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Authors' contributions

Author ORO designed the study. Author BO proofread the manuscript. Author OMA performed the statistical analysis. Author OA wrote the protocol. Author LU wrote the first draft of the manuscript. Author BSP managed the literature searches. Author HYA managed the data collection. All authors read and approved the final manuscript.

GENETIC PARAMETER ESTIMATES FOR MILK YIELD, UDDER AND BODY CONFORMATION TRAITS OF JERSEY CATTLE IN THE NEW DERIVED GUINEA SAVANNAH ZONE OF NIGERIA

Abstract

Despite the huge potential of utilizing Jersey cattle as dairy animals in the tropical countries, the genetic basis of the relationship between milk yield and conformation traits has been scarcely described in the literature especially in Africa. This trial therefore set a layout to estimate the additive genetic correlations, heritabilities and repeatabilities of milk, udder and conformation traits for Jersey cattle in the derived guinea savannah zone of Nigeria. Our study used a total of 4200 lactation records for milk yield and udder traits of Jersey cows. The milk and conformation data was analysed by fitting and solving a multiple trait animal model solutions using average information restricted maximum likelihood algorithm. Traits with high moderate to high heritabilities and repeatabilities estimates were milk yield (0.35; 0.53), body condition score (0.25; 0.31), chest ligament (0.72; 0.75), chest width (0.23; 0.28), body depth (0.61; 0.65), udder circumference (0.44; 0.45), rear udder height (0.38; 0.41), rear udder width (0.52; 0.63) and teat length (0.34; 0.40). Milk yield had the highest additive genetic correlation with body weight (0.86). We concluded that the heritability was high enough to consider the traits in selection programs. The high additive genetic correlation between milk yield and bodyweight in the derived Guinea Savannah Zone of Nigeria

36 validates the need to considering bodyweight in selection to improve milk yield of Jersey
37 cattle born in Nigeria.

38 **Keywords: Jersey, Udder, Aireml, Milk Yield, Conformation traits**

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40 **1. Introduction**

41 The improvement of cattle for milk production in Africa through selective breeding had been
42 successful through the exploitation of additive genetic variance in the population. Jersey
43 cattle had been extensively used for crossbreeding in Africa due to their high level of
44 adaptability and robust coping strategy to the tropical climate. In Africa, milk volume has
45 been the most important breeding objective, with minimal emphasis on functional traits [1].
46 The functional plan for genetic improvement of milk had relied solely on the use of imported
47 semen from high merit sires and the importation of pregnant heifers from the United States,
48 Germany and the Netherlands [2]. [3] found genetic correlation of near zero between
49 bodyweight and milk yield in Jersey cattle in Tunisia. Several researchers [3, 4, 5] had
50 reported low to high heritability estimates for milk yield in Jersey cattle in tropical and
51 temperate countries. [6] reported heritability estimate of 0.17 to 0.36 for milk yield in Jersey
52 cattle while permanent environmental effect ranged from 0.13 to 0.17 . In response to the
53 quest for protein sufficiency in Nigeria due to population explosion, there is a need to
54 establishing an effective and robust breeding program for improvement of milk yield from
55 adapted temperate and tropical dairy cattle. Therefore, this study aim to estimate the genetic
56 parameters for milk yield and biometric traits for genetic improvement of milk yield in Jersey
57 cattle born in Nigeria.

58

59 **2.0 Materials and Methods**

60 The database of Farm 10 purebred Jersey cattle production was assessed for pedigree
61 information of the biometric traits of 1080 cows born between 2009 and 2014. The number of
62 Jersey cows with records was 1080 with 3047 animals in the genetic relationship matrix. Cow
63 were sired by 12 bulls in a random mating and artificial insemination techniques. The
64 variable milk yield was adjusted for 305 days lactation length using multiplicative correction
65 factors [8]. Lactation records in the database were analysed to clean up the outliers detected
66 from short or extended lactations. Four thousand and two hundred (4200) lactations were
67 used after cleaning the data for animals who met the criteria of maintaining consistency in
68 subsequent lactations which was fed multiple trait animal model and solved using average
69 information restricted maximum likelihood algorithm. The variable body weight was
70 measured directly by placing the cows on the weighing bridge and was expressed in kilogram
71 (kg). The body conformation (chest ligament, chest width, body depth, stature, rump width
72 and heart girth) and udder (udder clearance, rear udder height, rear udder width and teat
73 length) traits were all measured in centimeters using flexible tape calibrated for cattle
74 measurement [9].

75 **2.1 Statistical analysis**

76 Milk yield and conformation traits were modeled as repeated measures across lactations. The
77 model used [10] was:

$$78 \quad y = Xb + Wpe + Za + e$$

79 where y are the vector of observations for milk yield and conformation traits across the
80 lactations; b = vector of fixed effects (herd, number of calving, and season). pe = vector of
81 random environmental effect that is permanent; a = vector of random animal effects; e =
82 vector of random residual effects; X , W , and Z = incidence matrices that establish
83 relationships between the records and the effects. The model assumed that random and
84 residual effects are independently distributed with mean zero and constant variance σ_e^2 , σ_a^2 ,

85 respectively. The convergence iterations and statistical analysis were done in python 3.7.1
 86 environment to estimate the heritabilities, repeatabilities and genetic correlations.

87

88 3.0 Results and Discussion

89 The fat corrected milk yield of Jersey cattle had a moderate (0.35) heritability with high
 90 repeatability estimates of 57% (Table 1). The estimate of heritability (35 %) in milk yield
 91 obtained for Jersey cows was within the range of 30-35 % under low and high input
 92 production system [12] but higher than the 30 % reported by [13] when the parity were
 93 pooled for genetic parameter estimation in Zimbabwe but lower to heritabilities and
 94 repeatabilities estimates of 0.54, 0.56 and 0.36, 0.38 for milk yield in Zimbabwean Jersey
 95 cows, respectively as reported by [14] and [15]. The differences between our estimates and
 96 the estimate obtained by [15] might be consequence of different data cleaning and statistical
 97 model. However, our heritabilities were slightly higher than those reported by [15] in Jersey
 98 cattle population in a subtropical environment. However, the most heritable type trait was CL
 99 (0.72) while BW (0.02) had the least heritability estimate. The repeatabilities estimate of
 100 linear type traits varied between 0.03 (BW) to 0.75 (CL) for body conformation traits. The
 101 low to high heritabilities (2-72 %) for conformation traits were within the range reported by
 102 several researchers [16, 17] in dairy cattle. Body conformation traits had positive, significant
 103 ($P < 0.05$) correlations with 305 d fat corrected milk yield. The environmental correlations was
 104 recorded between CL and BD (0.90) which implies that both chest ligament and body depth
 105 are driven by similar environmental factors.

Table 1: Heritability (diagonal), repeatability (*R*), genetic (above diagonal) and environmental correlations (below diagonal) of milk yield and body conformation traits in Jersey cattle

Traits	Milk yield	BW	BCS	CL	CW	BD	ST	Rump	HG
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Milk yield	0.35	0.86*	0.21*	0.42*	0.70*	0.67*	0.65*	0.69*	0.52*
BW (kg)	0.01	0.02	0.04	0.36*	-0.33*	-0.68*	0.71*	0.43*	-0.39*
BCS (cm)	0.05	-0.09	0.25	-0.34*	0.79*	0.23*	0.99*	-0.39*	0.53*
CL (cm)	-0.02	0.48*	0.64*	0.72	0.67*	0.64*	0.48*	0.37*	0.14
CW (cm)	-0.03	-0.05	-0.03	0.77*	0.23	0.10	-0.36*	-0.37*	-0.14
BD (cm)	0.38*	0.53*	0.56*	0.90*	0.81*	0.61	0.98*	0.87*	0.96*
ST(cm)	0.35*	0.27*	0.83*	0.73*	-0.17	-0.37*	0.12	0.95*	0.77*
Rump(cm)	0.01	0.05	0.77*	0.68*	-0.25*	-0.38*	0.08	0.04	0.02
HG(cm)	0.25*	0.26*	0.54*	-0.16	0.74*	0.65*	0.06	0.08	0.09
R	0.57	0.03	0.31	0.75	0.28	0.65	0.18	0.05	0.14

106 BW-Bodyweight, BCS-Body condition score, CL-Chest ligament, CW-Chest width, BD-Body depth, ST-
107 stature, HG-Heart girth. *-p<0.05

108 Table 2 shows that udder conformation traits had positive and significant correlations with fat
109 corrected milk yield. Udder conformation traits showed positive, significant (P<0.05)
110 moderate to high correlation with fat corrected milk yield. This implies that improvement of
111 udder conformation will cause a corresponding increase in milk production which agreed
112 with the report of [16, 17]. The strongest and positive genetic correlations for within udder
113 conformation traits was between TL and RUH (0.93). Environmental correlations among
114 udder conformation traits were weak with the exception of TL and RUH (0.22) and TL and
115 RUW (-0.22) which were positive, negative, with moderate associations. Moderate to high
116 repeatability estimates for milk yield, body condition score, chest length, chest width, body
117 depth, hearth girth, rear udder height and width were implicated with low variability within
118 lactations; implying that all the measurements taken on the body conformation traits were
119 closely related to bone structure of the cows. The positive genetic correlation between milk
120 yield and TL suggest that correlated responses from selection on milk yield would result in
121 longer teat length probably due to the prolonged effect of milking.

122 Table-2

Heritability (diagonal), repeatability (*R*), genetic (above diagonal) and environmental correlations (below diagonal) of fat corrected milk yield and udder conformation traits in Jersey cattle

Traits	Milk yield	UC	RUH	RUW	TL
Milk yield	0.35	0.29*	0.42*	0.10	0.34
UC (cm)	0.56*	0.44	-0.03	0.34*	0.42*
RUH(cm)	0.64*	-0.03	0.38	-0.28*	-0.81*
RUW(cm)	0.94*	-0.09	-0.14	0.52	0.93*
TL (cm)	0.34*	0.14	0.22*	-0.20*	0.34
R	0.57	0.45	0.41	0.63	0.40

UC-Udder circumference, RUH-Rear udder height, RUW-Rear udder width, TL-Teat length, *-p<0.05

4.0 CONCLUSIONS

Milk yield, body condition score, chest ligament, chest width, body depth, udder circumference, rear udder height, rear udder width and teat length were genetically determined which suggest strong signature for improvement in any of these traits when modeled with milk yield in the selection index program. Our study also detected strong genetic correlation between milk yield and conformation traits estimated in the present study, which reignite the importance of including conformation traits most especially body weight in dairy breeding programs for Jersey cattle.

6.0 References

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