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Diversifying Rural Livestock Production by the Introduction of Holstein Friesian on Zero Grazing for Rural Dairy Production, Employment, Poverty Alleviation and Food Security in the Tropics

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ABSTRACT

The review was conducted from studies/reports of the performance of Holstein Friesian routinely kept by Heifer Project International (HPI) Farmer groups on imported Holstein Friesian herds on zero grazing in the western highland region of Cameroon. The review provides insight to the reports of the studied area, its climatic conditions, management of the animals and the methodology adopted by the researchers. Their findings and recommendations were also highlighted in order to inform policy makers and agencies with the responsibility to design programmes for rural development and youth empowment in tropical countries, the potentials of this technology to alleviate poverty, hunger, rural-urban migration and unemployment. The mean age at first calving was higher compared to other reports. The additive genetic variance of the sire that sired the dam of the heifer, the breeding techniques of maintaining a central bull for several farmers and other management techniques employed elongated age at first calving. Calving interval and calf birth weight were appreciable, though longer and lower respectively compared to existing reports. They were greatly affected by the management techniques employed by the farmers. The mean gestation length was low despite the poor management indicating that, this breed with improved management can be integrated into the tropical conditions. The percentage calf mortalities were very high. It varied across herd, indicating that there was no standard routine management practice adopted at the herds locations. The herd with better management recorded lower calf mortality. The effect of calf mortality rate on calf crop and selection for genetic improvement were worse and also varied across herds. In some herds, all the heifers produced must be retained to maintain herd size. In other herds the cow must calve many times before it is able to produce a heifer, that would replace it and lactate in the herd. The higher the number of calving that produced a lactating heifer, the longer the generation interval, and the lower the genetic progress achieved through selection when generation intervals are elongated. The genotypic diversity created through independent assortment, segregation and recombination of genes as random effects through gametogenesis and fertilization, respectively were lost to calf mortality and never presented to the environmental challenges of the tropics for selection and adaptation. Superior genotypes that could have tolerated the tropical condition were never exposed to build physiological mechanism that would help them cope with tropical stress. The few genotypes that survived, were introduced into the stressful conditions of the tropics often too early and sudden with no time to allow them develop and build their survival techniques to enhance their adaptation in the tropics. There were high incidences of disease prevalence which also varied across herds, locations, type of bedding materials used and floor type in the housing. There was no housing design directed towards herd health as participating farmers erect structures they can afford. This was why calf mortality rate were very high. The calves are being introduced into an already diseased hazard environment without adequate time to develop their own defence mechanisms. The survival of some calves, reproductive performance of the herd and their lactation thus indicate that, this breed can be integrated into the tropical conditions. There is however, need for interested countries and agencies to design a low cost housing type and insist that, their potential beneficiaries must provide this housing and adequate feed from the zero grazing plots first before they acquire their animals. Mud floor must be replaced with laterite floor for easy drainage of urine and water. This will improve herd health, introduce calves into the challenging tropical stress gradually and allow them enough time to build their body defence against prevalent diseases. There is also the need to reduce the number of farmers attached to a central bull, to ensure that all heifers attached to a bull have successful services.

***Keywords*:** Adaptation, calf-mortality, disease-prevalence, Holstein Friesian, performance, selection, zero grazing, rural dairy production, food security

1. INTRODUCTION

The challenge to achieve food security for all is greater now than ever with one out of six people in the world unevenly been underfed (Hammond and Leicth, 1995). This thus necessitates the need to increase substantially production of food and thus livestock productivity to meet the ever increasing demands.

In the tropics, and most developing countries, several efforts to increase livestock production has been through breeding strategies and policies that encouraged the introduction and breeding of exotic temperate breeds (Stetshwaelo and Adebambo, 1992). These imported exotic breeds were either maintained at research stations or institutional farm centres that were designed to provide comparable management at agro climatic conditions similar to their temperate environment. The advent of the down trend economy of most tropical countries made funding of these farms difficult and hence sustaining the designed management practices impracticable. These animals were thus introduced into the high stress agro ecosystems of the tropics often too rapid to allow for natural selection in order to acquire adaptive and /or productive traits for the harsh ecological conditions (Hammond and Leicth, 1995). This led to the collapse of most of the exotic herds in government farms.

There is little or no information on attempts by prospective countries to integrate these exotic breeds into their local production systems to allow the animals go through the process of natural selection in order to help them acquire adaptive and / or productive traits for the diverse ecological conditions found in their respective countries (Ailmando, 1986).

Heifer Production International (HPI), a non-governmental organization, under the "acronym" (passing on the gifts), imports live Friesian cattle into Cameroon. These animals were given to resource limited farm families for milk production under the zero grazing production system. The scheme has become so successful that, aside proving the ability of the Holstein Friesian to survive under local management in the tropics, had also generated employment opportunities to most able-bodied farmers, turn barren land that were not suitable for grain production to pasture production.

The performance of Holstein Friesian under zero grazing at the Western highland regions of Cameroon is a potential lead to the possibility that this breed can be integrated in the tropics. These animals have, over the years, acquired adaptive features for tropical conditions. It is no doubt that, aside the tropical harsh conditions, the poor management practices employed by the local farmers will often affect the productivity and calf crop of these animals. Calf mortality is of economic importance in dairy enterprise as this affects the number of calves that will survive to weaning age.

In temperate regions, calf losses due to poor management and inadequate housing facilities (James *et al*., 1984; Martin *et al*., 1975), environmental influences (Azzam *et al*., 1998) and birth weight (Johanson and Berger, 2003) are quite high. In the tropics, calf losses of Holstein Friesian herds are perhaps higher. Ogata *et al*. (1999) explained the genetic cause for the inability of a calf to survive to pre-weaning age. Thus, information on the effect of calf mortality on selection intensity and generation interval is necessary in evaluation of genetic progress of Holstein Friesian herds which are managed by local farmers in the tropics. There is dearth of information on calf survival especially of Holstein Friesian herds introduced into the highland regions of Cameroon.

This project has become a major contributor of animal protein to the total animal protein sources available to the average Cameroonian, as the high cost of meat put it above the reach of most low income earners in Cameroon (Tambi, 1991).

The scheme in addition to increasing fresh milk production in the country has generated employment opportunities. It has also led to effective utilization of crop residues and agro-industrial by-products, as well as increased living standard of most farm families.

The challenges observed and mitigation strategies to cushion the experience at the Western highland region of Cameroon are also highlighted for potential policy makers, agencies, individuals, organisations and Agricultural rural development agencies to note while adopting the technology in order to improve its efficiency.

The potentials of this technology to improve living standards, provide employment, cushion risk of crop failures and diversify rural livestock production of rural farming communities, must not be overlooked. It is, no doubt that its success at the Western highland region can be duplicated in other tropical countries with similar or even better climatic conditions than those at the highland regions of Cameroon. This technology if adopted, and responses are directed to mitigate the observed challenges, will not only provide massive jobs, but may also help in stimulating the interest of the youths in agriculture for self employment and thus arrest the mentality of job seeking.

This review intends to provide information on:

- the reproductive and dairy performance potentials of Holstein Friesian and their adaptation under harsh tropical condition and substandard management practices by local farmers
- calf mortality and its effect on selection for genetic improvement of imported Holstein Friesian herds under local farmers in tropical regions,
- prevalent diseases and factors affecting disease incidences under the existing management practices adopted under tropical conditions, and
- the potentials of the Holstein Friesian (HF) to be integrated into the rural dairy production on zero grazing.

2. LOCATION

Western highland region of Cameroon is located between latitude 5°20’ and 7° North and longitude 9°40’ and 11°10’ East of the Equator. The rainfall ranges from 1,300-3,000 mm with a mean of 2,000 mm. The minimum and maximum daily temperature means of 15.50 °C and 24.50 °C respectively. The climate is marked by dry season (November – March) and a rainy season (April – October). The region is free from tsetse flies.

One hundred and thirty-seven calving records on age at first calving, calving interval, gestation length, calf birth weight and daily lactation yield of imported Holstein Friesian in the Western highland regions of Cameroon were obtained from records routinely kept by HPI farmer groups from 1986 to 2004 (Gwaza *et al*., 2007a).

The animals were housed in houses made of dwarf mud walls, wooden walls, or cement block walls. The roofs were either thatched or made of zinc roofs. In all, the milking parlours were cemented, but the stable areas (sections) were either mud floored, or cemented or laterite on mud floored. The cow dung and used fodders are carried on wheelbarrows to pits and stable cleared. The animals were maintained on zero-grazing system where cut and carry fodders (zero grazing) are fed in the rainy season. The fodder materials were *Pennisetum purpureum*, *Brachiaria decumbens*, *Guatemala desmodium*, *Stylosanthes* spp., *Calliandra* spp, *Acacia*, cowpea leaves, groundnut leaves and haulms, sweet potato and plantain leaves. In the dry season, hay, crop residues and fresh grass got from riversides and valleys supplemented with concentrate feed compounded from cotton seed cake, corn wheat or rice bran, palm kernel cake, bone meal, salt and limestone. The concentrate feed is fed twice daily (morning and evening) and water was provided *adlibitum* (Okwori *et al*., 2007).

The animals were routinely de-wormed four times a year with Albendazol and sprayed for ecto-parasites. They were also routinely vaccinated against contagious bovine pleuro-pneumonia (CBPP), hemorrhagic septicaemia and black quarter diseases. Veriben and other antibiotics were given as prophylactic treatment at the beginning of rainy season for haemo-parasites and other bacterial infections or used to treat animals with disease symptoms. Mating of dams was done through synchronization and artificial insemination. Calving takes place in the staple area. The calf is kept in cubicles and is housed individually until they are weaned after six months of age. The calf is not allowed to suckle directly but is bucket-fed. Two or three litres of milk are given to the calf from a plastic container for the first few days; the farmer uses his finger in the plastic container to serve as dam’s teat. This is to continue until the calf is able to drink milk.

3. DATA ANALYSIS

The data generated were subjected to Analysis of Variance according to the procedure adopted by Steele and Torrie (1980). The effect of sire, dam, year and sex of calf (for birth weight) were tested at 0.01 and 0.05 per cent probability levels. The mean sum of squares was equated to their expected mean sum of squares (EMS) to estimate the variance components due to error, sire and dam (Gwaza *et al*., 2007b).

The data were unbalanced (number of progeny per sire was not equal), $K_1 \neq K_2$, thus K_1, K_2 and K_3 were estimated by the following formulas:

$$K_1 = (n.. - \Sigma_i \frac{J^{\Sigma nij2}}{n_i}) \ / \ df\ (dam) \quad \text{Becker (1992)}$$

$$K_2 = (\Sigma_I \frac{\Sigma_j n_{ij}^2}{n_i.} - \Sigma_I \frac{\Sigma_j n_{ij}^2}{N..}) \ / \ df\ (sire) \quad \text{Becker (1992)}$$

$$K_3 = (n.. - \frac{\Sigma_I n^2_{i.}}{n..}) \ / \ df\ (sires)$$

where:

- $n..$ = Total number of progeny
- $n_i.$ = Number of progeny per sire
- n_{ij} = Number of progeny per dam
- df = degrees of freedom
- K_1, K_2, K_3 = Coefficient of Variance components being estimated

Having obtained K_1 and K_2, $ó^2_w$ and $ó^2_D$ were estimated by equating MS to EMS and solving appropriately for, $ó^2_w$ and $ó^2_D$. The estimate of $ó^2_S$ was obtained as follows:

$$ó^2_S = MSS - MS_w - \frac{K_2 / K_1}{K_3} (MS_D - MS_w) \quad \text{Becker (1992)}$$

The heritability estimates due to sire and dam were estimated as follows:

$$h^2_S = \frac{2ó^2_S}{ó^2_S + ó^2_w}$$

$$h^2_D = \frac{2ó^2_D}{ó^2_D + ó^2_w}$$

The standard error (S.E) of heritability was estimated using the formula:

$$SE\{h^2_S\} = \frac{2\sqrt{2\{1-t\}^2\,[1+\{K_1-1\}\,t\,]^2}}{K_1^2\,\{n.-s\}\,\{s-1\}}$$ Becker (1992)

$$\text{and } t = \frac{\acute{O}^2_S}{\acute{O}^2_S + \acute{O}^2_w}$$ Becker (1992)

where:

t = Intra class Correlation
K_1 = Coefficient of Variance components
S = number of sires
n. = Total number of progeny

Data for calf pre-weaning mortality were transformed by the Square Root transformation method to stabilize the variates before analysis. Means of effects, which were proved significant, were compared using the Duncan Multiple Range Test as described by Steele and Torrie (1980).

Parameter estimates relevant to the effect of mortality on selection intensity for genetic improvement due to selection were estimated by deductions from the pre-weaning mortality and the post-weaning mortality of 2% for every three months to age at first calving (AFCAL) for the Friesian (Jennifer *et al*., 1982).

Procedures for the calculation of rearing proportions, number of calving to produce a lactating heifer, replacement rates and generation intervals (Gwaza *et al*., 2007b) are shown in Appendix I (Jennifer *et al*., 1982; Ehiobu and Solomon, 1998). Selection intensity was calculated from Appendix II (Becker, 1992; Goddard, 1978).

Percentage disease prevalence records were transformed through the Root Square method. The transformed data were subjected to Analysis of Variance according to the procedure adopted by Steele and Torrie (1980) to detect the effects of location, herd, disease type and floor system by bedding materials interaction on disease prevalence (Okwori *et al*., 2007). Means that were significantly different were separated using the Duncan's Multiple Range Test (DMRT).

4. PRODUCTIVITY OF GENOTYPE

Age at First Calving

The mean age at first calving was 30.88 $\pm$0.60 months (Table I). Sire and year had significant ($P < 0.05$) effect on age at first calving. The heritability estimates of Age at first calving were 0.30 $\pm$0.06 and 0.03 $\pm$0.13 due to paternal half sib (h^2_{pHS}) and maternal half sibs (h^2_{mHS}) respectively (Table II) (Gwaza *et al*., 2007a).

Table I. Productivity of Holstein Friesian under zero grazing at Western Highland regions of Cameroon.

Traits	Mean $\pm$ S.E.	
Age at first calving (months)	30.88$\pm$0.60	(49)
Gestation length (days)	270.28$\pm$5.72	(137)
Calf birth weight (Kg)	39.15$\pm$0.20	(139)
Male calf birth weight (Kg)	40.70$\pm$0.38^b	(63)
Female calf birth weight (Kg)	37.84$\pm$0.35^a	(74)
Calving interval (months)	13.31$\pm$0.30	(78)
Daily lactation yield (Kg)	14.22$\pm$0.29	(124)

Note: Values in parenthesis are number of observations
a, b : Figures with different superscript(s) down the group are significantly different at P < 0.05
(Source: Gwaza *et al*., 2007a)

Gestation Length:

The mean gestation length was 270.28 $\pm$5.72 days (Table I). Sire and year significantly (P < 0.05) affected gestation length. Dam had no effect at (P < 0.05) on gestation length. The paternal and maternal half sibs heritability estimates were 0.34 $\pm$0.03 and 0.4 $\pm$0.12 respectively for gestation length (Table II) (Gwaza *et al*., 2007a; 2007b).

Table II. Heritability estimates due to Sire and Dam of age at first calving, calf birth weight, calving interval, Daily lactation yield and gestation length of Holstein Friesian on zero grazing.

Traits	$h^2_S \pm$ S.E.	$h^2_D \pm$ S.E.
Age at first calving	0.30$\pm$0.06	0.03$\pm$0.13
Birth weight of calves	0.09$\pm$0.09	0.02$\pm$0.02
Calving interval	0.02$\pm$0.14	0.01$\pm$0.08
Daily lactation yield	0.42$\pm$0.04	0.04$\pm$0.14
Gestation length	0.34$\pm$0.03	0.04$\pm$0.12

Note: h^2_S = Paternal half sib heritability
h^2_D = Maternal half sib heritability
S.E. = Standard error of heritability estimates.
(Source: Gwaza *et al*., 2007a)

Calving Interval:

The mean calving interval was 13.31 ±0.50 months (Table I). Year significantly ($P < 0.05$) affected calving interval. Sire and Dam had no effect ($P > 0.05$) on calving interval. The paternal half sib (h^2_S) and maternal half sib (h^2_D) heritability estimates for calving interval were 0.02 ±0.14 and 0.01 ±0.08 respectively (Table II).

Calf Birth Weight:

The birth weight of calves ranged from 28kg to 50 kg. The mean birth weight for all calves was 39.15 ±0.20 kg (Table I). The mean birth weight of male and female calves were 40.70 ±0.38 and 37.89 ±0.35 respectively. Sex, year of calving and Sire of calf significantly ($P < 0.05$) affected calf birth weight. The heritability estimates due to Sire (h^2_S) and Dam (h^2_D) were 0.09 ±0.09 and 0.02 ±0.02 respectively for calf birth weight.

Daily Lactation Yield:

The mean daily milk yield was 14.22 ±0.29 per day (TableI). Sire, dam and year of calving had significant ($P < 0.05$) effect on daily lactation yield. The heritability estimates due to Sire (h^2_S) and dam (h^2_D) were 0.42 ±0.04 and 0.04 ±0.14 respectively (Table II) for daily lactation yield.

Age at first calving

The mean age at first calving observed in Table I is higher than 28.80 months reported by Knudsen and Sohael (1970) for imported Friesian heifers at Vom. The result however compares favourably with 30.90 months also reported by Knudsen and Sohael (1970) for Vom bred Friesians. The high age at first calving observed here may be related to relatively poor management of the imported Friesians at Western highland regions of Cameroon.

Sire had significant ($P < 0.05$) effect on age at first calving in this result.Mrode and Akinokun (1986) however did not record significant effect of Sire on age at first calving. The heritability estimates due to sire (h^2_S) and dam (h^2_D) on age at first calving were 0.30 ±0.06 and 0.03 ±0.13 respectively (Gwaza *et al*., 2007a). These estimates agree with 0.29 heritability due to sire reported by Rege *et al*. (1992) for Sahiwal cattle. The significant effect and moderate heritability estimates due to sire on this trait implies that, there is a contribution from the genes to the observed phenotype. Thus, improvement on this trait can be achieved by a good selection programme combined with appropriate breeding systems. Effect of year was significantly ($P < 0.05$) on age at first calving. Mrode and Akinokun (1986), Oyedipe *et al*. (1982) also reported significant effect of year on age at first calving. The significant effect of year on age at first calving is an indication of the influence of the environment on this trait. Thus, the observed performance here is greatly linked to the management practices adopted and other climatic stress affecting the herd. Hence, there should be concerted efforts to improve the feeding and nutrient profile of feeds offered to the animals, housing, disease prevention and management in order to improve on age at first calving.

Gestation length

The mean gestation length of 270.28 ±5.72 days (Gwaza *et al*., 2007a) in this result is lower but close to 278.40 days reported by Osei *et al*. (2004) for the same breed. Sire had a significant (P <0.05) effect on gestation length in this result. This agrees with the report of Brakel *et al*. (1952), Joubert (1961) who reported significant effect of sire on gestation length in Holstein Friesian and South African Friesian cattle respectively. This indicates the contribution of the genes to the observed gestation length.

The heritability estimates due to sire on gestation length of 0.34 ±0.03 (Gwaza *et al*., 2007a) agrees with 0.32 ±0.83 reported by Singha and Singh (1958). Wheat and Riggs (1958) reported 0.22 ±0.50 heritability estimate due to dam higher than 0.04 ±0.12 obtained in this result. The lower estimate obtained in this study may have arisen from common maternal and environmental effects due to dam.

The moderate heritability estimate due to sire on gestation length means that the animals genotype also influences the gestation length. Thus selection for this trait will lead to an improvement in gestation length.

Calving Interval:

The mean calving interval (13.13 ±0.50 months) (399 days) (Gwaza *et al*., 2007a) observed here is higher than 12.29 months and 11.74 months reported by Knudsen and Sohael (1970); Mbap and Ngere (1988) respectively for imported Friesian at Vom. The high calving interval obtained here may be related to varied management practices and other environmental stress that could affect the animals return to oestrus, heat detection, serving and conception at the

Western highland regions of Cameroon.

Year effect significantly affected calving interval in this result. Oyedipe *et al*. (1982) also reported significant effect of year on calving interval. The significant effect of year on calving interval show that there is a high contribution of the environment to the observed calving interval. Thus, poor management and other environmental stress may affect calving interval. Dam effect was also significant (P < 0.05) on calving interval. Mbap (1996) also reported significant effect of dam on calving interval. The heritability estimates due to sire (h^2_S) and dam (h^2_D) on calving interval were 0.02 ±0.14 and 0.01 ±0.08 respectively (Gwaza *et al*., 2007a). Akinokun (1970) also reported heritability estimate due to sire of 0.12 ±0.11 for N'dama cattle. Mrode and Akinokun (1986) also reported low heritability estimates of 0.28 ±0.80 for White Fulani cattle. The low heritability estimates on calving interval indicate little genetic contribution to this trait. Thus, the significant effect of dam on calving interval may be due to maternal effects and common environmental factors due to dam like early return to oestrus, oestrus detection and servicing which are non genetic but may affect calving interval.

Birth weight:

The mean birth weight of calves (39.15 ±0.20kg) observed in this study (Gwaza *et al*., 2007a) is higher than that reported by Mbap and Ngere (1988); Mrode (1988). The higher birth weight observed here might be related to the influence of the genotype on birth weight which is consistent even under poor management.

Year had a significant (P < 0.05) effect on birth weight of calves. This was also noted by Ehoche (1992). This is an indication of the effect of management practices, housing, disease prevention and management, feeding and nutrient content of feed offered to the animals during gestation. Significant effect of sex of calf was also apparent in this result. Male and female calves weighed 40.70 ±0.38 and 37.84 ±0.35 kg at birth respectively. This result agrees with the report of Rachnefeed *et al*. (1980); Ehoche *et al*. (1992); Vesely and Robinson (1971) who also reported that male calves, significantly weighed heavier than female calves at birth. This observation may be due to the fact that male foetuses grow faster during gestation and will have higher weight at birth than female calves.

Effect of sire on birth weight of calves was also significant ($P < 0.05$) in this result. This was also reported by Ehoche et al. (1992) and Rachnefeed et al. (1980). The heritability estimates due to sire (h^2_S) and dam (h^2_D) in this result were low 0.09 ±0.09 and 0.02 ±0.02 respectively. Oni et al. (1989) reported heritability estimate of 0.33 for Bunaji cattle. The low heritability estimate observed in this result may have been influenced by the large error variance. However, the significant effect of sire on birth weight implies considerable genetic contribution to this trait. Appropriate selection programmes combined with good mating systems will yield good result.

Daily Lactation Yields:

The mean daily lactation yield of 14.22 ±0.29 kg (Gwaza *et al*., 2007a) recorded in this study, is lower than 16.47 ±0.46 kg reported by Knudsen and Sohael (1970) for the same breed at Vom. The lower value obtained here could have been influenced by varied management practices. This is supported by the significant ($P < 0.05$) effect of year observed in this study. Mrode (1988) also reported significant year effect on daily lactation yields of White Fulani cattle.

Sire effect was significant ($P < 0.05$) on daily lactation yield in this study. Knudsen and Sohael (1970) also observed significant effect of sire on daily lactation yields. The heritability estimate due to sire was 0.42 ±0.04 on this trait. The significant effect of sire coupled with the high heritability estimate due to sire point to the fact that, a though, the bull does not produce milk, it contributes genetically to the daily performance of the cow offspring. Consequently, adequate selective measures should therefore be taken for selecting a breeding bull in dairy herds for economic productivity.

The effect of dam was also significant ($P < 0.05$) in this result. Bailey and Booster (1954) also reported significant effect of dam on daily lactation yield. The heritability estimates due to dam was 0.04 ±0.14 on this trait. The significant effect of the dam on this trait while recording low h^2_D seems to indicate that aside the dam genotypic effect, other maternal effects like dams body condition, nutritional status, age of dam at calving and other common maternal environmental factors which are non genetic but affect the dams daily milk yield. This considerable attention should be given to the dam after each lactation before rebreeding it.

Application of Heritability Estimate to Selection for Genetic Improvement and Adaptation of Holstein Friesian in the Tropics.

The application of heritability estimate to the low herds through selection for genetic improvement will also increase the tolerance level of the breeds to environmental challenges of the tropics. Applying heritability estimates to selection on the following performance indices will be a welcome effort.

Age at First Calving

The heritability estimates due to sire (h^2s) moderate (0.30 $\pm$0.06). This indicated that selecting superior sires as heifers dam, sires will greatly shorten age at first calving. If this is combined effectively with appropriate breeding system with due regards to factors that allow the heifer to attain target weight early, this trait will be improved and improve the adaptation of Holstein Freisian cows on zero grazing in the tropics.

Birth Weight of Calves

The heritability estimates due to sire and dam were low (0.09 $\pm$0.09, and 0.02 $\pm$0.02) respectively. This implied that environmental factors like nutrition, dam's body condition during gestation, fitness and health status of the dam exert greater influence on this trait and must be given proper attention in order to improve on this trait. There is need to train the farmers to use simple but standard management techniques during gestation to improve calf birth weight. This will allow the calves to develop immunity to the tropical challenges and become fit, stabilized and adapted to the tropical conditions.

Calving Interval

The heritability estimates due to sire and dam were 0.02 $\pm$0.14 and 0.01 $\pm$0.08 respectively. These low heritability estimates indicated that family selection must be applied to the cow herd in order to improve calving interval. The environment of the animal also exerted significant effect on calving interval. There is therefore, need to employ techniques that improves the herd environment and management practices. Family selection alone will effect low selection response because of the high environmental influence on the trait.

Daily Lactation Yield

The heritability estimates due to sire and dam were 0.42 $\pm$0.04 and 0.04 $\pm$0.14 respectively. The high heritability estimates due to sire indicated that the sire exert greater effect on the dairy performance of is heifer. Selecting superior sires as breeding bulls will significantly improve dairy performance of their heifers.

The low heritability estimates due to type, other non genetic factors of maternal effect like the dam's body condition, udder conditions, health status of the dam, nutrition and management practices adopted exerted great influence on dairy performance of the dam. It is important therefore, to pay special attention to these non genetic factors affecting the dam; this will ensure that the dams are introduced into the tropical challenges slowly, to enable them build their defence mechanisms against the tropical challenges. This will improve their tolerance, adaptation to the challenges of the tropics and dairy performance under tropical conditions.

Gestation Length

The heritability estimates due to sire and dam on gestation length were 0.34 $\pm$0.03 and 0.04 $\pm$0.12 respectively (Gwaza *et al*., 2007a). The additive genetic effect of the sire enhances shorter gestation length. Selecting superior sires in this trait will greatly reduce gestation length of the dams. Maternal environment of the dam, nutrition and other management techniques that support the physiological conditions of the dam during gestation will enhance early parturition and reduced gestation length. Gwaza *et al*. (2007a) had reported significant effect of maternal effect on reproductive performance of Holstein Friesian on zero grazing in the western highland regions of Cameroon.

Calf mortality

The mean pre-weaning mortality at the five locations within the Western highland regions of Cameroon is presented in Table III. The effect of location of herd on pre-weaning mortality was highly significant ($P < 0.05$). The mean pre-weaning mortality of 22.30 ±0.20 % of Santa herd was significantly ($P < 0.05$) different from means (48.20 ±0.23 and 52.30 ±0.19%) of Fundlong and Nkwen herds respectively. It was however, not significantly ($P > 0.05$) different from means (35.11 ±0.22 and 40.20±0.21%) of Njinikong and Akum herds respectively. The means (35.11 ±0.22, 40.20 ±0.21, 48.20 ±0.23 and 53.20 ±0.19) at Nkwen, Njinikong, Fundlong and Akum herds respectively were statistically similar ($P > 0.05$) (Gwaza *et al*., 2007b).

Table III. Mean pre-weaning mortality of Holstein Friesian at Nkwen, Njinikong, Fundlong, Santa and Akum herds.

Location	Mortality ± S.E. (%)
Nkwen	53.20^{b} ± 0.19 (24)
Njinikong	35.10^{ab} ± 0.22 (18)
Fundlong	48.20^{b} ± 0.23 (17)
Santa	22.30^{a} ± 0.20 (24)
Akum	40.20^{ab} ± 0.21 (19)

a, ab: Figures with different superscript(s) down the group are significantly ($P<0.05$) different.
Figures in parenthesis are number of observations.
(Source: Gwaza *et al*., 2007b)

Effects of mortality rates on selection for genetic improvement

The summary of parameter estimates relevant to the effect of mortality on selection for genetic improvement is presented in Table IV. Parameter estimates relevant to the effect of mortality rates on genetic improvement were number of calving that produced a heifer that lactated in the herd and heifers replacement rate for the five herds studied. From these, calf and heifer rearing proportions, selection intensities and generation intervals were deducted (Table IV).

Mortality to age at first calving were 66.57, 55.47, 53.63, 37.37 and 58.68 % at Nkwen, Njinikong, Fundlong, Santa and Akum herds respectively (Table IV). Selection Intensities for the cow herd were 0.00, 0.09, 0.09, 0.45 and 0.00 in the same order from the Table (Goddard, 1978). Generation intervals for the herds are also presented in Table IV.

Table IV. Summary of parameter estimates relevant to the effect of mortality on selection for genetic improvement.

Traits	Nkwen	Njinikong	Fundlong	Santa	Akum
Mortality to age at first calving (%)	71.33	54.71	63.67	37.30	58.60
Calf rearing proportion (%)	28.67	45.29	36.30	62.70	4140
Heifer rearing proportion (%)	14.33	22.64	18.16	31.35	20.70
No. of calving to produce a lactating heifer in the herd (No.)	7.10	4.40	5.60	3.20	5.00
Heifer replacement rates (%)	154	93	125	73	124
Selection intensity (No.)	0.00	0.14	0.00	0.45	0.00
Longevity (No.)	4.62	4.75	4.48	4.39	4.02
Generation Interval (months)	125.31 (10yrs)	89.20 (7yrs)	105.50 (8.70yrs)	73.00 (6.10yrs)	97.40 (8yrs)

(Source: Gwaza *et al*., 2007b)

Calf mortality

Calf mortality is of economic importance in dairy enterprise as this affects the number of calves that will survive to weaning age. In temperate regions, calf losses due to poor management and inadequate housing facilities (James *et al*., 1984; Martin *et al*., 1975), environmental influences (Azzam *et al*., 1998) and birth weight (Johanson and Berger, 2003) are quite high. In the tropics, calf losses of Holstein Friesian herds are perhaps higher. Ogata *et al*. (1999) explained the genetic cause for the inability of a calf to survive to pre-weaning age. Thus, information on the effect of calf mortality on selection intensity and generation interval is necessary in evaluation of genetic progress of Holstein Friesian herds which are managed by local farmers in the tropics. There is dearth of information on survival especially of Holstein Friesian herds introduced into the highland regions of Cameroon.

Mortality rates differed significantly ($P < 0.05$) across the locations studied. This may imply that, there was no routine management practices adopted at these locations. The calves are therefore being exposed into the challenging tropical environment too sudden that, they have too little or no time to develop immunity that would assist them cope with the environmental stress of the tropical conditions.

A well designed management practice, routinely followed, will not only provide protection to the calves at their early fragile life, but will also introduce them gradually into the tropical environmental stress. This will provide the calves enough time to develop immunity to the common environmental challenges of the tropics. Calves exposed gradually to the tropical stress that survived to age at first calving would be better adapted to the tropical conditions than their dams. This underscores the need to adopt a uniform routine management technique at all locations that would protect the calves and expose them gradually, to allow them develop immunity for common environmental stress of the tropics.

The pre-weaning calf mortality observed in this result is higher than the report of Osei *et al*. (2004) and Stephen (2000) who reported 17.80 and 14.90 % calf mortality of tropical breeds in Ghana and Tanzania respectively. The finding of Payne (1951) of 19.70 % mortality of Friesian calves at Fiji is low compared to this report.

The high pre-weaning mortality observed in this result may be due to diseases and nutritional deficiencies arising from poor management. This is consistent with the observations of McDoweil (1972) and Rendel (1972) who reported that hostile climate, poor feeding and diseases are the major causes of calf death in the tropics.

Effect of herd location on calf mortality

The effect of location of herd on calf mortality was highly significant ($P < 0.05$). Kilfaro (1995) also reported that calf mortality varies significantly from herd to herd depending on the management practices adopted. This indicates that there is no standard routine management practice as regards quality of feed fed to the animals, sanitary conditions in the pens, disease prevention and management, the hygiene of feeding utensils and milk bucket-fed to the calves at all the locations. Perhaps this explains the varying disease incidences and calf mortality as observed at all the locations.

The mean pre-weaning mortality at Santa, Nkwen and Fundlong (Table I) were significantly ($P < 0.05$) different. Kilfaro (1995) also reported that calf mortality varies significantly ($P < 0.05$) from herds due to differences in herd management. The mean calf mortality at Santa was least (22.30 $\pm$0.02%). This could be so, because of the better feeding and health care attention given to these animals. The floor system, "cemented floor and laterite on mud" will also allow for easy drainage of urine and water. Roughages fed to the animals will be less contaminated by urine and stagnant water. The sanitary conditions in pens at Santa location will be better compared to those at Nkwen and Fundlong. Consequently, there will be less multiplication of disease causing pathogens, less disease incidence and hence lower calf mortality as observed.

Calf mortality at Nkwen was highest followed by Fundlong (Table I) where the management practices were very poor. The mud floor system will not help matters, as animals foot print will become water logged with urine, water and faeces; making drainage difficult. Hence, there will be high multiplication of disease causing organisms, high incidence of diseases, which will cause more calf death as observed in this study.

The degree of calf mortality at each location will also be influenced by nutrition, disease prevention and other management techniques. This appears to vary, as Nkwen, Akum and Njinikong on the same floor system recorded numerical differences of average calf death. The management practices were worst at Nkwen, worse at Fundlong followed by Akum respectively (Table I). Santa with the least pre-weaning mortality (22.30 $\pm$0.20 %) has the best management system in place followed by Njinikong with (35.10 $\pm$0.20 %) calf death respectively.

Effect of herd location on adaptation of Holstein Friesian on zero grazing

Mortality rates differed significantly ($P < 0.05$) across the locations studied. This may imply that there was no routine management practices adopted at these locations. The calves were therefore being exposed to the challenging tropical environment too sudden that they have too little or no time to develop immunity that would assist them cope with the environmental stress of the tropical conditions. A well designed management practice routinely followed, will not only provide protection to the calves at their early fragile life, but will also introduce them gradually into the tropical environmental stress. This will provide the calves enough immunity to the common environmental challenges of the tropics. Calves exposed gradually to the tropical stress that survived to age at first calving would be better adapted to the tropical conditions their dams. This underscores the need to adopt a routine management technique at all locations that would protect the calves and expose them gradually, to allow them develop immunity for common environmental stress of thetropics.

Effects of mortality rates on selection for genetic improvement

Mortality to age at first calving in respect of the five herds (Gwaza *et al*., 2007b) were higher than the 38 % reported by Ehiobu and Solomon (1998) for Holstein Friesian at Vom in Nigeria. The higher values obtained here may be related to high pre-weaning calf mortality arising from poor management and other environmental stress on the herds. Approximately 154, 93, 125, 73 and 124 % female calves will be available as replacement to maintain herd size at Nkwen, Njinikong, Fundlong, Santa and Akum. These are higher than the 47 % heifer replacement rate reported by Ehiobu and Solomon (1998) for Friesian herd at Vom in Nigeria.

Selecting 154, 93, 125, 73 and 124% heifers for replacement at Nkwen, Njinikong, Fundlong, Santa and Akum herds respectively gives selection intensities of 0.00, 0.14, 0.00, 0.45 and 0.00 in the same order. These are lower than 0.80 selection intensity reported by Ehiobu and Solomon (1998) in a Friesian herd at Vom in Nigeria. The lower selection intensities observed in this study could be due to the large proportion of heifers that must be retained to maintain herd size. The effect of the very low selection pressures of 0.00, 7.00, 0.00, 27.10 and 0.00 % at Nkwen, Njinikong, Fundlong, Santa and Akum herds respectively on selection intensity could be another reason for the observed low selection intensities. The larger the proportion of animals selected, or the smaller the selection pressure, the lower the selection intensity. On the other hand, the smaller the proportion of animals selected, or the larger the selection pressure, the higher the selection intensity (Gwaza *et al*., 2007b).

Effect of calf mortality rate on generation interval

The observed generation intervals of 9.10, 7.70, 7.30 and 7.90 years for Nkwen, Njinikong, Fundlong and Akum were also higher than the reports of Fall *et al*. (1982) and

Ehiobu and Solomon (1998). This is could be because the heifers rearing proportion are low (14.33, 22.64, 18.16 and 20.70) in the locations respectively. The cows at these herds will have to calve for many times before they can produce a heifer that would lactate in the herd. The higher the number of calving that produce a heifer that lactate in he herd, the higher would be the generation interval. And the longer the generation interval, the lower the selection response achieved through selection. This is further compounded when the calving interval is very high. The generation interval of the herd at Santa (6.10 years) which was the least agrees with the report of Ehiobu and Solomon (1998) who noted 6.10 years generation interval for Holstein Friesian at Vom. This could be due to the fact that, the heifers rearing proportion for Santa herd is high (31.35) and the number of calving to produce a lactating heifer in the herd is low (3.20). In general, the observed generation interval in this study is higher than 6.70 to 7 years generation length reported as normal for cattle breeds in the tropics (Fall *et al*., 1982). Again, the high number of calving before a lactating heifer could be produced along with low heifers rearing proportion caused by high pre-weaning calf mortality is responsible for this observation.

Effect of calf mortality rate on genetic improvement through selection

Genetic gain due to selection at Nkwen, Fundlong and Akum herds is not possible. The heifers replacement rates in these herds is so low that more than 100 % of the heifers produced must be retained in order to maintain herd size. It is not possible to employ selection for genetic improvement, hence the selection intensities at the three herds is 0.00. The elongated generation intervals of 10.00, 8.70 and 8.00 years further ruled out the possibility of genetic improvement through selection (Gwaza *et al*., 2007b). At Njinikong 93.00% of the heifers produced for replacement must be retained to maintain herd size. The selection pressure is so low (7.00 %). The larger the number of animals selected, the lower the selection intensity. Thus, selecting 93% of the heifers gives low selection intensities of 0.14. The low selection intensities, coupled with the effect of elongated generation intervals of 7.00 years will undo the little progress made through selection for genetic improvement. At Santa herds, 72.90 % of the heifers will be needed to maintain herd size. The number of calving that produces a heifer that lactates in the herd is low (3.20). Thus, cows in this herd will be able to produce more heifers that lactate in the herd than are needed for replacement. The selection pressure (27.10%) is high compared to the other herds. Thus, selecting 72.90% of the heifers gives a selection intensity of 0.45. The effect of generation interval of 6.10 years on selection response will also be low. Hence genetic gain due to selection can be achieved at Santa herd, because more cow calves survived to lactating age than are required for replacement. The low performing heifers (27.10%) could be culled from the herd (Gwaza *et al*., 2007b).

Effects of calf mortality rates on selection for genetic improvement on adaptation of the Friesian in the tropics

Gwaza *et al*. (2007b) observed that the effects of calf mortality rates on selection for genetic improvement indicated that, approximately 154, 93, 125, 73 and 124 percent female calves will be required as replacement in order to maintain herd size at Nkem, Njinikong, Fundlong, Santa and Akum respectively. This implied that the cows at Nkem, Fundlong and Akum will have to produce 154, 125, and 124 percent heifers in order to maintain herd size at these locations respectively. All the heifers produced must be retained in order to maintain herd size, no heifer will be rejected, and as such the selection pressures at these herds were

0.00, 0.00, and 0.00 respectively. The very low selection pressures (0.00) exerted at these herd would also give selection intensities of 0.00, 0.00, and 0.00 at these herds respectively. Thus genetic variability that was created through independent assortment of genes segregation and recombination as random effects gametogenesis and fertilization respectively, were lost to mortality and never presented to the environmental challenges of the tropics for selection and adaptation (Gwaza *et al*., 2007b). This implied that the processes of genetic improvement through adaptation of the Holstein Freisian in the tropics would be very difficult at these locations. However, improved management may reverse this trend.

At Njinikong and Santa, where the selection pressures were 7.00 and 27.00 percent respectively, with corresponding selection intensities of 0.14 and 0.45 respectively. Gwaza *et al*. (2007b) noted that genetic improvement through adaptation is possible especially at Santa herd. Giving low calf mortality, diverse genotype of Holstein Friesian would be presented to the environmental stress of tropical conditions, superior genotype would then be selected, improved and become adapted to tropical conditions. This is only possible if the calves are given maximum protection at early life and are exposed gradually to the tropical challenges through improved management, giving them adequate time to develop immunity against these challenges.

Disease prevalence and adaptation of Holstein Friesian cattle on zero grazing in the western highland regions of Cameroon

The percentage disease prevalence recorded at Nkwen, Njinikong, Fundlong, Santa and Akum herds are presented in Table V. Fundlong herd recorded the highest disease incidence (38.09%) followed by Akum with 20.24%. Nkwen and Njinikong herds both recorded 16.67%; while Santa herd recorded the least (8.33%) disease incidence (Okwori *et al*., 2007).

There was a significant effect of herd on percentage disease prevalence observed. The average percentage disease prevalence at Nkwen and Njinikong herds were statistically similar at P > 0.05), but differed significantly (P < 0.05) from those of Fundlong, Santa and Akum herds (Table V). The mean percentage disease prevalence at Fundlong, Santa and Akum herds also differed significantly (P < 0.05) (Table V) (Okwori *et al*., 2007).

Table V. Disease prevalence affecting Holstein Friesian on zero grazing at highland region of Cameroon.

Herd / Location	Mean disease prevalence $\pm$ S.E.
Nkwen	$16.67^{a} \pm 0.25$
Njinikong	$16.67^{a} \pm 0.28$
Fundlong	$38.09^{b} \pm 0.23$
Santa	$8.33^{c} \pm 0.21$
Akum	$20.24^{d} \pm 0.22$

a, b, c, d: Means followed by different superscript in the column are significantly (P < 0.05) different.
(Source: Okwori *et al*., 2007)

The prevalence of bacterial, parasitic and other diseases in all the herds are presented in Table VIA. There was more prevalence of bacterial diseases compared to parasitic and other diseases (Table VIA). The total mean percentage bacterial disease prevalence was 40.46% while parasitic and other diseases recorded 24.24% and 32.14% prevalence respectively (Table VIB).

Table VIA. Effect of location on mean percent prevalence of bacterial, parasitic and other diseases affecting Holstein Friesian at Nkwen, Njinikong, Fundlong, Santa and Akum herds.

Herds	Parasitic diseases Mean % $\pm$ S.E	Bacterial diseases Mean % $\pm$ S.E.	Other diseases Mean % $\pm$ S.E
Nkwen	$9.52^{a} \pm 0.12$	$4.76^{a} \pm 0.02$	$2.38^{a} \pm 0.11$
Njinikong	$5.95^{b} \pm 0.13$	$5.95^{a} \pm 0.18$	$4.76^{a} \pm 0.14$
Fundlong	$2.38^{c} \pm 0.16$	$13.09^{b} \pm 0.12$	$22.62^{b} \pm 2.03$
Santa	$1.19^{c} \pm 0.02$	$5.95^{a} \pm 0.12$	$1.19^{a} \pm 0.46$
Akum	$5.75^{b} \pm 0.17$	$10.71^{b} \pm 0.15$	$3.57^{a} \pm 0.20$

a, b, c : Figures with different superscript (s) down the group are significantly different at $P < 0.05$.
(Source: Okwori *et al*., 2007)

Table VIB. Effect of disease type on its prevalence at Nkwen, Njinikong, Fundlong, Santa and Akum herds.

Herd	Parasitic disease % mean $\pm$ S.E	Bacterial disease % mean $\pm$ S.E.	Other diseases % mean $\pm$ S.E.
Nkwen	$9.52^{a} \pm 0.12$	$4.76^{b} \pm 0.02$	$2.38^{b} \pm 0.11$
Njinikong	$5.95^{a} \pm 0.13$	$5.95^{a} \pm 0.18$	$4.76^{a} \pm 0.14$
Fundlong	$2.38^{a} \pm 0.16$	$13.09^{b} \pm 0.14$	$22.62^{c} \pm 2.03$
Santa	$1.19^{a} \pm 0.22$	$5.95^{b} \pm 0.31$	$1.19^{a} \pm 0.46$
Akum	$5.95^{a} \pm 0.17$	$10.71^{b} \pm 0.23$	$3.57^{a} \pm 0.20$
Total	24.99^{a}	40.46^{b}	32.14^{c}

a, b, c,: Figures with different superscript(s) along a row are significantly different at $P < 0.05$
(Source: Okwori *et al*., 2007)

Okwori *et al*. (2007) reported that the prevalence of bacterial, parasitic and other diseases varied significantly ($P<0.05$) with location of herds (Table VIA). At Nkwen, the mean prevalence of parasitic disease ($9.52 \pm 0.12\%$) varied significantly ($P < 0.05$) from 5.95

±0.13% at Njinikong. The mean prevalence of bacterial and other diseases at these two locations were however statistically similar ($P > 0.05$). At Fundlong and Santa, the mean prevalence of parasitic diseases was statistically similar ($P > 0.05$). The average prevalence of bacterial and other diseases were significantly ($P < 0.05$) different at the two locations. At Akum the prevalence of parasitic disease was statistically similar ($P > 0.05$) to that at Njinikong but differed significantly ($P < 0.05$) from others. The bacterial disease prevalence was also similar ($P > 0.05$) to that at Fundlong, but also differed significantly ($P < 0.05$) from the other locations. The prevalence of other diseases was similar ($P > 0.05$) at all locations except Fundlong (Table VIA).

The effect of disease type on its prevalence at the five herds is presented in Table VIB. At Nkwen the prevalence of parasitic diseases significantly ($P < 0.05$) differed from bacterial and other diseases prevalence. The last two were statistically similar ($P > 0.05$). The prevalence of all the disease types was statistically similar ($P > 0.05$) at Njinikong. The prevalence of all disease types varied significantly ($P < 0.05$) at Fundlong; the other diseases recorded the highest mean percent (22.62 ±2.03); while bacterial and parasitic diseases recorded 13.09 ±0.14 % and 2.38 ±0.16% respectively (Table VIB). Bacterial diseases significantly ($P < 0.05$) recorded higher incidence than parasitic and other diseases at Santa herd. The prevalence of parasitic and other diseases were statistically similar ($P > 0.05$) at Santa and Akum respectively (Table VIB).

The effect of the floor system X bedding materials interaction on disease prevalence at Nkwen, Njinikong, Fundlong, Santa and Akum herds are presented in Table VII. The mud floor X dry banana leaves / dry leaves / dry grass bedding materials interaction recorded higher incidence of all the diseases as compared to laterite on mud floor X dry banana leaves / dry grass / dry bedding materials interaction (Table VII). There was significant ($P < 0.05$) effect of floor system X bedding materials interaction on disease prevalence. The mud floor X (dry banana leaves / dry grasses) bedding materials disease prevalence significantly ($P < 0.05$) differed from the disease prevalence recorded on the laterite on mud floor X (dry leaves / banana / grasses) bedding materials interaction.

The prevalence of diseases reported at Nkwen and Njinikong were higher than the reports of Wasting *et al.* (1999). This may be due to poor infrastructures, which made it difficult to maintain strict sanitary condition in the farmhouses.

Table VII. Effect of floor system X bedding material interaction on disease prevalence at Nkwen, Njinikong, Fundlong, Santa and Akum herds.

Floor system X Bedding materials	Bacterial diseases mean ± S.E. (%)	Parasitic diseases mean ± S.E. (%)	Other diseases mean ± S.E (%)
Mud floor X dry Banana leaves / Dry leaves / dry Grasses bedding Materials	8.63^a ± 0.32 (50)	5.95^a ± 0.26 (45)	7.74^a ± 0.37 (40)

Laterite on mud Floor X dry Banana leaves / dry leaves / dry grass bedding materials	$2.55^b \pm 0.27$ (10)	$0.51^b \pm 0.32$ (9)	$0.41^b \pm 1.02$ (5)

a, b, : figures with different superscript down the group are significantly different at $P < 0.05$.
Values in parenthesis are number of observations.
(Source: Okwori *et al.*, 2007)

The farmers at these herds could reduce the disease prevalence by improving their nutritional status, maintaining low stocking rate, pay more attention to hygiene and sanitation of the houses and animals. The similarity in the prevalence of disease at the two locations also indicated that the same level of management practices was used at the two herds.

Fundlong and Akum recorded 38.09 $\pm$0.23 and 20.24 $\pm$0.22 percent disease prevalence respectively. These are high for small scale holder farms when compared to the report of Rook and Larry (1997) and Cossiv *et al*. (1995). The high values of disease prevalence here indicated very poor management practices, low nutrient profile of feeds, contaminated water source, untimely vaccination and over stocking in pens may collectively increase the susceptibility of animals to diseases. This is supported by the reports of Bellworn (1980) and Awil (1992).

The significant effect of herd on disease prevalence agrees with the report of Anzaldo *et al.* (1994) and Cohen *et al*. (1990) who reported that poor housing and management practices could promote disease prevalence which could vary significantly from herd to herd depending on the level of management adopted. The significant effect of herd on disease prevalence indicates that, there was no standard management practices adopted in rearing these animals in all the farms especially hygiene and sanitation of animals and infrastructure. Nkwen and Njinikong, which recorded 16.67 $\pm$0.25% mean disease prevalence each may be said to practise same level of management in maintaining animal health and sanitation.

Fundlong and Akum have relatively poor or low nutrient profile of feeds, poor water quality, poor hygiene and sanitary conditions and poor housing system. These poor management may increase the multiplication of disease-causing organisms. It could also increase susceptibility of animals to disease infection and hence lead to more disease outbreak. Santa recorded the least disease incidence. This may be related to the level of management of the herd as reported by Okwori *et al*. (2007).

The significant effect of location of herd on disease prevalence observed in this study agreed with the report of Payne (1985) and Brown (1986) who reported that environmental factors such as marshy areas, high temperature and humidity could facilitate the outbreak and spread of insect-borne and bacterial diseases in a location. Defra (2003) reported that poor nutrition, high stocking density, poor selection for health and poor welfare could cause inherent susceptibility to diseases and hence enhance disease outbreak in a herd at a given location.

The significant effect of parasitic bacterial and other diseases prevalent at Nkwen, Fundlong and Akum locations from Santa and Njinikong may be due the fact that they are located near cattle routes through which indigenous cattle are led to cattle markets. These herds could be infected from cut forages from the infected pasture or contaminated water. Air borne diseases could be carried easily to these herds. The reports of Anne *et al*. (2004), Payne (1985) and Carrey and Fletcheri (1985) that contact of local breeds with exotic breeds could increase disease prevalence affecting the exotic breed support this view. The variation in disease prevalence within these three locations is related to different level of management at each location. Farmers in these locations may reduce prevalence of diseases by avoiding pasture and water sources contaminated by indigenous cattle breeds. Strict hygiene and sanitation should be maintained always.

The prevalence of diseases at Santa and Njinikong locations are low although the prevalence of parasitic and other diseases at Njinikong differed significantly from that at Santa, the prevalence of bacterial diseases were statistically similar ($P > 0.05$). This may be due to that fact that Santa and Njinikong are situated away from the main cattle routes. The risk of being infected from infected pasture and contaminated water are thus minimized. At Santa, the village head banned the rearing of indigenous cattle within the village. This could further reduce the risk of disease transmission from the local breeds; hence the low disease prevalence observed.

In general, the disease prevalence observed at these two locations does not show good management. Attention should be given to hygiene and sanitary condition of herds and infrastructure in order to reduce disease prevalence.

The effect of disease type was significant ($P < 0.05$) on disease prevalence. The prevalence of bacterial diseases significantly differed from the prevalence of parasitic and other diseases. This agrees with the report of Rook and Carrey (1997), Defra (2003) who reported that poor management will lead to an increase in bacterial diseases like mastitis, foot and mouth diseases etc. The significant effect of bacterial diseases is an indicator that there is relatively poor hygiene and sanitation in all the herds. This encourages the multiplication of bacterial diseases. The significant effect of floor system by bedding materials interaction on disease prevalence was also reported by Ann *et al*. (2001) who noted that soiled and dirty bedding materials could cause high disease prevalence.

Okwori *et al.* (2007) reported that mud floor X dry banana / grass / leaves bedding materials interaction recorded higher disease incidence than laterite on mud floor by dry / banana / grass / leaves bedding materials interaction. This is understandable since muddy floor could hardly drain water and urine properly as footprints of animals will become waterlogged. The bedding materials on this floor type could be soiled and dirty either with urine or over-turned water. This could create enabling environment for multiplication of disease causing microorganisms. On the other hand, the laterite floor will easily drain water as it is more compact, hardy and less absorbent than the mud floor. The floor will thus retain less water and bedding materials on this floor will be relatively drier and less favourable for multiplication of disease causing microorganisms. This floor system by bedding materials interaction will therefore record lesser incidence of diseases as observed by Okwori *et al.* (2007).

The laterite floor will be easier to maintain than the mud floor. Farmers could therefore put a layer of laterite on the muddy floors to exploit this advantage. In general, drainages must be created properly on this floor to allow water and urine drain properly. Bedding materials must be changed and replaced daily.

Zero grazing

Zero grazing is a system of feeding ruminant and pseudo-ruminant animals whereby the animals are not allowed to go to the pasture to graze directly, rather the forage materials from the pasture are harvested and fed to the animals in their stalls

Under the zero-grazing system, cattle are confined in one place where feed and water are brought to them. Other animal husbandry activities such as animal health, are also carried out under this system.

Zero-grazing is a good system for keeping dairy cattle in densely populated, high potential areas, where land per farm family is small to allow open grazing.

Other dairy cattle rearing systems which also require housing are semi-zero grazing and free grazing. Different dairy cattle rearing systems have different requirements for housing although they share some common needs (Ibrahim, 1988).

Climatic differences between the Coastal/hot humid areas and the highland areas necessitates that there will be slight modifications of the unit depending on where the dairy cattle are reared. Thus in Coastal and hot humid conditions, more open units which allow for air circulation will be appropriate.

Generally, the main advantages of the zero-grazing system include the following:

- Cows are confined and therefore use most of the energy from feeds for growth and milk production.
- Saves land for other enterprises by allowing the use of high yielding forage crops like Napier grass (*Pennisetum purpureum*), gamba grass (*Andropogon gayanus*), ruzi grass (*Brachiaria ruziziensis*), Rhodes grass (*Chloris gayana*), kikuyu grass (*Pennisetum clandestinum*), etc.

- Enables on farm clean milk production.
- Good calf rearing is possible
- Manure can be easily collected for the benefit of fodder crops
- The animals are better protected against diseases, especially tick-borne diseases.
- Close observation of the animals is possible, making heat detection and attendance to animals easier and faster.
- The animals are kept inside which is more secure and protect them from attack by predators
- Little or no time is spent on herding the animals. Therefore labour for other farm tasks is saved.

However, there are some disadvantages which include the following:

- Much labour is required to take feed and water to the animals.
- Much capital is required for construction of a ‘zero-grazing unit.
- The possibility that animals are stressed because of too much confinement inside the zero grazing unit
- Much labour is needed to clean pens of feed left-over and faeces.

In this review, explanations are given about the layout and construction of a zero-grazing unit. The guidelines contained here are mainly for farmer-families. The zero grazing housing system has various areas some of which are essential and therefore must be included in the structure while others are optional and need not necessarily be part of the unit. Accordingly, these parts or areas are as follows:

Basic parts: (These are the very essential parts for better practice of zero grazing)

1. The cubicles (the unit that holds the animal)
2. The walking area (an area for easy movement of both animal and operator)
3. The feed and water troughs (for holding the feed and water for the animal)
4. The milking palour (where are kept and milked)
5. The calf pen (where calves are kept after parturition)
6. The fodder chopping area (where the cut forage materials are put and cut to size for the animal)

Basic optional Parts: (These parts are optional but if the farmer can afford them, they are also necessary)

1. The store (where to put materials that are not in immediate use, concentrates milk utensils, etc.)
2. The manure storage (where the cleared feed left-over and faeces are put before evacuation to the farm, a dug-out pit)
3. Fodder cutter (instrument for chopping the forage materials)
4. Roof water catchment (a roof construction for water harvest to tide over period of water scarcity)
5. Water tank (for storage of water)
6. A holding crush (for easy handling of the animal especially during treatment)

Zero-grazing system requires intensive (i.e. a lot of) labour for cutting and carrying forage crops (e.g. *Pennisetum purpureum*; which is very bulky), milking and carrying water and other feed materials to the animals. This means that the tasks of some of the farm-family members may increase. Proper planning is therefore required before starting a zero-grazing system. This will enable the farmer to appreciate the high financial and labour demands of zero-grazing before getting involved (Ibrahim, 1988).

Because zero-grazing requires a lot of initial capital for the construction of the unit, it can be done in phases by first constructing the essential parts of a zero-grazing unit. The optional parts can then be added as money becomes available.

One option is starting with semi-zero grazing as a first phase before turning to full zero-grazing unit. This can be the case where farm size is large enough to allow for free grazing.
The basic parts in a semi-zero-grazing system are the feed and water troughs and the milking place. The cubicles and walking area are optional.
These options, in zero-grazing and semi zero-grazing, are necessary when you have inadequate fund and cannot meet the labour and high skills demanded by zero-grazing immediately.

The following are strongly-recommended as considerations during construction of a unit:

1. Ensure that the correct site, considering the direction of wind, is chosen for the unit. The choice of site influences the security and protection of animals from rain, sunshine and other weather effects.
2. The unit should be closer to the house and on the opposite side of the wind. The location of the unit in relation to the house should ensure minimal smell from manure

pit. It should be noted that it is more important to protect an animal from the rain than from wind or sunshine.

3. Ensure that the person carrying out the construction work is properly supervised by a Livestock Extension Officer. This is necessary because some parts (i.e. walking area, troughs) once constructed are permanent. Mistakes made during construction can be very costly.
4. Use of local materials for construction of the unit will reduce cost.
5. Finally, one should as much as possible, carry out regular maintenance of the zero-grazing unit while in use. This is usually very important for the walking area.

The health of the animal at any point in time is very important and should be adequately provided for particularly that the animals are not allowed to move out. This is because a milking cow that is happy and content with no stress will produce the highest amount of milk. If cows weren't content living in free-stall barns, then the volume of milk would not be near as high. Also, quality of milk is determined by the rations that cows are fed. By controlling the rations and making a mixed ration served to cow, the farmer is not only producing high quality milk, but also keeping his or her cows as healthy as possible. The quality is not determined solely by the rations, or solely by the habitat. Both are very important.

This system can allow for the utilization of once inaccessible land, reduce damage to soils, extend the grazing season and increase grass intake, resulting in higher milk production. Less concentrates can be used in feed, arguably due to the increase of quality grass in the forage, which can be a huge money saver and catalyst toward higher profits.

This system can lead to diversification in the farming system. This can be possible as individuals who cannot afford to own cows can go into producing good quality forage crops and sell these to the animal farmers who may not be able to combine the cropping of forage crops and, at the same time keep animals. Or who may not have access to enough land the way the forage crop farmers may have.

Potentials of the holstein friesian on zero grazing for diversification of rural livestock production, rural dairy production, employment, poverty alleviation and food security in the tropics

Inferring from the performance and values from the rural dairy production reports from the highland regions of Cameroon, it is evident that this technology can be adopted by other countries under similar tropical conditions for integration into their rural livestock production programmes. This, if achieved, will not only diversify rural livestock production, but may also provide employment for the rural youths (rural dairy producers, fodder crop producers, milk and milk product vendors, feeders, etc. to modernized dairy enterprises or industries).

This may also assist in improving the nutritional status of the rural populace. Proceeds from the rural dairies may also stabilise rural farmers during crop failures or may provide additional support to increase crop production for food security. The sum total of these will improve the economy and standard of living of the rural dwellers thereby reducing poverty. This may not only improve on the socio-cultural lives of the rural people, but may over time, grow to attract further development and draw other social amenities closer to the rural dwellers.

5. CONCLUSIONS AND RECOMMENDATION

Conclusions

The mean age at first calving were higher due to sire effects, the breeding techniques of maintaining a central bull for several farmers and other management techniques employed. Calving interval and calf birth weight were appreciable, they were however affected by the poor management techniques employed by the farmers. The mean gestation length was low; despite the poor management. The percentage calf mortalities were high, varied across herds indicating the absence of routine uniform management techniques. In some herds, the cow must calve many times before it is able to produce a heifer that would replace it. In others, all the heifers produced must be retained in order to maintain herd size. The generation intervals were elongated due to the several calving a cow must have before it is able to produce a replacement for itself. The genotypic diversity created through independent assortment, segregation and recombination of genes as random effects through gametogenesis and fertilization respectively were lost to calf mortality and never presented to the environmental challenges of the tropics for selection and adaptation. The few genotypes that survived were introduced into the stressful (harsh climatic, poor housing, high disease prevalence) environmental conditions of the tropics often too early and sudden, with no time to allow them develop resistance techniques to enhance their survival and adaptation in the tropics. There were high incidences of disease prevalence which also varied across herds, locations, types of bedding materials used and follr type in the housing. The reproductive performance of the herds the survival of some calves and the lactation of the dams did indicate that this breed can be integrated into the tropical conditions.

Recommendations

There is need for interested countries, agencies, organizations and individuals interested in this technology to review and redesign a low cost housing type directed towards maintaining herd health and insist that their beneficial farmer families provide this housing first, before they acquire their animals. This will improve herd health; introduce the calves into the challenging tropical conditions gradually allowing them time to build their immunity to prevalent stress and increase calf crop.

There is also need to design standard but affordable routine management techniques and train all beneficial farmer families and ensure thorough extension services and supervision that these management techniques are followed. This will provide an initial protection especially to the calves at their early fragile life and give them room to react to the tropical stress gradually to evolve their adaptive strategy for fitness, stabilization and integration.

The zero grazing system can lead to diversification in the farming system and should be encouraged. This is because individuals who cannot afford to own cows can go into producing good quality forage crops and sell these to the animal farmers.

Quality of milk is determined by the rations that cows are fed. By controlling the rations and making a mixed ration served to cow, the farmer is not only producing high quality milk, but also keeping his or her cows as healthy as possible. The quality is not determined solely by the rations, nor solely by the habitat. Both are very important.

There is need to review and reduce the number of farmer groups attached to a central bull. This will ensure that all heifers attached to a bull have successful services. This will reduce the high age at first calving observed due to loss of heat periods arising from services that do not produce conception or inability of the bull to serve.

There is need for policy makers, agencies and Agricultural Authorities in tropical countries to take advantage of the potentials of this laudable programme. This can be done by identifying locations in each deserving country with more favourable climatic conditions for this breed, introduce the rural farmers to a cheap but well-designed housing system, provide extension services for good management and disease control.

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Appendix

Appendix I: The effect of mortality rates on selection intensity for genetic improvement

	N	NJ	F	S	A
Age at first calving (AFCAL)	30.88	30.50	30.92	30.67	30.80
Calving interval (CATVL)	13.30	13.34	13.31	13.24	13.32
Longevity (LOGTY)	4.62	4.75	4.48	4.39	4.02
Pre-weaning mortality to six months (PWMS)	50.00	38.90	47.06	20.80	42.11
Post-weaning mortality to age at First calving (POWMAFCAL) (%)	2.00	2.00	2.00	2.00	2.00

(Source: Gwaza *et al.*, 2007)

<u>Nkwen herd</u>

Mortality to age at first calving (MAFCAL) = Pre-weaning mortality + Post-weaning mortality at six months to age at first calving.

Pre-weaning mortality to six months = 50%

Post-weaning mortality rate of 2% per 3 months to age at first calving

$$= \frac{(\text{Age at first calving} - \text{calf age at weaning}) \times 2\%}{3 \text{ months}}$$

$$= \frac{(30.88 - 6) \times 2\%}{3} = 21.33\%$$

Total mortality to age at first calving = 50 + 21.33 = 71.33%

Total calf rearing proportion = 100 – 71.33 = 28.67%

Since the cow has equal probability of producing either a heifer or a bull calf, the heifer rearing proportion = 28.67/2 = 14.33%. (to whole numbers = 14.33/100 = 0.14).

No. of calving to produce a heifer that will lactate in the herd = 1/0.14 = 7.14.

The heifer replacement rates = No. of calving to produce a lactating heifer X 100

/ longevity = $\frac{7.14 \times 100}{4.62}$ = 154.55

Selection intensity from Table appendix II = 0.00 (Goddard, 1978)

Generation interval = No. of calving that produces a lactating heifer X calving Interval + age at first calving = 7.14 x 13.30 + 30.88 = 125.84 months (Gwaza *et al.*, 2007b)

<u>Njinikong herd</u>

Mortality to age at first calving (MAFCL) = Pre-weaning mortality at six months (PWMS) +Post weaning mortality at six months to first calving (POWMAFCAL).

PWMS = 38.38

POWMAFCAL = $\frac{(\text{AFCAL} - 6 \text{ months}) \times 2\%}{3 \text{ months}}$

= 16.33 % (Gwaza *et al.*, 2007b)

Total mortality to AFCAL = 38.38 + 16.33 = 54.71%

Total calf rearing proportion (TCRP) = 100 - 54.71 = 45.29,%

Hence, heifer rearing proportion (HRP) 45.29 / 2 = 22.64%

22.64 to whole number = 0.23

Number of calving to produce a lactating heifer in the herd = 1 / 0.23 = 4.40

Heifer replacement rates = $\frac{4.40 \times 100}{4.75}$ = 93 %

Selection intensity from Table **Appendix II** = 0.142

Generation Interval (GI) = No. of calving to produce a heifer X CATVL + AFCAL = 89.20 months (7 years) (4.40 x 13.34 + 30.50)

Fundlong herd

MAFCAL = PWMS + POWMAFCAL

PWMS = 47.06%

$$POWMAFCAL = \frac{(AFCAL - 6\ months)}{3\ months} \times 2\% = 16.61\ \%$$

MAFCAL = 47.06 + 16.61 = 63.67 %

Hence, TCRP = 100 - 63.67 = 36.30%

HRP = 36.30 / 2 = 18.16%

18.16 to whole number = 0.18

Number of calving to produce a lactating heifer in the herd = 1 / 0.18 = 5.60

and the HRR = 5.60 / 4.48 X 100 = 125

Selection Intensity from Table appendix II = 0.00

Generation Interval = 5.60 X 13.31 + 30.92 = 105.50 (8.7 years) (Gwaza *et al.*, 2007b).

Santa herd:

MAFCAL = PWMS + POSWMAFCAL

But PWMS = 20.80%

$$POWMAFCAL = \frac{(AFCAL - 6\ months)}{3\ months} \times 2 / 100 =$$

$$= \frac{(30.67 - 6\ months)}{3} \times 2 / 100 = 16.50\ \%$$

MAFCAL = 20.80 + 16.50 = 37.30 %

TCRP = 100 - 37.30 = 62.80 %

HRP = 62.80 / 2 = 31.40%

31.40 to whole number = 0.31

Number of calving to produce a lactating heifer in the herd = 1 / 0.31 = 3.20

HRR = 3.20 / 4.39 X 100 = 72.90%

Selection Intensity from Table appendix II = 0.45

Generation Interval = 3.20 x 13.24 + 30.67 = 73.0 (6.10 years) (Gwaza *et al.*, 2007b).

<u>Akum herd:</u>

MAFCAL = PWMS + POWMAFCAL

PWMS = 42.11%

$$POWMAFCAL = \frac{(AFCAL - 6\ months)}{3\ months} \times 2 / 100 = 16.50\ \%$$

MAFCAL = 42.11 + 16.50 = 58.60 %

TCRP = 100 - 58.60 = 41.40%

HRP = 41.40 / 2 = 20.70%

20.70 to whole number 0.20

Number of calving to produce a heifer that lactate in the herd = 1 / 0.20 = 5

HRR = 5 / 4.02 x 100 = 124%

Selection intensity from Table appendix II = 0.00

Generation Interval = 5 x 13.32 + 30.80 = 97.40 (8 years) (Gwaza *et al.*, 2007b).