THE JOURNAL OF AGRICULTURE AND NATURAL RESOURCES SCIENCES

Journal homepage: http://www.journals.wsrpublishing.com/index.php/tjanrs

Online ISSN: 2383-238X Print ISSN: 2423-4397

Original Article

Genetic and Phenotypic Correlations between Fertility and Milk Composition traits of Friesian x Bunaji cows

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Abstract

This study was conducted to determine the genetic and phenotypic relationship between fertility and milk production traits of Friesian x Bunaji dairy cows. The estimates of heritability (h^2) for fertility traits were low and ranged from 0.014 to 0.035. This indicates that the fertility traits are largely influences by management and environmental factors. The genetic correlations were generally stronger than the phenotypic correlations, but the direction of the relationship was similar. The magnitude and direction of the estimated genetic correlation coefficients between milk yield and fertility traits was unfavourable; cows selected for high milk yield may have prolong interval to insemination after calving (DFI = 0.435) due to delay in resumption of ovarian activity (DO = 0.485) and may require high number of insemination per conception (NIC = 0.299) and therefore, are not likely to become pregnant within 56 days after the first insemination (NRR56= -0.044). The genetic correlation between milk fat content (MFC) and fertility of dairy cows in early lactation was also unfavourable; high MFC in early lactation is associated with poor fertility, decreased conception rate to first services (DFI = 0.290), prolong calving to conception interval (DO = 0.216) and increased number of service per conception (NIC= -0.197). However, cows with high milk protein in early lactation are likely to have shorter intervals to first insemination after calving (DFI = - 0.290), with high probability of first insemination conception rate (NIC = -0.114) and therefore, are likely to become pregnant within 56 days after first insemination (NRR56 = 0.096). There is a close relationship between milk composition yield and fertility, such that increase milk yield and composition yield is associated with lower fertility of dairy cows, decrease conception rate, prolong calving to conception interval and increase number of insemination per conception.

Keywords: fertility, heritability, milk composition, genetic, phenotypic, correlation

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How to Cite this Article: Alphonsus, C., Akpa, G.N., Achi, N.P., Sam, I.M., & Abdullahi, I. (2017). Genetic and Phenotypic Correlations between Fertility and Milk Composition traits of Friesian x Bunaji cows. *The Journal of Agriculture and Natural Resources Sciences,* 4(1), 23-29. Retrieved from http://www.journals.wsrpublishing.com/index.php/tjanrs/article/view/315

Article History: Received: 2015-08-11 Accepted: 2016-09-10

Introduction

The genetic composition of a population can be studied by considering the relative importance of heritability (h^2) and environmental factors affecting the performance of individuals in that population (Javed *et al.*, 2001). The concept of heritability is important for dairy cattle breeders since it is a limiting factor in the rate of genetic change in a trait (Wilcox, 1992). The effect of direct and indirect selection for parameters of fertility in dairy cattle population depends to the highest degree on the value for heritability (h^2) and genetic correlation of the traits (Dedovic *et al.,* 2005). Knowledge of genetic correlation is especially important when selecting individuals based on several traits and even more important for indirect selection under conditions when it is not possible to directly improve certain traits, such as fertility traits. Thus, application of indirect selection opens the possibility to increase intensity of selection, due to the possibility to reach conclusion more quickly. Knowledge of coefficients of h^2, as well as the nature of genetic correlations of the traits of interest influences the choice of the method of selection, and also contributes to a higher level of success (Dedovic *et al.,* 2005).

Due to the significant influence of non-genetic factors on the variability of parameters of reproduction, coefficients of h^2 for fertility are low (Pryce *et al.,* 2001; Berglund *et al.,* 2008), which complicates breeding or the genetic improvement of these traits. In spite of low heritability, the phenotypic variation for most fertility traits is relatively large and provides a favorable opportunity for selection (Norman *et al*., 2009). If cow fertility is not included in the breeding objective of dairy cattle, then there is a tendency for genetic decline in reproduction as an unwanted side effect of selection for reproduction. Thus, genetic evaluation of milk production and fertility traits of dairy cows is very important in determining the method of selection, to predict direct and correlated response to selection, choosing a breeding system to be adopted for future improvement as well as in the estimation of genetic gains (Javed *et al.,* 2001).

This study therefore, was design to determine the genetic relationship between fertility and milk production traits of Friesian x Bunaji dairy cows.

Materials and Methods

Experimental site:

The study was conducted on the dairy herd of the National Animal Production Research Institute (NAPRI) Shika, Nigeria, located between latitude 11^0 and 12^0N at an altitude of 640 m above sea level, and lies within the Northern Guinea Savannah Zone (Oni *et al.,* 2001). The mean annual rainfall in this zone is 1,100mm, which commenced from May and last till October, with 90% falling between June and September (Oni *et al.,* 2001).

Animals and managements:

Data for this study were collected from sixty (F_1) Friesian x Bunaji cows who are progenies of four Friesian sires. The pedigrees of the animals were properly kept at the record books of the institute and could be trace with utmost certainty. The cows were managed semi-intensively whereby they were grazed during the rainy season on both natural and paddock–sown pasture, while hay and/or silage were offered during the dry season. Concentrate mixture of undelinted cotton seed cake and grinded maize were offered to the cows daily during milking. They had access to water and salt lick *ad-libitum*. Unrestricted grazing was allowed under the supervision of herdsmen for about 7 – 9 hours per day. Routine spraying against ticks and other ecto-parasites was done.

The study was conducted in accordance with Institutional guidelines on the care and use of animals for scientific research, and in compliance with generally accepted rules of best practice worldwide.

Milk production measures

Cows were milked twice daily (morning and evening) and milk yield was recorded on daily basis. The milk sampled for the determination of fat and protein content was taken once per week starting from 4 to 100 days postpartum. The milk samples were frozen immediately after collection and stored at -20^{o}C until analyzed. The milk composition analysis was carried out at the Food Science and Technology Laboratory of Agricultural Research Institute, Ahmadu Bello University, Zaria-Nigeria. The following milk production measures were calculated: milk fat content (MFC), milk protein content (MPC), milk yield (MY), milk fat yield (MFY) and milk protein yield (MPY),
Note: Content values were in percentages (%) Yield values were in kilograms/day (kg/day).

Fertility traits
In National Animal Production Research Institute (NAPRI), artificial insemination records are well kept, therefore insemination dates are reliable and accurate thus, these records were used to calculate the fertility traits. The fertility traits measured were: Number of Inseminations per Conception (NIC); Days from Calving to First Insemination (DFI), Non-Return rate 56 days after first insemination (NRR56) and Days Open (DO), these were computed using insemination and calving records. The computation was as follow: non-return rate was a binary trait, coded 1 if a cow had only the first insemination date and no second insemination within 56 days after first insemination in a given lactation. Otherwise, NRR56 was coded zero "0" if a cow had two consecutive inseminations within 12days, those inseminations were considered to be for the same heat and code remained as 1. Days to first insemination (DFI) was computed as number of days between calving and first insemination date in a given lactation (Kadarmideen *et al* 2003). Non return rate (NRR56) and DFI covers the two most important aspects of female fertility: the ability of cow to cycle and conceived normally (Kadarmideen *et al.,*2000) and has been recommended by EU concerted action on "Genetic Improvement of Functional Traits in cattle FIFT"(Groen *et al.,*1997) for national genetic evaluation.
In addition, number of insemination per conception (NIC) and days open (DO) was also recorded. The NIC was defined as the number of times a cow was inseminated before conception in a particular lactation, while days open (DO) was taken as the number of days from calving to successful conception.

Data Analysis
Genetic parameters were estimated using the sire model whereby the variance component was partitioned into sire and environmental variance; this was done using variance component procedure of SAS (2000). The fitted sire model was as follows

$Y_{ij}= \mu + \alpha_i + e_{ij}$

Where:

Y_{ij} = records of milk and fertility characteristics of progeny of each sire

μ= overall mean

α_i = random effect of the ith sire

e_{ij} = the uncorrelated environmental and genetic deviations attributed to individual cows within each sire group.

The heritability (h^2) of the traits was estimated using sire component variance method as describe by Cameron (1997).

$$h^2 = \frac{4\sigma_s^2}{\sigma_s^2 + \sigma_e^2}$$

Where, σ_s^2 = sire variance; σ_e^2 = error variance.

Results and Discussion

The decline in the female fertility over the years has led to prolonged days to first insemination (DFI), delays in resumption of ovarian activity, additional percentage non-return rate 56 days after first insemination (NRR56). Therefore, genetic improvement in female fertility is an important issue in dairy cattle breeding. However, the heritability estimates of fertility traits are very low. In the present study, estimates of heritability (h^2) for fertility traits were low and ranged from 0.014 to 0.035 (Table 1). This indicates that the fertility traits are largely influences by management and environmental factors. Thus, it is difficult to improve the fertility of the dairy cows through direct selection, unless moderate to highly correlated and heritable traits are used as indicator or correlated traits (Berry *et al.,* 2003; Sun *et al.,* 2010; Alphonsus *et al.,* 2014b). The h^2 estimates for milk production traits in this study ranged from 0.226 to 0.329, while the genetic correlation between fertility and milk production traits was moderate except for non-return rate (NRR56) which was very low. These estimates of genetic parameters suggest that milk production traits could be used as correlated traits for fertility evaluation. Therefore, genetic evaluation of fertility in dairy cows can be improvement using milk production traits. The moderate h^2 of milk production traits agreed with other previous studies (Pryce *et al.,* 2001; Kadarmideen *et al.,* 2000; Sun *et al.,* 2010)

The magnitude and direction of the estimated genetic correlation coefficients between milk yield and fertility traits (Table 2) suggested that cows selected for high milk yield may have prolong interval to insemination after calving (DFI= 0.435) due to delay in resumption of ovarian activity (DO = 0.485) and may require high number of insemination per conception (NIC = 0.299) and therefore, are not likely to become pregnant within 56 days after the first insemination (NRR56 = -0.044). This antagonistic relationship between milk yield and fertility is related to higher energy utilization from the mammary gland in early lactation to sustain elevated production, leading to an amended hormonal and metabolic profile, which in turn exerts a negative effect on ovulation rates, estrous behavior, and embryo establishment (Veerkamp, *et al.,* 2003). Previous experiments that compared animals of high and low genetic merit for milk production came to a consensus that increased genetic merit for milk production is associated with reduced fertility (Kelm *et al.,* 1997; Pryce *et al.,* 1999; Alphonsus *et al*., 2014a). Likewise, Pryce and Veerkamp (2001) reported that the genetic correlation between fertility and milk production is unfavourable. Cows with high milk yield production generally conceive later during lactation (Roche *et al.,* 2007). Genetically, the antagonistic relationship between the milk yield and fertility traits could probably be as a result of pleiotropic gene effect between the milk and fertility traits, whereby the genes that affect the milk yield also influenced the fertility traits.

Table 1: Additive genetic variance (σ^2_s), residual variance (σ^2_e) and heritability (h^2) estimates for fertility traits using univariate sire model on the whole data set

Items	Fertility traits			
	DFI	DO	NIC	NRR56
σ^2_s	63.48	1572.80	0.0067	0.0023
σ^2_e	18360.20	53510.10	1.1081	0.264
h^2	0.014	0.029	0.024	0.035

DFI = days to first insemination, DO = days open, NRR56 = non-return rate 56 after first insemination, NIC= number of insemination per conception, GL= gestation length

Table 2 : Additive genetic variance (σ^2_s), residual variance (σ^2_e) and heritability (h^2) estimates for milk yield traits using univariate sire model on the whole data set

Items	Milk yield and milk composition traits				
	TMY	MFY	MPY	MFC	MPC
σ^2_s	29.518	34.107	31.919	0.004315	0.002573
σ^2_e	344.193	381.224	366.891	0.07214	0.12113
h^2	0.316	0.329	0.320	0.226	0.279

IMY = initial milk yield, ADY = peak yield, PY= peak yield, TMY = total milk yield, LL= lactation length, MFC= milk fat content, MPC=milk protein content, MLC= milk lactation content

Table 3: Genetic and phenotypic correlations between milk production and fertility traits using bivariate sire model on whole data set

Milk composition variables	Fertility traits			
	DFI	DO	NI	NRR56
Genetic correlation				
Total milk yield	0.435	0.485	0.299	-0.044
Milk fat yield	0.401	0.415	0.206	-0.043
Milk protein yield	0.459	0.424	0.316	-0.095
Milk fat content	0.290	0.216	0.197	-0.044
Milk protein content	-0.252	-0.207	-0.114	0.096
Phenotypic correlation				
Total milk yield	0.191	0.235	0.134	-0.010
Milk fat yield	0.141	0.166	0.096	-0.009
Milk protein yield	0.209	0.154	0.136	-0.005
Milk fat content	0.101	0.120	0.009	0.001
Milk protein content	-0.113	-0.105	-0.018	0.003

DFI=days to first insemination, DO=days open, NI=number of inseminations per conception, NRR56= non-return rate within 56 days of insemination

Estimated genetic correlation between fertility and milk composition yield (MFY, MPY) were also unfavourable; the ability of the cow to conceive within 56 days from the first insemination (NRR56) might decrease as milk fat and protein yield increased (-0.043 and –0.095 for MFY and MPY, respectively). Similarly, estimated genetic correlation between DFI and milk composition yield suggested that high milk composition yield is associated with longer interval to first insemination DFI (r_g = 0.401 and 0.453 , respectively for MFY and MPY) and higher number of insemination before conception NIC(r_g = 0.206 and 0.316, respectively, for MFY and MPY). The estimated phenotypic correlations between the fertility and milk composition traits were however, smaller in magnitude than the genetic correlations but had a similar direction of relationship.

The genetic correlation between milk fat content (MFC) and fertility of dairy cows in early lactation was unfavourable; high MFC in early lactation is associated with poor fertility, decreased conception rate to first services (DFI = 0.290), prolong calving to conception interval (DO = 0.216) and increased number of service per conception (NIC= -0.197).

However, the estimates of genetic correlations between milk protein content (MPC) and the fertility traits were favourable; cows with high milk protein in early lactation are likely to have shorter intervals to first insemination after calving (DFI = - 0.290), with high probability of first insemination conception rate (NIC = -0.114) and thus, are likely to become pregnant within 56 days after first insemination (NRR56 = 0.096). Therefore, high milk protein content in early lactation is associated with high fertility, while low MPC is associated with poor fertility. However, high milk fat content or low milk protein content during early lactation does not cause poor fertility; the results are telling us that there is simply an association between the two, whereby cows with high MFC or low MPC during early lactation are likely to have poor fertility.

Studies have shown that cows with a higher milk protein percentage in early lactation had substantially better reproductive performance and that the relationship between milk protein percentage and fertility was stronger during early lactation (Morton, 2000 Fahey *et al.,* 2003). Hence, a positive relationship between milk protein percentage and reproductive performance exists. Phenotypically, milk protein percentage has been reported to be a good indicator of fertility (Fahey *et al.,* 2003; Harris and Pryce, 2004; Alphonsus *et al.,* 2014b).

Conclusion

The genetic and phenotypic correlations sufficiently explain the general magnitude and direction of the relationship between milk production and fertility traits. There is a close relationship between milk composition yield and fertility, such that increase milk yield and composition yield is associated with lower fertility of dairy cows, decrease conception rate, prolong calving to conception interval and increase number of insemination per conception.

The heritability estimates and the magnitude of the genetic correlations between milk production traits suggested that milk composition traits can be used as indicator traits for reproductive performance in dairy cows.

Acknowledgements

We wish to acknowledge the valuable contribution of the staffs of Dairy Research Program, National Animal Production Research Institute (NAPRI), Shika Zaria, who assisted in the collection of data and Edward Adegbe of Food Science and Technology Laboratory of Institute for Agricultural Research (IAR), Ahmadu Bello University (ABU), Zaria, Nigeria, who analyzed the milk composition.

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