International Journal of Dairy Science 2 (4): 380-386, 2007
ISSN 1811-9743

Measures of Daily Weight Gain in Friesian-Bunaji Crossbred Heifers and Their Relationship with First Lactation Milk Yield

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Abstract: This study was conducted to ascertain the relationship between Birth weight, Average Daily Gain (ADG) at 3, 6, 9 and 12 month of age and their first lactation milk yield in Friesian Friesian-Bunaji crossbred heifers. The effects of non-genetic factors such as season, parity and year of calving on the measured characteristics were also investigated. The average daily gains were computed from the monthly weight data. Other variable collected was milk production at first lactation. A total of 585 lactation records were used for the analysis. The average birth weight, ADG at 3, 6, 9 and 12 months and first lactation milk yield (FLMYD) were 26+0.4 kg, 0.39±0.03 kg, 0.43±0.05 kg, 0.4±0.4 kg and 945 kg. Average daily gains were significantly ($p<0.05$) affected by season of the year and the effect of calving year was highly significant ($p<0.01$). FLMYD was significantly affected by season ($p<0.05$) and calving year ($p<0.01$). There were positive genetic correlations between growth at 3, 6, 9 and 12 month and FLMYD. The environmental and phenotypic correlations between them were also positive. The heritability estimate was 0.21±0.09, 0.17±0.06, 0.17±0.08 and 0.13±0.01, for ADG at 3, 6, 9 and 12 months, respectively. The results of this study demonstrate that heifers with high genetic growth potentials would reach puberty earlier and would likely be bred and calve at an earlier age with high milk yielding ability.

Key words: Heifers, Friesian-Bunaji , relationship, genetic parameters, growth, milk yield

INTRODUCTION

Selection for milk yield in dairy cattle leads to a correlated increase in body growth capacity of heifers and milk yield of cows (Sejresen *et al*., 2000). Thus indicating a positive relationship between growth rate of heifers in their rearing period and subsequent milk yield potentioal. The genetic and phenotitypic correlations between body weight at first calving and first lactation milk yield have been reported to be positive (Veerkemp and Brotherstone, 1997). Also, positive correlations between calving age and milk yield have been reported (Catillo *et al*., 2002)

High milk yield is in line with the frequently observed positive relationship between milk yield and body weight at calving (Hoffman and Funk, 1992). This implies a positive relationship between growth rate of heifers in the rearing period and their subsequent milk yield potential. The relationship, however, is not straightforward, because high prepoubertal growth rate caused by increased feeding level often leads to reduced milk yield (Sejresen and Purup, 1997). The milk yield capacity is determined largely by the number of milk synthetic cells (Grossman and Koops, 2003) which may depend to a large extent on mammary development.

The need for replacement heifers in dairy production have under-scored the importance of producing replacement heifers, which increases the production cost. Since rearing costs constitute a large part of milk production cost (Cardoso *et al*., 1999), replacement cost can be decreased by shortening the rearing time. This is achieved by selecting fast growing heifer calves that would mature early, since puberty is a function of attaining a particular body weight. Genetic and phenotypic correlations between body weight at first calving and first lactation milk yield have been reported to

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be positive in many studies (Lin *et al*., 1985; Van Elzakker and Van Arendonk, 1993; Veerkamp and Brothrstone, 1997). Also, positive phenotypic correlations between calving age and milk yield have been reported (Moore *et al*., 1991; Catillo *et al*., 2002). This study, therefore, was carried out to examine the genetic and phenotypic relationships between average daily gain at 3, 6, 9 and 12 month of age before breeding and birth weight with first lactation milk yield among Friesian-Bunaji crossbred heifers. Also investigated, were the effects of year of birth, season of birth and parity of the dam on average daily gain at (3, 6, 9 and 12 month) of age.

MATERIALS AND METHODS

Location and Management of Animals

The data used for this study originated from the herd of National Animal Production Research Institute (NAPRI), Shika, Zaria, Nigeria. Shika is located between latitude 11° and 12° North at an altitude of 640 m above sea level. The average annual rainfall is 1100 mm, 72% relative humidity and 25°C daily temperature.

The animals were raised during the rainy season on paddock-sown pastures. Hay or silage, supplemented with concentrate mixtures of undelinted cotton seed cake, maize or guinea corn were offered during the dry season at 3.5 kg day^{-1}, when animals were housed in open sheds. Water and salt lick were supplied *ad libitum*. Regular spraying against tick and vaccinations were observed. Calves were separated from their dams three days after birth and bucket fed until three months of age, when they were weaned. The cows were milked twice daily. The birth weight of calves were taken and thereafter, body weight was taken on monthly basis.

Data Source

The data was sourced from the dairy research breeding records kept at NAPRI between 1980 and 2000. The data consist of 735 body weight records at birth and Average Daily Gains (ADG) at 3,6, 9 and 12 month of age of half-bred Friesian-Bunaji haifers and their 280 days first lactation milk yield. The average daily gains were obtained by subtracting the birth weight from weight at that period and dividing the difference by the age of the heifers at that period. The heifers whose lactation was less than 100 days and milk yield less than 600 kg or their first lactation record was missing, were discarded as out liers. Thus the final data set in the analyses contained records of 585 heifers.

Statistical Analysis

The data were analysed using proc GLM and proc var com of SAS (1987)
The following model was used in the analysis.

$$Y_{ijk} = \mu + \beta_I + S_j + P_k + e_{ijk}$$

Where,

Y_{ijk} = ADG (3, 6, 9 and 12 month) and first lactation milk yield;
μ = Overall mean;
B_i = Effect of the i^{th} year of birth;
S_j = Effect of the j^{th} season of birth;
P_k = Effect of the k^{th} parity;
e_{ijk} = Random error components assumed to be normally distributed with zero mean and constant variance.

Heritability Estimates

In this, pairs of dam and offspring traits records were used for the estimation of heritabilities by the daughter dam method as follows:

Then the heritability equation follows:

$$b = \frac{xy}{x^2}, h^2 = 2b$$

Where

b = Regression coefficient;

XY = Covariance of dam and offspring records;

X^2 = Corrected dam's sums of squares;

h^2 = Heritability estimates.

Covariance and variance components were estimated using proc. GLM. Method of SAS (1987). The estimated covariance and variances, were used to estimate correlations using SAS program (SAS 1987).

RESULTS

The least-squares mean for birth weight, ADG and FSTLMD and their influencing factors are presented in Table 1-4. Parity of the dam did not significant ($p>0.05$) affect birth weight, ADG at (3, 6, 9 and 12 month) and First lactation milk yield. Year of birth showed highly significant ($p<0.01$) influence on birth weight, ADG and first lactation milk yield, respectively. The mean birth weight, ADG at 3, 6, 9 and 12 month and first lactation milk yield was 27, 0.39, 043, 0.40, 0.39 and 945 kg, respectively. Calves born during the late dry and early wet season had the lowest weight of 25.5 and 23 kg, while their counterparts born during the late wet and early dry season had the highest weight of 27.5 and 30.2 kg, respectively. The highest average daily gains at 3 month of age of 0.49 and

Table 1: Least squares means of growth trait (kg) across season of birth

	No.	BWT (Kg)*	No.	ADG3M (Kg)*	No.	ADM6M (Kg)*	No.	ADG9M (Kg)*	No.	ADG12M (Kg)*
Season of birth										
Early wet	223	25.5 ± 0.45^{bc}	99	0.49 ± 0.012^{a}	200	0.32 ± 0.018^{c}	158	0.37±0.013	126	0.30±0.014
Late wet	68	27.4 ± 0.45^{b}	176	0.36 ± 0.012^{c}	121	0.45 ± 0.017^{b}	173	0.45±0.015	119	0.29±0.01
Early dry	74	30.2 ± 0.52^{a}	121	0.40 ± 0.014^{b}	84	0.75 ± 0.02^{a}	97	0.39±0.011	149	0.32±0.015
Late dry	206	23.0±0.46	184	0.24 ± 0.012^{d}	162	0.30 ± 0.018^{c}	130	0.36±0.013	1452	0.31±0.014
Overall mean	585	27±0.46	580	0.39±0.05	567	0.43±0.05	558	0.40±0.016	536	0.39±0.017

*$p<0.05$; Means within the same column represented by different subscript differ significantly ($p<0.05$)

Table 2: Least squares means of growth trait (kg) across year of birth

Year of birth	No.	BTW**	No.	ADG3M**	No.	ADG6M**	No.	ADG9M**	No.	ADG12M**
1980	35	24.8	33	0.32	30	0.24	29	0.27	26	0.28
1981	25	27.1	25	0.34	23	0.40	22	0.26	22	0.41
1982	19	32.6	17	0.81	16	0.89	15	0.77	15	0.32
1983	26	26.8	24	0.41	22	0.34	22	0.33	20	0.29
1984	36	24.6	33	0.33	32	0.35	29	0.33	29	0.35
1985	27	26.3	25	0.39	23	0.37	22	0.62	22	0.75
1986	36	24.4	34	0.36	34	0.58	32	0.55	30	0.36
1987	31	23.8	30	0.42	28	0.44	27	0.39	26	0.33
1988	29	27.1	25	0.51	23	0.73	23	0.33	21	0.41
1989	39	24.5	33	0.34	34	0.46	32	0.39	31	0.44
1990	32	18.6	28	0.30	28	0.20	27	0.44	26	0.38
1991	31	24.5	29	0.32	26	0.33	25	0.31	23	0.31
1992	22	22.9	20	0.35	19	0.34	18	0.29	18	0.31
1993	19	26.4	17	0.28	17	0.39	15	0.44	15	0.41
1994	35	23.9	31	0.24	28	0.33	28	0.35	25	0.36
1995	18	28.9	16	0.32	14	0.46	14	0.58	12	0.47
1996	27	20.7	27	0.29	26	0.36	23	0.23	23	0.38
1997	25	21.0	24	0.27	22	0.32	19	0.32	19	0.29
1998	26	22.4	24	0.28	23	0.30	22	0.32	21	0.31
1999	21	24.5	19	0.31	18	0.42	16	0.46	15	0.42
2000	26	22.2	26	0.29	25	0.34	23	0.37	22	0.35
Overall mean	585		540		511		483		461	0.39±0.02kg

**$p<0.01$

Table 3: Least squares means of first lactation milk yield (FSTMYD) across season of birth

Season of birth	FSTLMYD (kg)	SE
Early wet	1340.1[a]	±43.5
Late wet	971.6[b]	±40.2
Early dry	851.4[bc]	±39.1
Late dry	615.3[c]	±26.4
Overall mean	945.01	±41.5

a, b and c means within the same column represented by different subscript differ significantly (p<0.05)

Table 4: Least squares means of first lactation milk yield (FSTLMD) across Year of birth

Year of birth	FSTLDYD**	SE
1980	916.1	±48.8
1981	927.6	±45.7
1982	696.2	±25.9
1983	1047.5	±51.9
1984	877.3	±33.1
1985	1037.9	±32.5
1986	1634.7	±29.4
1987	971.2	±43.3
1988	999.5	±42.8
1989	962.1	±34.9
1990	1048.0	±34.6
1991	958	±45.2
1992	892	±37.1
1993	971	±40.3
1994	968	±40.8
1995	816	±33.1
1996	718	±29.2
1997	649	±20.1
1998	817	±35.2
1999	850	±40.1
2000	668	±24.1
Overall mean	945.01	±41.5

** = Means within the same column differ significantly at p<0.01

Table 5: Genetic (r_g), environment (r_e) and phenotypic (r_p) correlations between ADG at (3, 6, 9 and 12 month) with 1st lactation milk yield

Trait	r_g±SE	r_e±SE	r_p±SE
ADG3M X FLMY	0.13±0.04	0.13±0.04	0.14±0.03
ADG6M X FLMYD	0.14±0.08	0.09±0.01	0.15±0.05
ADG9M X FLMYD	0.16±0.02	0.06±0.01	0.12±0.04
ADG12 X FLMYD	0.19±0.01	0.04±0.02	0.10±0.02

0.40 kg was recorded for calves born during the early wet and late wet seasons and the lowest average daily gains at 3 month of age, of 0.24 kg was recorded for calves born during the late dry season.

Calves that attained the age of 6 month during the late wet and early dry seasons had the highest average weight gain of 0.75 and 0.45 kg respectively; with the lowest average daily gains coming from those that attained the age of 6 months at late dry season of 0.30 kg.

The effect of year of birth was highly significant (p<0.01) on ADG at all ages. The year, 1982 recorded the highest average daily gain of 0.81 kg at 3 month of age, while the least was in 1994 of 0.24 kg. Similarly the highest daily gains recorded at 6 month of age was 0.89 kg in 1982 with the lowest of 0.20 kg in 1990. The highest ADG at 9 month was 0.77 kg in 1998 and the lowest was 0.23 kg in 1996. The highest ADG at 12 month of Age was 0.75 kg recorded in 1985.

The estimate of genetic correlation between ADG and FSTLMD was found to be positive (Table 5). Estimates of phenotypic and environmental correlations between ADG and milk yield were also positive. The heritability estimates for ADG at 3, 6, 9 and 12 month of age was 0.21±0.09, 0.07±0.06, 0.17±0.08 and 0.13±0.1, respectively (Table 6).

Table 6: Heritability estimates of average daily gains at 3, 6, 9 and 12 month

Traits	$h^2 \pm SE$
ADG 3	0.21±0.09
ADG 6	0.17±0.06
ADG 9	0.17±0.08
ADG 12	0.13±0.1

DISCUSSION

The significant effect of calving season and year of calving on Birth weight, ADG at 3, 6, 9 and 12 month and First lactation milk yield in this study was consistent with earlier studies (Adulli 1992, Akpa *et al*., 2002; Catillo *et al*., 2002). The inconsistency in birth with values and average daily gains at (3, 6, 9 and 12 month of age) across years of birth could be due to fluctuations in rainfall over the years. Oni *et al.* (1988) had reported that in a situation where both the amount and distribution of annual rainfall fluctuate greatly, such significant differences are expected. Variations in weight, ADSG at (3, 6, 6 and 12 month) could be due to seasonal fluctuations in forage availability. The mean birth weight of 27 kg is close to the value of 26.7 kg reported by Adulli (1992) in Friesian-Bunaji crossbred cows but higher than 18.8 kg recorded by Das *et al.* (1999) in Friesian-Mpwapwa cows. The mean average daily gain at 3, 6, 9 and 12 month (0.39, 0.43, 0.40 and 0.39 kg) were close to values of 0.34 and 0.30 kg obtained for ADG at 3 and 6 month by Das *et al.* (1999) in Friesian-Mpwapwa crossbred cows and 0.52, 0.34 kg for ADG at 9 and 12 month by De Behr *et al.* (2001) in Belgian Blue calves

The mean First lactation milk yield of 945 kg was lower than 6198 and 6440 kg reported by Mantyssari *et al.* (2002) for Friesian and Ayrshire breeds. The Friesian and Ayrshire are pure breeds developed as dairy animals that are bound to be superior in milk production even when compared with the performance of their crossbreds of native type origin. This may explain the lower value observed in the current study as compared with the values obtained from Friesian and Ayrshire pure breeds.

The estimated small but positive genetic correlations between ADG and first lactation milk yield was consistent with report from the literature (Lin *et al*., 2002). This implies that heifers with higher genetic growth potentials also have a higher milk production capacity. The positive environmental correlations found between ADG before breeding and first lactation milk yield was opposite to what would have been expected based on feeding trial. In many feeding studies, a high feeding level before puberty was reported to decrease mammary development and milk production (Serjsen *et al*., 1998; Harrison *et al*., 1983; Mantyssari *et al*., 1995). In the current study, the ADG before breeding (ADG at 3, 6, 9 and 12 month of age for the heifers did not represent solely the growth in the critical periods, but a point in time during the growth in critical period. Secondly the heifers were not on feeding trails and therefore could not have been fed beyond the critical level that would have impaired mammary development.

The heritability estimate for ADG of 0.21±0.09, 0.17±0.06, 0.17±0.08 and 0.13±0.1) at (3, 6, 9 and 12 month) of age, respectively were in conformity with what was reported by Maiwashe *et al.* (2002) of 0.17; but lower than the report of 0.42 by Sondergaard *et al.* (2002). With this observed report low heritability, genetic progress due to individual selection would be low, however, selection index method of selection that would combine a number of other economic important traits can be employed in order to achieve a reasonable progress.

CONCLUSION

This study has shown that environmental factors (i.e., season and year of birth) were the key elements responsible for variations in ADG and FLMY in Friesian-Bunaji heifers. The ADG at 3, 6, 9 and 12 months of age for these heifers were of low to medium inheritance (h^2 = 0.13 to 0.21).

However, with the positive genetic corrections between ADG at 3, 6, 9 and 12 months of age and FLMY, the heifers with higher genetic growth potentials would have higher milk production capacity. Therefore, selection for milk production in these heifers can be done at an earlier age.

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