (7)	48.0 (24)	38.0 (19)	0 (0)
All Heifers (pooled)	97	7.2 (7)	37.1 (36)	47.4 (46)	8.2 (8)

Figures in parenthesis are the number of heifers.

3.3. Body growth and condition scores

The mean liveweight of MBE heifers at puberty (224.4 ± 4.2 kg) was significantly ($P < 0.05$) lower than that of the NBE heifers which was 255.8 ± 4.2 kg (Tab. I). The average daily gain (ADG) for MBE heifers (0.34 kg) was not significantly ($P > 0.05$) different from that of the NBE (0.32 kg) group. The mean body condition scores at puberty for MBE and NBE heifers did not differ significantly (Tab. II). The mean liveweights at puberty for MBE.BJ and NBE.BJ were 228.3 ± 8.4 kg and 228.9 ± 8.4 kg respectively with no significant differences ($P > 0.05$; Tab. II). ADG and body condition scores were not significantly different for MBE.BJ, NBE.BJ, MBE.FR × BJ and NBE.FR × BJ heifers (Tab. II). The mean liveweight of MBE.FR × BJ heifers at puberty of 259.8 ± 8.4 kg was significantly lower than that of the NBE.FR × BJ heifers (280.6 ± 8.4 kg; $P < 0.05$). The liveweight of FR × BJ heifers at puberty (270.2 ± 4.2 kg) was significantly higher than that of BJ heifers (228.6 ± 4.2 kg; Tab. I). The ADG of FR × BJ heifers was 0.42 kg significantly ($P < 0.05$) higher than the ADG of BJ heifers which was 0.24 kg.

3.4. Progesterone concentrations

Heifers that stood to be mounted, showed evidence of palpable corpora lutea from rectal examination post-standing estrus. The progesterone concentrations (P_4) at puberty for MBE and NBE treatment groups were 3.4 and 3.0 $ng \cdot mL^{-1}$ with no significant difference (Tab. I). Similarly, the P_4 concentrations at puberty for BJ and FR × BJ heifers were 3.2 and 3.2 $ng \cdot mL^{-1}$ with no significant differences.

4. DISCUSSION

The results show that bull biostimulation significantly reduces the age at the onset of puberty of MBE and NBE heifers, with a significant difference of 3.3 months in favour of MBE heifers. This finding is in agreement with the study by Skinner and Bonsma [24] who reported an increased conception rate of 41.6% when aproned bulls were used for stimulation. The authors in the same study found 22.6% more calves born from teased heifers. The bull- exposed Bunaji heifers and Friesian × Bunaji heifers attained puberty at respectively 3.5 and 2.9 months earlier than their counterparts that were not exposed to vasectomised bulls. The findings of the present study are consistent with the observations of Izard and Vandenbergh [8, 9], and support the hypothesis that the social interaction between bulls and prepubertal heifers results in a decreased age at puberty. The findings further corroborate the research works of Skinner and Bonsma [24], Roberson et al. [20] and further support the role of bull biostimulation in influencing or hastening the onset of estrus in heifers. On the contrary, several reports have shown that the proximity of the male does not hasten puberty in the bovine species. For example, exposure of heifers to bulls had no effect on the occurrence of puberty [2, 12, 13, 19, 26].

Age at the onset of puberty in this study is in agreement with the range of 19.0 to 23.5 months at puberty of zebu heifers placed on varying levels of protein [15]. Similarly, the ages at the onset of puberty in this study are in agreement with the work of Tan et al. [25] which reported that the mean age at first calving for indigenous cattle in Malaysia was about 36 months and that less than 50% of heifers had detectable ovarian activity before 24 months of age. The reported values of age at the onset of puberty were 22.1, 24.3, 25.0 and 27.8 months for the four treatment groups, and these values were within the range reported for zebu cattle by earlier workers [18, 21]. The Friesian × Bunaji heifers in this study grew faster for genetic reasons and were younger and heavier at puberty than the Bunaji heifers. This corroborates with the work of Werre [27]. This finding is also in agreement with the work of Arije and Wiltbank [1] who reported that average daily gain and weight at puberty of heifers can be affected by breed. The liveweights of heifers at the onset of puberty obtained in this study are within the range of values reported earlier [15]. Generally, age at puberty in heifers is influenced by the plane of nutrition and growth rate and the responsiveness of prepubertal heifers to potential pheromonal cues from bulls seems to be dependent on body weight of heifers [20].

Improved management practices and selection for associated reproductive traits can enhance physiological processes related the attainment of puberty in an effort to maximize the number of heifers that reach puberty before initiation of the breeding season [11]. In conclusion, bull-heifer interactions do influence age at the onset of puberty in this study. The role of the vasectomised bulls may have occurred through olfactory or pheromones transmitted from the bulls to the heifers. The use of vasectomised bulls for estrus detection especially in some elite farms, that do not keep breeding bulls but rely on artificial insemination services may be an effective management tool that can decrease age at puberty. More work is required to determine the relative contribution of visual, auditory, olfactory and tactile stimuli in bull biostimulation.

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