Journal Homepage: -www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI:10.21474/IJAR01/7011
DOI URL: http://dx.doi.org/10.21474/IJAR01/7011

RESEARCH ARTICLE

EFFECT OF HERD, AGE, PARITY AND STAGE OF LACTATION ON MILK PRODUCTION TRAITS IN INDIGENOUS BORGOU CATTLE BREED IN BENIN.

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Manuscript Info

Manuscript History

Received: 01 March 2018
Final Accepted: 03 April 2018
Published: May 2018

Keywords:-
Milk production traits, Indigenous, Borgou, Breed, Benin.

Abstract

Borgou cattle breed represent more than 50 % of cattle population in Benin. However, there is very little data on the variation of their major milk components. The aim of this study was to assess the effect of herd, age, parity and stage of lactation on milk production traits in Borgou cattle breed. A total of 95 Borgou cows in lactation were included in the study and the contents of major milk components were determined using MilkoScan FT 6000 Series mid-range infrared Fourier transform infrared-based spectrometers. Results showed that, differences in test-day milk, protein and fat yields ($P<0.01$), milk urea nitrogen % ($P<0.001$) and lactose % ($P<0.05$) were observed between herds. The Borgou cows of 3-5 years old presented higher test-day fat yield (44.32 vs 33.95 g, $P<0.05$) and higher protein yields (34.63 vs 30.05 g, $P<0.05$) than the Borgou cows of more than 5 years old. The cows on second parity presented higher test-day milk (1.12 kg; $P<0.05$) and protein yields (38.14 g, $P<0.05$) than cows on first and third or more parity. However, the lactation stage did not show significant effect on milk production traits in Borgou cattle breed ($P>0.05$). The test-day milk yield showed negative correlation with protein content (-0.233, $P<0.05$) and positive correlations with test-day fat yield (0.676, $P<0.001$) and test-day protein yield (0.809, $P<0.001$). The fat content showed positive and moderate correlations ($P<0.001$) with protein content (0.495) and negative correlation with lactose content (-0.379). The findings from this study will be taken into consideration when designing a breeding program to improve milk production traits in indigenous Borgou cattle breed in Benin.

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Introduction:-

The cattle population of Benin was estimated at approximately 2.3 million head in 2016 (FAOSTAT, 2018). The cattle population consists mainly of indigenous *Bos taurus* cattle breeds namely, Borgou, Somba, N'dama, and Lagune and *Bos indicus* namely, M'bororo, Gudali and White Fulani (DAGRIS, 2018). Borgou cattle breed represents more than 50 % of the total cattle population in Benin (MAEP, 2007). However, the herds are not able to guarantee the full coverage of the milk needs of the human population because of the low productivity of animals (Youssao et al., 2009).

The current policy on agricultural development of Benin has mainly focused on increasing milk and meat production (PAFILAV, 2010). Raw milk produced in Benin is consumed at household level and mostly processed into yoghurt, curds and traditional cheese known as *Wagashi*. *Wagashi* is a rich nutritional cheese produced by women and is the most consumed among the dairy products in Benin (Aïssi et al., 2009).

The milk consumption in Benin was estimated to 11.2 kg/capita/year lower than 30.2 kg recorded in sub-Saharan Africa (FAOSTAT, 2013). Consequently, the importation of milk and dairy products is increasing annually and was reported to have increased from approximately USD 17 million in 2003 to approximately USD 24 million in 2013 (FAOSTAT, 2018). Previous studies in Benin have focused on cattle breeding system (Assani et al., 2016), pathologies challenging cow milk production (Koutinhouin et al., 2003; Farougou et al., 2006), growth genetic parameters in Borgou cattle breed (Youssao et al., 2007), nutritional value of Borgou cattle meat (Salifou et al., 2013) as well as the evaluation of milk production in Borgou and White Fulani cattle breeds (Kassa et al., 2016). However, there is no study on the effect of non genetic factors on major milk component in Borgou, the main indigenous cattle breed of the country. Furthermore, it's known that calving season, parity number, production system, lactation stage etc… are major factors that affect the milk production and composition in cattle (Bucholtz and Johnson, 2007). Considering the importance of cow milk in Benin and the critical deficit in milk and dairy products, it is necessary to understand the non genetic factors that affect the milk yield as well as the major milk components in order to take corrective measures. The aim of this study was therefore to assess the effect of herd, age, parity and stage of lactation on test-day milk yield and major milk components in indigenous Borgou cattle breed. The findings from the study will serve as basis of development of a breeding program taking into consideration the studied non genetic factors.

Materials and methods:-

Animal Selection and Sampling Sites:-

The Borgou cattle are derived from crossing between *Bos taurus* and *Bos indicus*. The horns are medium in size and the face profile is flat. The body weight is between 200kg and 250kg and sometimes more. The coat is usually white, gray and sometimes piebald (Figure 1).

A total of 95 Borgou indigenous cattle breed in lactation were sampled in this study between May-July 2016 during the rainy season. The animals were sampled from state owned farms (Betecoucou, Okpara and Samiondji) and privately owned farms in Benin. Figure 2 shows locations where the sampling was conducted. It was critical that the government farms were included in the sampling because they are centers of conservation of the indigenous Borgou cattle breed. The feeding system adopted in all the farms we obtained samples from was natural grazing without concentrate supplementation. The cows were milked once a day in the morning. The sample collection procedures were in accordance with the ethical standards and were approved by the Livestock Research Subdivision in Benin. Additional meta data on sampled cows obtained from the livestock keepers and herders following a written consent permitting sampling included: herd, age, lactation stage (days in milking) and parity number. The stage of lactation or days in milking (DIM) was separated in three intervals as DIM <100 days (early lactation), DIM from 100 to 200 days (mid lactation) and DIM >200 days (late lactation) (Kgwatalala et al., 2009).

Milk Sampling:-

Milk samples were obtained from three to ten cows per herd from a total of 12 herds. Milk samples were aseptically collected into 50ml falcon tubes each containing one tablet of Bonopol milk preservative (Systems Plus, Canada) and sent to Valacta laboratories (Valacta Laboratories Inc., Canada, www.valacta.com) for the analysis of milk components. The sampling day milk yield was recorded for each cow using a 20 kg weighing scale.

Milk Component Analysis:-
Test-day milk fat, protein, milk urea nitrogen and lactose contents were determined in milk samples with MilkoScan FT 6000 Series mid-range infrared Fourier transform infrared-based spectrometers (Foss, Hillerod, Denmark) by Valacta Laboratories. The test-day protein and fat yields were determined by multiplying the test-day protein and fat percentages respectively with the test-day milk yield.

Statistical Analysis:-
To investigate the effect of Herd, age, parity and stage of lactation on milk production traits, the dataset was analyzed with IBM SPSS version 20 software package. The following linear model was used:
$Y_{ijklm} = \mu + H_i + A_j + P_k + DIM_l + e_{ijklm}$ in which Y_{ijklm} is the dependent variable i.e. value of each trait (Protein%, lactose%, fat%, milk urea nitrogen mg/dl, test-day milk yield (Kg), test-day protein yield (g) and test-day fat yield (g)), μ is the population mean, Hi is the fixed effect of Herd, A_j is the fixed effect of age, P_k is the fixed effect of Parity number, DIM_l is the fixed effect of days in lactation and e_{ijklm} is the random residual term. The means were compared paired using the t-test. The Pearson correlation indices were calculated among the various milk traits using the IBM SPSS version 20 software package. Significance was declared at $p<0.05$.

Results:-

Effect of Herd and Age on Milk Production Traits in Borgou Cattle Breed:-
The variation of milk production traits between herds in Borgou cattle breed is presented in Table 1**.** Significant differences in test-day milk, protein and fat yields ($P<0.01$), milk urea nitrogen % ($P<0.001$) and lactose % ($P<0.05$) were observed between herds (Table 1). The test-day milk yield ranged from 0.2 kg in herd 2 to 1.8 kg in herd 11. The highest milk urea nitrogen was observed in herd 11 (14.2 mg/dl) and the lowest in herd 12 (3.6 mg/dl). The highest lactose content (4.9 %) was observed in herd 6 and herd 9 while the lowest lactose content (4.1 %) was observed in herd 10 (Table 1). The highest test-day fat and protein yields were respectively 68.8 g and 61.1 g and were observed in herd 11 while the lowest test-day fat and protein yields were 20.3 g and 15.3 g respectively and observed in herd 2 **(**Table 1**)**.

The Table 2 presents the effect of age on milk production traits in Borgou cattle breed. The Borgou cows of 3-5 years old presented higher test-day fat yield (44.32 vs 33.95 g, $P<0.05$) and higher protein yields (34.63 vs 30.05, $P<0.05$) than the Borgou cows of more than 5 years old (Table 2). However, no significant effect of age was observed on test-day milk yield, fat, protein, milk urea nitrogen and lactose contents ($P>0.05$).

Effect of Parity and Stage of Lactation on Milk Production Traits:-
The effect of parity on milk production traits in Borgou cattle breed is presented in Table 3**.** The cows on second parity presented higher (1.12 kg; $P<0.05$) test-day milk and protein yields (38.14 g, $P<0.05$) than cows on first and third or more parity (Table 3). However, no significant difference was observed for test-day milk and protein yields between the cows on first parity and those on third and more parity ($P>0.05$). On the other hand, the parity number did not show any significant effect on fat, protein, milk urea nitrogen and lactose contents (Table 3).

The effect of the stage of lactation on milk production traits is presented in Table 4. The lactation stage did not show significant effect on milk production traits in Borgou cattle breed ($P>0.05$). However, the lowest milk yield (0.84 kg/d) was observed at early lactation while the highest values (0.90 and 0.94 kg/d) were observed at mid and late lactation respectively. The highest fat content (5.35%) was observed in late lactation and the lowest (4.07%) at mid lactation. The highest protein content (4.02%) was observed at late lactation while the lowest was observed at early lactation (3.55 %). For the milk urea nitrogen content, the highest value was observed at early lactation (11.34 mg/dl) and the lowest at mid lactation (9.53 mg/dl). The highest (4.58%) and lowest (4.35%) lactose contents were observed at early and late lactation respectively (Table 4).

Phenotypic Correlations:-
The phenotypic correlations between milk production traits are presented in Table 5. The test-day milk yield showed significantly ($P<0.05$) negative correlation with protein content (-0.233) and positive correlations with test-day fat yield (0.676, $P<0.001$) and test-day protein yield (0.809, $P<0.001$). The fat content showed positive and moderate correlations ($P<0.001$) with protein content (0.495), test-day fat yield (0.477) and negative correlation with lactose content (-0.379). The test-day fat yield showed high significant and positive correlation (0.841, $P<0.001$) with test-day protein yield.

Discussion:-

This study investigated for the first time the effect of non genetic factors such as herd, age, parity and stage of lactation on test-day milk yield and major milk components in indigenous Borgou cattle breed in Benin. Thus, high variability was observed between herds for milk urea nitrogen content, lactose content, test-day milk, protein and fat yields in Borgou. The effect of herd on cow milk components has been reported in many studies (Jílek et al., 2006; Stocco et al., 2016). The variability of milk components between herds may be attributed to the differences in day-to-day herd's management. High variability of milk urea nitrogen between herds was reported in Czech Holstein cows (Jílek et al., 2006). Milk urea nitrogen corresponds to the portion of milk non protein nitrogen and is an indicator of the amount of degradable protein in the rumen (Gustafsson and Palmquist, 1993). High levels of milk urea nitrogen in milk indicate an imbalance between the cow's intake of protein and energy and this may affect feed cost, fertility, production efficiency and the environments (Jonker et al., 2002).

In the current study, there was no significant effect of age on test-day milk yield, fat, protein, milk urea nitrogen and lactose contents. This is not in agreement with previous studies which showed that the milk protein content was significantly lower in young Holstein cows than adult cows (Gurmessa and Melaku, 2012; Pratap et al., 2014). On the other hand, Pratap et al. (2014) found no significant difference between age groups for fat and lactose contents which is similar to the results from the present study.

The present study showed that the cows on second parity presented higher test-day milk and protein yields than the cows on other parities. However, it was reported that Korean Holstein dairy cows showed the highest milk yield at the third lactation (Vijayakumar et al., 2017). This difference in results may be explained by differences in breed. The test-day milk yield observed in Borgou breed in the present study increased from first to second lactation (0.84-1.12 kg) and decreased to 0.82 kg from the third lactation. The effect of parity number on daily milk yield was reported in Borgou, N'Dama and Girolando cows in Benin (Gbangboché and Alkoiret, 2011; Alkoiret et al., 2011). At the Okpara breeding farm in Benin, it was reported that the daily milk yield in Borgou cattle breed increased from first lactation (0.4 l) to the fifth lactation (1.1 l) (Gbangboché and Alkoiret, 2011). Similarly, the daily milk yield in indigenous N'Dama cattle breed varied from 0.5 l to 1 l for first and fifth lactation respectively and decreased to 0.6 l at the sixth lactation (Gbangboché and Alkoiret, 2011). Another study in Girolando cattle breed in Benin showed that the daily milk yield increased from first lactation (5.9 to 6.14 l) to the third lactation (8.43 to 8.74 l) and decreased thereafter to 7.79 l in the seventh lactation (Alkoiret et al., 2011). In the current study, the parity number did not show any significant effect on fat, protein and lactose contents. Similar results were reported in Holstein Friesian cows (Gurmessa and Melaku, 2012; Pratap et al., 2014). The stage of lactation did not significantly affect the test-day milk yield and milk component in this study. However, the fat content was higher in early and late lactation than mid lactation. This is in agreement with previous studies showing that milk fat contents was lower at mid lactation compared to early and late lactation in Holstein-Friesian cows (Stoop et al., 2009; Gurmessa and Melaku, 2012; Pratap et al., 2014). However, Bohmanova et al. (2009) found that milk fat content was especially lower at late lactation in Canadian Holstein cows.

Correlations are very important in selection where selection of one trait can alter the other trait with which a negative genetic correlation exists. In the present study, the test-day milk yield was negatively correlated to protein content (-0.233). Similar correlation was reported between milk yield and milk protein (-0.23) in Nigerian White Fulani (Ndubueze et al., 2006). This implies that an increase in daily milk yield will lead to a decrease in protein content. Moreover, the positive phenotypic correlation between fat and protein content (0.495) was in agreement with the study of Sourabh et al. (2017).

Studied animals were raised in the traditional system on natural grazing without concentrate supplementation and the sampling was done at the same period eliminating the effect of season. Except the effect of herd, age and parity number, the observed variation between major milk components could also be due to the composition of the forage consumed by the cows on natural grazing. It's important to highlight that the forage species and variety, climate and stage of growth are important factors that affect composition of forage (Kalač and Samková, 2010; Salifou et al., 2013) and can therefore affect the milk composition of the cows.

Table 1:- Effect of herd on milk production traits in Borgou (Mean±SE)

	Herds												
Traits	1	2	3	4	5	6	7	8	9	10	11	12	P-Value
Test-day milk yield (kg)	0.8±0.1	0.2±0.2	1.1±0.8	0.8±0.2	1±0.5	0.8±0.3	0.8±0.2	0.6±0.2	1±0.2	1±0.24	1.8±0.2	0.8±0.3	<0.001***
Fat (%)	4.5±0.6	4.7±0.6	4.1±0.7	3.7±0.7	5.2±1.9	4.3±1.7	5.0±0.7	4.8±0.7	4.7±0.1	5.3±0.10	3.7±0.7	6.4±1.2	0.852
Protein %	3.9±0.8	3.7±0.2	3.7±0.2	3.5±0.2	4.1±0.6	3.4±0.4	3.7±0.2	3.7±0.2	3.6±0.3	3.3±0.30	3.5±0.2	5±0.4	0.066
Milk urea nitrogen (mg/dl)	7.2±0.7	11.3±0.8	9.0±0.9	9.5±0.9	10.3±2.5	10.3±1.7	11.7±0.9	11.4±0.9	12.6±1.3	9.9±1.3	14.2±0.9	3.6±1.6	<0.001***
Lactose (%)	4.3±0.1	4.5±0.10	4.4±0.10	4.5±0.1	4.6±0.3	4.9±0.9	4.4±0.1	4.4±0.1	4.9±0.14	4.1±0.2	4.6±0.1	4.2±0.2	0.017*
Test-day fat yield (g)	32.7±6.5	20.3±7.4	46.9±1.7	30.7±8.2	42.6±22.5	35.6±13.8	33.6±7.9	26.4±8.0	49.5±11.2	50.2±11.4	68.8±8.1	44.9±13.8	0.003**
Test-day protein yield (g)	28.1±3.5	15.3±3.9	38±4.01	28.3±4.3	33.9±11.9	27.2±7.3	25.9±4.12	20.7±4.2	42.7±5.9	28.8±6.04	61.1±4.3	35.9±7.3	<0.001***

* P<0.05; ** P<0.01; *** P<0.001. SE: Standard Error

Table 2:- Effect of age on milk production traits in Borgou cattle breed

	Borgou				
	3-5 years (47)		6+ years (48)		
Trait	Mean	SE	Mean	SE	P-value
Test-day milk yield (kg)	0.95	0.08	0.79	0.08	0.466
Fat (%)	4.54	0.32	4.39	0.31	0.174
Protein %	3.7	0.1	3.76	0.1	0.261
Milk urea nitrogen (mg/dl)	10.11	0.43	10.45	0.42	0.328
Lactose (%)	4.50	0.05	4.46	0.05	0.176
Test-day fat yield (g)	44.32	3.76	33.95	3.69	0.047*
Test-day protein yield (g)	34.63	1.99	30.05	1.95	0.024*

* P<0.05. SE: Standard Error

Table 3:-Effect of parity on milk production traits in Borgou cattle breed

	Borgou						
	Parity 1 (24)		Parity 2 (16)		Parity 3+ (55)		
Trait	Mean	SE	Mean	SE	Mean	SE	P-value
Test-day milk yield (kg)	0.84^{a}	0.11	1.12^{b}	0.14	0.82^{a}	0.08	0.016*
Fat (%)	4.89	0.44	4.642	0.54	4.14	0.30	0.888
Protein %	3.81	0.14	3.631	0.17	3.70	0.09	0.412
Milk urea nitrogen (mg/dl)	10.6	0.59	9.678	0.73	10.2	0.40	0.182
Lactose (%)	4.54	0.07	4.4	0.08	4.49	0.05	0.084
Test-day fat yield (g)	42.4	5.20	50.4	6.46	34.7	3.58	0.155
Test-day protein yield (g)	30.95^{a}	2.74	38.14^{b}	3.41	31.96^{a}	1.89	0.010*

* P<0.05. SE: Standard Error. Means with different superscript letters in the same row differ significantly.

Table 4:-Effect of stage of lactation on milk production traits in Borgou cattle breed

	Borgou						
	Early lactation (29)		Mid lactation (38)		Late lactation (28)		
Trait	Mean	SE	Mean	SE	Mean	SE	P-value
Test-day milk yield (kg)	0.84	0.11	0.90	0.09	0.94	0.11	0.618
Fat (%)	4.24	0.41	4.07	0.35	5.35	0.44	0.095
Protein %	3.55	0.13	3.65	0.11	4.02	0.14	0.096
Milk urea nitrogen (mg/dl)	11.34	0.56	9.53	0.47	9.80	0.59	0.222
Lactose (%)	4.58	0.06	4.50	0.05	4.35	0.07	0.236
Test-day fat yield (g)	40.66	4.91	39.40	4.16	41.64	5.23	0.986
Test-day protein yield (g)	34.01	2.59	32.55	2.20	32.05	2.76	0.323

SE: Standard Error.

Table 5:-Phenotypic coefficient of correlations (Pearson) between milk production traits

Trait	TDMY (kg)	Fat %	Protein%	Urea (mg/dl)	Lactose%	TDFY (g)	TDPY (g)
TDMY[1] (kg)	1	-0.086	-0.233*	0.022	-0.006	0.676***	0.809***
Fat %		1	0.495***	-0.073	-0.379***	0.477***	0.061
Protein %			1	-0.158	-0.124	0.021	-0.029
Urea (mg/dl)				1	0.169	-0.030	0.007
Lactose %					1	-0.152	0.041
TDFY[2] (g)						1	0.841***
TDPY[3] (g)							1

* P<0.05; *** P<0.001. [1]TDMY=Test-day milk yield; [2]TDFY: Test-day fat yield; [3]TDPY= Test-day protein yield.

Figure 1:-Borgou cattle breed of Benin (Houaga, 2016)

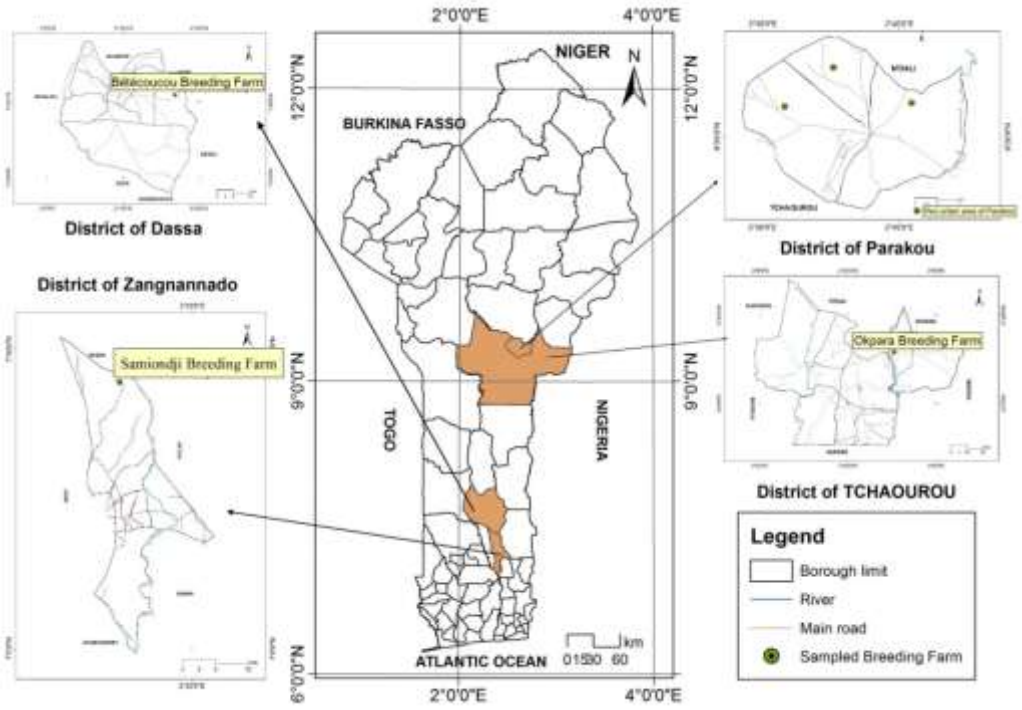

Figure 2:-Map of Benin indicating the sampling sites.

Conclusion:-

This study presented for the first time the effect of herd, age, parity and stage of lactation on major milk components in indigenous Borgou cattle breed in Benin. The herd showed significant effect on the test-day milk, protein and fat yields, milk urea nitrogen and lactose contents. The Borgou cows of 3-5 years old presented higher test-day fat yield and higher protein yields than the Borgou cows of more than 5 years old. The cows on second parity presented higher test-day milk and protein yields than cows on other parity. However, the stage of lactation did not show significant effect on test-day milk yield and major milk component. This study highlighted the effect of non genetic factors on milk production which will be taken into consideration when designing a breeding program in indigenous Borgou cattle breed in Benin. However, further study on a large population of Borgou cattle breed will be needed to

better understand the specific herd management factors that explain the variation of milk production in order to take corrective measures.

Declarations:-

Acknowledgments:-

This study was supported by the Pan African University Institute of Basic Sciences, Technology and Innovation (PAUSTI) based at Jomo-Kenyatta University of Agriculture and Technology (JKUAT), Kenya. The authors are grateful to Dr Eveline M. Ibeagha-Awemu and Mr Roger Ekuh-Ngwese for facilitating the milk sample shipping to Valacta Laboratories in Canada.

Conflict of interest:-

The authors declare no conflict of interest

Ethical approval:-

This Manuscript does not report studies involving human participants, human data or human tissue. The use of animals and sample collection procedures were in accordance with the ethical standards and were approved by the Livestock Research Subdivision (LRS) ethics committee in Benin. The farmers gave a written consent prior to milk sample collection.

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