Trop Anim Health Prod (2010) 42:349–356
DOI 10.1007/s11250-009-9425-5

Milk yield and lactation length of Ghana Sanga and its crosses with the Friesian Raised under agropastoral system

K. A. Darfour-Oduro · E. T. Sottie · B. A. Hagan · S. A. Okantah

Accepted: 11 August 2009 / Published online: 23 August 2009

Abstract Milk yield traits and lactation length of two breeds of cattle raised on natural pasture with little or no supplementation were assessed. A total of 42 573 daily milk records on 98 Friesian-Sanga cows collected over a period of 10 years and 17 790 daily milk records on 72 Sanga cows spanning a 6-year period were used in the study. Traits examined for each breed were daily milk yield, total milk yield, 305-day milk yield, 305-day milk yield/day and lactation length. Friesian-Sanga cows outperformed their Sanga counterparts in all traits studied. Friesian-Sanga cows had an average daily milk yield of 1.35±0.00 kg; average total milk yield of 266±12 kg; average 305-day milk yield of 339±10 kg; average 305-day milk yield/ day of 1.11±0.03 kg and mean lactation length of 201.1±6.9 days. Average values for Sanga cows were 1.01±0.00 kg as daily milk yield; 162±12 kg as total milk yield; 244±10 kg as 305-day milk yield; 0.80±0.03 kg as 305-day milk yield/day. Mean lactation length for Sanga cows was 164.1±9.4 days. Season of calving significantly ($P<0.05$) influenced daily milk yield of Friesian-Sanga cows and all traits of Sanga cows with animals calving in the major rainy season surpassing those that calved in the minor and dry seasons. Daily milk yield for both Friesian-Sanga and Sanga cows was significantly ($P<0.05$) influenced by season of lactation. Daily milk yield gradually declined from second parity towards the sixth parity for Friesian-Sanga cows. A gradual increase in daily milk yield from first to third parity was observed in Sanga cows. Year of calving significantly influenced all traits for both breeds. Genetic improvement in milk yield traits and lactation length is achievable for both breeds of cattle as co-efficient of variation of traits were moderate to high.

Keywords Cattle · Friesian-Sanga cattle · Ghana · Lactation length · Milk yield · Sanga cattle

Abbreviations

DMY	Daily milk yield
TMY	Total milk yield
305-dayMY	305-day milk yield
305-dayMY/D	305-day milk yield/day
LL	Lactation length
CSIR-ARI	Animal Research Institute of the Council for Scientific and Industrial Research Institute

K. A. Darfour-Oduro (✉) · E. T. Sottie · B. A. Hagan · S. A. Okantah
CSIR-Animal Research Institute,
P.O. Box AH 20, Achimota, Ghana
e-mail: kazanze@yahoo.co.uk

Introduction

The dairy industry in Ghana is underdeveloped (Okantah et al. 2005). Among the factors accounting

for the poor performance of the industry is inherently low milk producing indigenous cattle and poor nutrition and management practices the animals are exposed to (Aboagye 2002). The main production system under which cattle are raised in Ghana is agropastoralism, an extensive system with little or no supplementary feeding (Bekura et al. 1991).

Selections within indigenous breeds and cross-breeding of indigenous breeds with exotic breeds have been some strategies evolved to improve milk production of indigenous cattle in developing countries. Of the two, the latter has been the method of choice as the former requires large-scale milk and pedigree recording which is most often absent in developing countries. Crossbreeding seeks to combine the adaptive characteristics of indigenous breeds and the high milk production ability of the exotic breeds.

Towards the late 1980s, the Animal Research Institute of the Council for Scientific and Industrial Research (CSIR-ARI) of Ghana embarked on series of crossbreeding of exotic Friesian and local cattle to evolve a dual-purpose breed for use on the Accra Plains. Ten Sanga cows were sent to Amrahia Dairy Farm in 1989 where they were kept and mated with acclimatized Friesian bulls. In subsequent years Friesian semen was used for breeding. The F1 progeny were inter-mated at Katamanso station of ARI to produce the Friesian-Sanga cross breed. Currently the Institute maintains two breeds of cattle at Katamanso namely the Sanga and the Friesian-Sanga crossbred on natural pasture. There is paucity of information on milk yield of these two breeds and factors that influence it. Aside its importance in effective management of production (Mukasa-Mugerwa et al. 1992), analysis of factors that affect production traits makes clear factors which obscure genetic variation in performance of animals (Lewer et al. 1983).

The objectives of this study were to evaluate milk yield and lactation length of Friesian-Sanga crossbred and Sanga cows and investigate the effect of some non genetic factors on these traits.

Materials and methods

Location and management of cattle herds

The study was based on data from milk records of two herds of cattle comprising the Sanga and Friesian-Sanga crossbred kept at the CSIR-ARI on the Accra Plains of Ghana. The area has a bimodal rainfall pattern with a major wet season occurring from April to July and a minor season from September to November. The remaining months constitute the dry period (Fig. 1). Annual rainfall and temperature ranges between 600–1000 mm and 15–34°C respectively (Okantah et al. 2005).

The management of the animals is as described by Sottie et al. 2009. Purposely, the animals are raised under agropastoral system to acclimatize them to the management practices on the Accra Plains.

Partial milking was practised. Under this system of milking, calves were separated from their dams in the evening and were brought to suckle for a few minutes to stimulate milk let down before milking (Karikari et al. 2008). The daily milk was collected in a bowl and transferred into a measuring cylinder after which the volumetric values were converted into weight using a milk specific gravity of 1.03. Daily milk yield form the cows were recorded in a small note book and later entered in Excel.

Statistical analysis

A total of 17790 daily milk records collected from 2003 to 2008 involving 72 Sanga cows and 42573 daily milk records involving 98 Friesian-Sanga crossbred obtained from 1999 to 2008 were used. Data were analysed separately for each breed. From daily milk records, total milk yield per lactation period for each individual cow was computed. Multiplicative extension factors were then used to standardize total milk yield to 305-day milk yield. A method by Mchau and Syrstad (1991) was employed to arrive at multiplicative extension factors. Briefly,

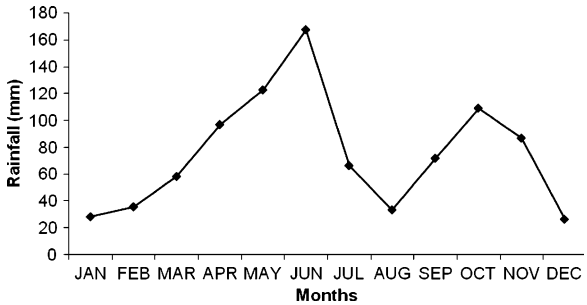

Fig. 1 Monthly rainfall distribution for 12 year- period (1997–2008) at Animal Research Institute Katamanso station

factors were derived as the ratio between the mean yield of the complete lactation (restricted to 305 days) and the cumulative yield up to the stage in question. The trait 305-day milk yield/day was obtained as the ratio between 305-day milk yield and 305 days.

The data were analysed using the Generalised Linear Model (GLM) procedure of SAS (1999). Differences among means of a trait for different factors were analyzed by PDIFF/SAS. The statistical model for daily milk yield was as follows:

$$Y_{ijkl} = \mu + S_i + L_j + P_k + e_{ijkl}$$

Where:

- Y_{ijkl} is the individual observation of daily milk yield.
- μ is the overall mean.
- S_i is the fixed effect of the ith season of calving.
- L_j is the fixed effect of the jth season of lactation.
- P_k is the fixed effect of the kth parity of dam.
- e_{ijkl} is the random error term associated with each observation.

The model below described total milk yield, 305-day milk yield, and 305-day milk yield/day and lactation length:

$$Y_{ijk} = \mu + S_i + P_j + e_{ijk}$$

Where:

- Y_{ijk} is the individual observation of total milk yield, 305-day milk yield, 305-day milk yield/day and lactation length.
- μ is the overall mean.
- S_i is the fixed effect of the ith season of calving.
- P_j is the fixed effect of the jth parity of dam.
- e_{ijk} is the random error term associated with each observation.

Results were considered statistically significant when $P<0.05$.

Results

The means and standard errors of the milk yield traits for Friesian-Sanga crossbred and Sanga cattle are presented in Tables 1 and 2 respectively. Milk yield traits and lactation length were higher in the crossbreds than the Sanga cows. Coefficient of variation for traits of Friesian-Sanga crossbred cows ranged from 41 to 65% (Table 1) while those of their Sanga counterparts ranged from 26 to 55% (Table 2). Variations within all traits in Friesian-Sanga crossbred were higher than corresponding traits in Sanga cows except for lactation length.

Season of calving

Friesian-Sanga cows that calved in the minor rainy season had the highest daily milk yield of 1.38 kg (Table 1). This was significantly ($p<0.05$) higher than the 1.34 kg obtained from cows calving in the dry season. Season of calving had no significant ($p>0.05$) influence on total milk yield, 305-day milk yield, 305 day milk yield/day and lactation length of Friesian-Sanga crossbred cows.

Season of calving had significant ($p<0.05$) effect on all milk yield traits of Sanga cows. Cows calving in the major rainy season had the highest daily milk yield, total milk yield, 305-day milk yield and 305 day-milk yield/day (Table 2). Sanga cows calving in the dry season had the highest lactation length of 179.1 days.

Season of lactation

Daily milk yield for both breeds was significantly ($p<0.05$) influenced by season of lactation of cow. Friesian-Sanga cows lactating in the major rainy season had a daily milk yield of 1.47 kg which was significantly ($p<0.05$) higher than the 1.39 kg and 1.22 kg for cows lactating in the minor and dry seasons respectively (Table 1).

Daily milk yield of Sanga cows was lowest (0.87 kg) for cows lactating in the dry season. Cows lactating in the major rainy season had the highest daily milk yield of 1.00 kg.

Parity

Parity of cows significantly ($p<0.05$) influenced daily milk yield of both breeds. Friesian-Sanga cows of second parity had the highest daily milk yield of 1.53 kg which declined along with increasing number of calving (Table 1). For the Sangas, primiparous cows gave the lowest milk yield of 0.88 kg a day while the highest yield of 1.02 kg was obtained by the third parity cows (Table 2).

Table 1 Least square means and standard error of milk yield traits of Friesian-Sanga Crossbred as influenced by season of calving, season of lactation and parity of dam

Effect	DMY (kg)		TMY (kg)		305-dayMY (kg)	305-dayMY/D (kg/day)	LL (days)
	N	$\bar{x}$± SE	N	$\bar{x}$±SE	$\bar{x}$± SE	$\bar{x}$±SE	$\bar{x}$±SE
Overall	42,573	1.35±0.00	216	266±12	339±10	1.11±0.03	201.1±6.9
CV (%)	47		65		41	41	47
Season of calving							
Dry	13,132	1.34±0.00^{b}	67	255±23	336±18	1.10±0.06	194.8±12.4
Major	18,198	1.37±0.01^{a}	92	260±21	348±17	1.14±0.05	190.8±11.3
Minor	11,243	1.38±0.01^{a}	57	246±26	336±20	1.10±0.07	185.9±14.0
Season of lactation							
Dry	18,492	1.22±0.01^{c}					
Major	11,240	1.47±0.01^{a}					
Minor	12,841	1.39±0.01^{b}					
Parity							
1	20,271	1.28±0.01^{d}	97	262±19	321±15	1.05±0.05	207.8±10.4
2	12,478	1.53±0.01^{a}	63	278±23	358±19	1.17±0.06	191.8±12.8
3	5,531	1.50±0.01^{b}	33	245±23	355±25	1.16±0.08	175.0±17.0
4	3,027	1.35±0.01^{c}	23	230±39	325±31	1.07±0.10	187.4±21.1
5	807	1.32±0.02^{cd}					
6	459	1.20±0.03^{e}					

^{abc} Means in a column with difference superscripts differ significantly ($P<0.05$), $\bar{x}$-Mean, SE-Standard error, N-Number of observations

DMY - Daily milk yield, TMY-Total milk yield, 305-dayMY- 305-day milk yield, 305-dayMY/D- 305-day milk yield/day, LL-Lactation length

Year of calving

Year of calving significantly ($P<0.05$) influenced all traits of Friesian-Sanga cows (Table 3). Daily milk yield was highest in 1999 and lowest in 2008. Lactation length, total milk yield, 305-day milk yield and 305-day milk yield/day were highest in 2000 and lowest in 2008. Generally, milk yield traits fluctuated over the years for Friesian-Sanga cows.

Daily milk yield, 305-day milk yield and 305-day milk yield/day increased gradually from 2003 to 2007 for Sanga cows (Table 4). Lactation length and total milk yield also increased from 2003 to 2006.

Phenotypic correlations

Phenotypic correlations among total milk yield, 305-day milk yield and lactation length for Friesian-Sanga cows and Sanga cows were positive and ranged from medium to high (Table 5). Correlation among lactation length and 305-day milk yield were the lowest for both breeds.

Discussion

The low milk yield of the Friesian-Sanga crossbred is arguably due to poor nutrition associated with agro-pastoral practices. Therefore improvement in nutrition of cows under agropastoral conditions would be necessary for the crossbred to express their potential for milk production.

The relatively high performance of Friesian-Sanga cows in terms of milk yield traits as compared with Sanga cattle could partly be attributed to differences in lactation lengths of the two breeds. Lactation length of Friesian-Sanga breed exceeded that of their Sanga counterparts by 37.0 days and as cows with short lactation lengths

Table 2 Least square means and standard error of milk yield traits of Sanga as influenced by season of calving, season of lactation and parity of dam

Effect	DMY (kg)		TMY (kg)		305-dayMY (kg)	305-dayMY/D (kg/day)	LL (days)
	N	$\bar{x}$±S.E	N	$\bar{x}$± S.E	$\bar{x}$±S.E	$\bar{x}$±S.E	$\bar{x}$±S.E
Overall	17,790	1.01±0.00	111	162±12	244±10	0.80±0.03	164.1±9.4
C.V (%)	46		55		26	26	48
Season of calving							
Dry	4228	$0.88±0.01^{b}$	25	$162±22^{ab}$	$228±15^{b}$	$0.75±0.05^{b}$	$179.1±19.2^{a}$
Major	10,713	$1.11±0.01^{a}$	56	$199±14^{a}$	$284±10^{a}$	$0.93±0.03^{a}$	$174.1±12.7^{a}$
Minor	2849	$0.86±0.01^{c}$	30	$105±22^{b}$	$232.±16^{b}$	$0.76±0.05^{b}$	$104.4±19.5^{b}$
Season of lactation							
Dry	6368	$0.87±0.01^{c}$					
Major	6340	$1.00±0.01^{a}$					
Minor	5082	$0.97±0.01^{b}$					
Parity							
1	8663	$0.88±0.01^{d}$	69	155±13	249±9	0.82±0.03	155.2±11.2
2	5504	$0.92±0.01^{c}$	29	130±20	233±14	0.76±0.05	139.7±17.4
3	2132	$1.02±0.01^{a}$	13	181±28	262±20	0.86±0.06	162.7±24.4
4	491	$0.98±0.02^{b}$					

^{abc} Means in a column with difference superscripts differ significantly ($P<0.05$) $\bar{x}$-Mean, SE-Standard error, N-Number of observations

DMY - Daily milk yield, TMY-Total milk yield, 305-dayMY- 305-day milk yield, 305-dayMY/D- 305-day milk yield/day, LL-Lactation length

Table 3 Least square means and standard errors of milk yield traits of Sanga-Friesian crossbred as influenced by year of lactation

Year	DMY (kg)		TMY (kg)		305-dayMY (kg)	305-dayMY/D (kg/day)	LL (days)
	N	$\bar{x}$±S.E	N	$\bar{x}$±S.E	$\bar{x}$±S.E	$\bar{x}$±S.E	$\bar{x}$±S.E
1999	2816	$1.75±0.01^{a}$	18	$352±45^{ab}$	$430±36^{a}$	$1.41±0.12^{a}$	$230.3±24.4^{abc}$
2000	3800	$1.66±0.01^{b}$	20	$373±42^{a}$	$438±33^{a}$	$1.44±0.11^{a}$	$250.5±22.6^{a}$
2001	4892	$1.26±0.01^{f}$	22	$288±39^{abcd}$	$329±31^{bc}$	$1.08±0.10^{b}$	$239.6±21.1^{ab}$
2002	5365	$1.33±0.01^{d}$	19	$308±41^{abc}$	$361±33^{ab}$	$1.18±0.11^{ab}$	$223.2±22.3^{abc}$
2003	5947	$1.25±0.01^{f}$	26	$194±36^{de}$	$247±29^{d}$	$0.81±0.09^{c}$	$186.8±19.7^{bcd}$
2004	4690	$1.19±0.01^{g}$	27	$256±34^{bcd}$	$341±27^{bc}$	$1.12±0.09^{b}$	$195.6±18.7^{abcd}$
2005	4579	$1.30±0.01^{e}$	30	$205±33^{cd}$	$322±26^{bc}$	$1.06±0.09^{b}$	$154.9±18.2^{d}$
2006	4904	$1.51±0.01^{c}$	25	$251±35^{bcd}$	$363±28^{ab}$	$1.19±0.09^{ab}$	$171.8±19.0^{cd}$
2007	3800	$1.21±0.01^{g}$	20	$241±39^{bcd}$	$322±31^{bc}$	$1.05±0.10^{b}$	$199.2±21.4^{abcd}$
2008	1780	$1.15±0.02^{h}$	9	$71±60^{e}$	$247±47^{d}$	$0.81±0.16^{c}$	$53.6±32.5^{e}$

^{abcdefgh} Means in a column with difference superscripts differ significantly ($P<0.05$) $\bar{x}$-Mean, SE-Standard error, N-Number of observations

DMY - Daily milk yield, 305-dayMY - 305-day milk yield, LL - Lactation length, TMY - Total milk yield, A305-dayDMY - 305-day milk yield/day

Table 4 Least square means and standard errors of milk yield traits of Sanga as influenced by year of lactation

Year	DMY (kg)		TMY (kg)		305-dayMY (kg)	305-dayMY/D (kg/day)	LL (days)
	N	$\bar{x}$±S.E	N	$\bar{x}$±S.E	$\bar{x}$±S.E	$\bar{x}$±S.E	$\bar{x}$±S.E
2003	535	0.52 ± 0.02^{e}	15	67 ± 31^{c}	96 ± 22^{d}	0.31 ± 0.07^{d}	107.1 ± 27.3^{b}
2004	5736	0.81 ± 0.01^{d}	36	139 ± 20^{b}	194 ± 14^{c}	0.64 ± 0.05^{c}	172.8 ± 17.3^{a}
2005	3800	1.00 ± 0.01^{c}	20	178 ± 24^{b}	262 ± 17^{b}	0.86 ± 0.05^{b}	175.0 ± 20.9^{a}
2006	2725	1.16 ± 0.01^{b}	11	260 ± 28^{a}	328 ± 20^{a}	1.08 ± 0.07^{a}	219.4 ± 24.8^{a}
2007	3816	1.19 ± 0.01^{a}	18	251 ± 22^{a}	329 ± 16^{a}	1.08 ± 0.05^{a}	207.2 ± 19.9^{a}
2008	1178	1.02 ± 0.01^{c}	11	37 ± 30^{c}	278 ± 22^{a}	0.91 ± 0.07^{ab}	33.8 ± 27.0^{b}

[abcde] Means in a column with difference superscripts differ significantly ($P<0.05$) $\bar{x}$-Mean SE-Standard error N-Number of observations

DMY - Daily milk yield 305-dayMY-305-day milk yield LL-Lactation length TMY - Total milk yield A305-dayDMY-305-day milk yield/day

are generally low producers, the relatively lower milk yields of Sanga breeds are expected. That milk production of indigenous breeds is generally lower than that of their crosses with exotic breeds especially the F1 generation is well documented (Aboagye 2002, FAO, 1987 as cited by Weller 2007).

The high variability in all traits for both breeds presents an opportunity for improvement in milk yield through genetic means. Total milk yield is the most important trait amenable to such an improvement as it had the highest coefficient of variation.

Season of calving

The current finding of a significantly high daily milk yield for Friesian-Sanga cows calving in the major and minor rainy season and in the case of Sanga cows significant high yields of daily milk yield in the major rainy season as compared with their dry season calving counterparts is in conformity with other findings in cattle (Okantah 1992; Bajwa et al. 2001). Total milk yield, 305-day milk yield and 305-day milk yield/day were highest in the major rainy season of calving for Sanga and this could be attributed to the availability of feed in this period which puts the animal in a good condition for milk production. The significantly long lactation length of Sanga cows calving in the dry season as compared with those that calved in the minor rainy season may be due to the short duration of the minor season and calvings that occur late in the dry season. Sanga cows with short lactation length in the minor season of calving could be due to the fact that they experience the dry season soon after they have calved in the minor rainy season. Sanga cows that calved late in the dry season also have most part of their lactation occurring in the major rainy season.

Table 5 Phenotypic correlations among TMY, 305-dayMY and LL for Friesian-Sanga crossbred and Sanga cattle

	TMY	305-dayMY	LL
Friesian-Sanga TMY	1.00		
305-dayMY	0.87***	1.00	
LL	0.84***	0.54***	1.00
SangaTMY	1.00		
305-dayMY	0.81***	1.00	
LL	0.90***	0.57***	1.00

***P<0.001

Season of lactation

Season of lactation affects daily milk yield through the availability of feed and its quality. In the major rainy season, natural pastures become high in biomass and with importance in nutritional value resulting in an increase in milk production in animals lactating. The converse holds for cows lactating in the dry season and hence the observed high daily milk yield of cows lactating in the major rainy season as compared with their dry season lactating counterparts in this study.

Parity

The observation that primiparous Friesian-Sanga and Sanga cows were among the worst performers in terms of daily milk yield could be attributed to the fact that the growth in the animals is still taking place and therefore nutrients are used for both body building and milk production (Bajwa et al. 2001). The average age of Friesian-Sanga and Sanga cows at first calving was 41.2 and 41.5 months respectively. Daily milk yield of Friesian-Sanga cows declined from second parity to the sixth parity. This could be due to a gradual loss of secretory tissue of the udder with increasing parity in Friesian-Sanga cows. That third parity Sanga cows had the highest daily milk corroborates the observation by Okantah (1992) that cattle in the tropics attain peak production in their third or fourth lactation.

Year of calving

Significant differences among years for milk production are usually due to changes in management, feeding regime and other environmental factors (Hatunglumukama et al. 2006). The high performance of Friesian-Sanga cows in 1999 for daily milk yield and for the rest of the traits in 2000 could partly be attributed to better management of the cows at the start of dairy work at the Institute. However, changes in the species of grass on grazing lands and infrastructural developments on pasture over the years have led to the animals travelling long distances to graze. Cows therefore tend to expend a lot of energy in acquiring food. They are also watered once a day unlike earlier years when they were watered twice daily. These might have contributed to animals producing lower milk yields over the years.

That Sanga cows experienced an increase in daily milk yield, 305-day milk yield and 305-day milk yield/day from 2003 to 2007 indicates that variations in management and environmental factors over the period did not have adverse effects on Sanga cows. Probably the Sanga cattle are better adapted to the environment.

Phenotypic correlations

High correlation between total milk yield and lactation length for Friesian-Sanga and Sanga cows indicates a close association between the two traits. Cilek and Tekin (2005) reported a much lower correlation of 0.39 between total milk yield and lactation length for Simmental cows. As 305-day milk yield is estimated from total milk yield, the high correlation between these two traits is expected. The correlation here is higher than 0.37 reported by Amimo et al. (2007) for Ayrshire cattle.

Conclusion

The crossbreeding work undertaken by the CSIR-ARI has been worthwhile as the Friesian-Sanga cattle had higher milk production than the Sangas under agropastoral practices. However, the performance of the two breeds needs improvement. The high coefficient of variation for traits of both breeds suggests the use of selection to improve these traits is possible. It is recommended that further studies should be done to improve the milk production performance of the two breeds by artificial selection. There is a need to improve the management, particularly nutrition of the crossbreds so as to support improved dairy production.

Acknowledgements We are grateful to all the members of the Ruminant Production Division of Animal Research Institute, Ghana and particularly Messrs A. Mamah, A. Alhassan and S.A. Quaye for their assistance in collecting data for this study.

References

Aboagye, G. S., 2002. Phenotypic and genetic parameters in cattle populations in Ghana. A Review Paper presented to International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia. http://agtr.ilri.cgiar.org

Amimo, J.O., Wakhungu, J.W., Inyangala and Mosi, R.O., 2007. The effects of non-genetic factors and estimation of genetic and phenotypic parameters and trends for milk yield in Ayrshire cattle in Kenya. *Livestock Research for Rural Development*. Volume 19, Article #13. Retrieved January 8, 2009 from http://www.cipav.org.co/lrrd/lrrd19/1/amim19013.htm

Bajwa, I. R., Khan, M. S., Khan, M. A. and Gondal, K. Z., 2001. Environmental factors affecting milk yield and lactation length in Sahiwal cattle. *Pakistan Veterinary Journal* (Abstract).

Bekura, S., de Leeuw, P.N., Grandin, B.E. and Neate, P.J.H. (eds.) 1991. Maasai herding: An analysis of livestock production systems of Maasai pastoralists in Eastern Kajiado District, Kenya. ILCA Systems Study 4. ILCA

(International Livestock Centre for Africa), Addis Ababa, Ethiopia. 172 pp

Cilek, S. and Tekin, M. E., 2005. Environmental Factors Affecting Milk Yield and Fertility Traits of Simmental Cows Raised at the Kazora State Farm and Phenotypic correlations between these traits. *Turkish Journal of Veterinary and Animal Science*.**29**, 987–993.

Hatunglumukama, G., Idrissa, D. S., Leroy, R. and Detilleux, J., 2006. Effects of non-genetic and crossbreeding factors on daily milk yields of Ayrshire x (Sahiwal x Ankole) cows in Mahwa station. *Livestock Science*, **110**, 111–117.

Karikari, P. K., Asare, K., and S. A. Okantah., 2008. The Economic feasibility of concentrate supplementation of lactating Sanga cows grazing natural pasture in the dry season. *Livestock Research for Rural Develpoment*. Volume 20, Article # 203. Retrieved December 9, 2008 from http://www.lrrd.org/lrrd20/12/kari20203htm

Lewer, A. P. Rae, A. L. and Wickham, G. A., 1983. Analyses of records of Perendale Flock. III. Estimates of environmental effects on productive traits of mature ewes. *New Zealand Journal of Agricultural Research* **26**, 303–307

Mchau, K. W. and Syrstad, O., 1991. Production characteristics of Mpwapwa cattle. 2. Shape of lactation curve. *World Animal Review*, **66**, 49–54

Mukasa-Mugerwa, E., Mutiga, E. R. and Girma, A., 1992. Studies on the reproductive performance of Ethiopian sheep by means of Enzyme Immunoassay Technique. Review. *Reproduction, Fertility and Development* **4**, 523–532

Oddoye, E.O.K., Amaning-Kwarteng, K., Fleischer, J.E. and Awotwi, E.K., 2002. Response of cattle to dry season supplementation of urea-ammoniated rice straw or untreated rice straw fed with *Griffonia simplicifolia* or wheat bran. *Bulletin of Animal Health and Production in Africa*. **50**, 96–105

Okantah, S. A., 1992. Partial milking of cattle in smallholder herds on the Accra Plains. Some factors affecting daily milk yield and milk composition. *Animal Production*. **54**, 15–21

Okantah, S. A. Obese, F. Y. Oddoye, E. O. K. Karikari, P. K. Gyawu, P. and Bryant, M. J., 2005. The effect of farm (herd) and season of calving on the reproductive performance of Sanga cows in smallholder peri-urban dairy farms in the Accra Plains. *Ghana Journal of Agricultural Science*. **1**, 37-42

SAS, 1999. Statistical Analysis Systems. SAS for Windows, Release 8.01 (1999–2000) SAS Institute Inc., Cary, NC.

Sottie, E.Y, Darfour-Oduro, K.A. and Okantah, S.A., 2009. Comparative studies on growth traits of Sanga and Friesian-Sanga cross bred calves raised on natural pasture on the Accra Plains of Ghana. *Tropical Animal Health and Production*: **41**, 321–328

Weller, J.I., 2007. Marker assisted selection in dairy cattle. In: E.P. Guimaraes, J. Ruana, B.D. Scherf, A. Sonnino and J. D. Dargie (eds), Marker-assisted selection- Current status and future perspectives in crops, livestock, forestry and fish. (FAO). 199–228