Growth Performance of Holstein-Friesian heifer calves weaned at different ages and raised in mobile calf hutches and conventional calf pens in Botswana

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ABSTRACT
This study was designed to evaluate the growth performance of Holstein-Friesian heifer calves weaned at three different ages and reared in two housing types i.e. mobile calf hutches and conventional calf pens at Sebele Agricultural Research Station, Botswana. Forty-eight Holstein-Friesian heifer calves from five dairy farms around Gaborone were weighed and allocated randomly to two calf housing types and three weaning age treatments with 8 heifer calves per treatment. In both housing types heifer calves were weaned at 6, 9 and 12 weeks of age. All heifer calves were given four litres of whole milk twice a day until a week before weaning. A week prior to weaning, calves were fed half quantity of milk once a day. Heifer calves also received calf starter meal, chopped lablab hay and water according to appetite until 22 weeks of age. Feeds and orts were weighed and recorded daily. Heifer calves were weighed every week and performance, as reflected in live-weight changes, was evaluated for type of housing and weaning age. Data was analysed using GLM of SAS [R]. Heifer calves' performance was similar across housing type during the pre-weaning period. At 22 weeks of age, heifer calves weaned at 9 weeks of age had a mean weight of 140.5 ± 5.7 which was significantly higher ($P<0.05$) than mean weight of 128.2 ± 3.5 and 131.0 ± 3.7kg for calves weaned at 6 and 12 weeks of age respectively in both conventional calf pens and mobile calf hutches. Post-weaning average daily gain (ADG) of heifer calves housed in conventional calf pens and weaned at 9 weeks of age were 1.06 ± 0.17 kg compared to those weaned at 6 and 12 weeks of age which were 0.78 ± 0.11 and 0.94± 0.25kg respectively. Post-weaning ADG of heifer calves housed in mobile calf hutches and weaned at 9 weeks of age were 0.98 ± 0.31 kg compared to those weaned at 6 and 12 weeks of age, which were 0.74 ± 0.12 and 0.84± 0.18kg, respectively. In both housing types calves weaned at 9 weeks were heavier than those weaned at 6 and 12 weeks of age therefore heifer calves can be successfully weaned at 9 weeks of age. Since the performance of heifer calves reared under the two housing systems did not differ significantly ($P<0.05$) and the mobile calf hutches were cheaper to construct than conventional calf pens, mobile calf hutches can be an alternative housing system for dairy calves in Botswana.
Keywords: Botswana, Calf housing type, Heifer calves, Growth performance, Weaning age

INTRODUCTION
The national dairy herd in Botswana has remained small, with about 4 000 cows. One of the major reasons is the poor management of young calves, which results in high mortality of 26.3% and poor growth (TAHAL-NAMPAADD, 2000). Poor housing and inadequate feeding are among the factors that contribute to poor performance of dairy calves. Most of the existing calf housing systems on dairy farms consist of traditional open kraals fenced with

thorn bushes or clad with corrugated iron sheets. In the make-shift structures calves are subjected to all types of weather conditions such as rainstorms, scorching heat, cold and strong winds. Very few dairy farms in Botswana have well ventilated calf pens due to high cost of construction. Most of the calves are housed in groups. The need for a newly born calf to be provided with shelter is well established (Moeller and Friday, 1973), especially during the first few days of life, when the calf's temperature control mechanism is still poorly developed (Mathewman, 1993). Individual calf housing systems are preferred because they reduce transmission of diseases (Kung *et al.*, 1997; Waltner-Toews *et al.*, 1986). Two types of individual calf housing systems are available, namely conventional calf pens (Figure 1) and mobile calf hutches (Figure 2). Calf hutches are preferred over calf pens because of low initial construction and labour costs, and fewer disease problems especially respiratory diseases (Morrill, 1999). The use of calf hutches has also been associated with increased body weight gain and improved health of calves (Quigley III *et al.*, 1995) and reduced calf mortality (Lance *et al.*, 1992). Berhane *et al.* (1998) in Tanzania reported that an early weaning program could reduce feed costs and labour requirements on calf rearing practices.

Khalili *et al.* (1992) reported some loss in calf performance observed with early weaning. Heinrichs *et al.* (1990) found that age at weaning had no effect on any measured growth rate when Holstein calves were early weaned (4 weeks) or late weaned (7 weeks) in Pennsylvania, U. S. A.

The objectives of the study were to evaluate the growth performance of heifer calves when reared in two housing types i.e. mobile calf hutches and conventional calf pens and weaned at different ages on subsequent growth in Botswana.

MATERIALS AND METHODS

The study was conducted at Sebele Agricultural Research Station, about 10 km Northeast of Gaborone, Botswana (25° 59' South and 24° 94' East). The mean maximum and mean minimum temperatures are 28.4°C and 12.9°C respectively. The study was conducted from September 2003 to March 2005.

Newly born Holstein-Friesian heifer calves obtained from five dairy farms near Gaborone were allowed to suckle adequate quantities of colostrum for four to five days after birth before being separated from their dams and transported to Sebele. A total of 48 heifer calves were weighed and allocated randomly to two individual calf housing types and three weaning age treatments (Table 1).

Table 1: The experimental design with the number of heifer weaned at different ages and housed in two housing types at Sebele Agricultural Research (ARS), Botswana

Weaning age (weeks)	Number of calves Housing type	
	Mobile calf hutches	Conventional calf pens
6	8	8
9	8	8
12	8	8

Each heifer calf was fed 4 litres of whole milk per day in two equal feedings (at 07h30 and 15h30) in a bucket until a week before weaning when the allowance was reduced to 2 litres and fed only in the mornings. A calf starter meal (Table 2 and 3), containing at least 180 g crude protein (CP) per kg was offered *ad libitum* to heifer calves from week 1 up to 22 weeks of age. The daily allowances of starter meal and coarsely chopped lablab hay (*Lablab purpureus:*140 g CP/kg, 12 g calcium/kg, 1.8 g phosphorus/kg, 18 g potassium/kg, 0.1 g

sodium/kg and a dry matter digestibility coefficient of 0.550) were gradually increased to 7.5 kg and 1 kg respectively towards the end of the study. Water was offered *ad libitum* from the second week until the end of the study.

Table 2: Ingredients of calf starter meal for heifer calves at ARS, Botswana

Ingredient	g/kg (air dry basis)
Maize meal	560
Sunflower oil cake meal	200
Molasses (powder)	50
Fish meal	75
Lucerne meal	100
Dicalcium phosphate	5
Salt	5
Calf starter vitamins and minerals premix**	5

** Provided per kg diet: Vitamin A - 6000000 I.U.; vitamin D_3 - 300000 I.U.; vitamin E - 5000 I.U.; Thiamine - 600 mg; Riboflavin - 400 mg; Pyrodoxine - 600 mg; vitamin B_{12} - 5 mg; vitamin K_3-400 mg; Niacin - 3000 mg; Pantothenic Acid - 2000 mg; Choline - 40 g; Antioxidant - 13 g; Iron - 20 g, Manganese - 12 g; Copper - 6 g; Zinc-18 g; Magnesium - 16 g; Cobalt - 0.1 g; Iodine - 0.2 g; Selenium premix - 20 mg; Zinc Bacitracin - 7 g.

Table 3: Chemical composition of calf starter meal for heifer calves on experiment at ARS, Botswana

Component	g/kg (air dry basis)
Dry matter (DM) Maize meal	957.6
Crude Protein (CP)	182.7
Lipids	15.3
Neutral detergent fibre (NDF)	226.6
Acid detergent fibre (ADF)	106.7
Calcium (Ca)	7.6
Phosphorus (P)	7.0
Potassium (K)	13.2
Magnesium (Mg)	2.5

Twenty four of the 48 heifer calves used in the study were housed individually in mobile calf hutches and another 24 housed individually in conventional calf pens until 22 weeks of age (Table 1). Conventional calf pens consisted of two brick sidewalls and corrugated iron sheet roofs, while diamond mesh was used to enclose the front part (Figure 1). The main roofed part of the calf pen was about 4.5 m^2, while the front part (unroofed area) was about 5.5 m^2. The concrete floor areas had a slightly rough surface to allow calves a good footing when walking on the floor. A large gate at the front gave easy access to each conventional calf pen. A mobile rack designed to hold feed buckets was placed in each calf pen.

Mobile calf hutches were designed according to the specifications used at Tweespruit, South Africa (H.O. de Waal, W.J. Combrinck & F.J.L. Burger; personal communication, 2000). The roofed area of mobile calf hutch was 2.3m^2 while the front part (unroofed area) was about 0.7m^2 (Figure 2). The existing Sebele conventional calf pens were thoroughly cleaned before heifer calves were housed in them. Calf pens were cleaned daily and bedded with fresh grass hay. No bedding was used in calf hutches; these were moved to fresh dry patches weekly to prevent accumulation of manure and urine. All buckets were cleaned daily before being used.

Heifer calves in conventional calf pens or mobile calf hutches were further allocated to three weaning ages of 6, 9 and 12 weeks (Table 1). A week before weaning, the total daily milk fed to heifer calves was reduced by half and calves were only fed milk in the morning. After weaning, heifer calves continued to be daily given calf starter meals and crushed lablab hay *ad libutum* and fresh water free choice and were also individually housed until end of study when they were 22 weeks of age.

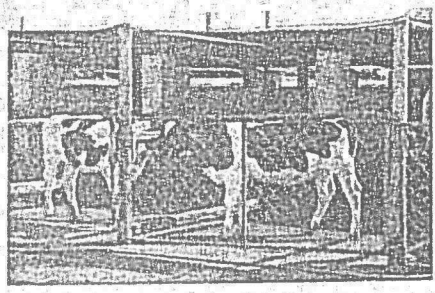

Figure 1:Conventional calf pens at ARS, Gaborone.

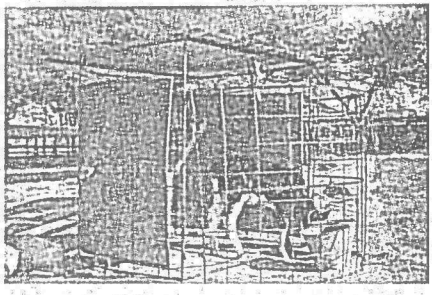

Figure 2: A mobile calf hutch at ARS, Gaborone

Navels of heifer calves were dipped once into a tincture of iodine solution when calves were a week old. Vaccination was done once for calf parathyphoid (salmonella) within two weeks after birth. Heifer calves showing symptoms of diarrhoea, bloat, other diseases or abnormal conditions were treated accordingly.

Feed offered and orts were weighed and recorded daily for each heifer calf to enable calculation of the individual feed intake.

Heifer calves were weighed weekly to monitor live weight changes. Weighing was done before feeding in the morning.

Data were subjected to analysis of variance (ANOVA) using the General Linear Models (GLM) of Statistical Analysis System (SAS, 1991). The models of ANOVA included house type and weaning age as main effects and their interactions. Variables were weaning weight, live weight at 22 weeks of age and average daily gain (ADG). Treatments means were separated using Duncan's multiple range tests using 5% probability level.

RESULTS AND DISCUSSION

One heifer calf housed in mobile calf hutch, to be weaned at 9 weeks died due to bloat during the pre-weaning period, while another calf housed in calf pen weaned at 9 weeks died at 17 weeks of age. Total whole milk consumed was 134, 218 and 302 litres for calves weaned at 6, 9 and 12 weeks respectively. Intake of calf starter meal and lablab hay by heifer calves housed in calf hutches and calf pens are shown in Table 4. Feed intake was not significantly different ($P<0.05$) for calves housed in calf hutches and calf pens. All calves in the three weaning age treatments and in the two housing types consumed less than 1kg /day calf starter meal and less than 0.3kg/day lablab hay during the pre-weaning period. This was expected since calves were still consuming adequate amounts of whole milk. Chua *et al.* (2002) and Kung *et al.* (1997) also observed low average daily consumption of calf starter meal during the first 2 to 3 weeks of life with consumption rapidly increasing after 4 weeks of age. Within each weaning age treatment, daily calf starter meal intakes were not significantly different ($P< 0.05$) for calves housed in mobile calf hutches compared to those housed in conventional calf pens during the pre-weaning period (Table 4). There were also no significant differences ($P<0.05$) in daily average calf starter meal

and lablab hay intake for calves weaned at the same age across the two housing types during the post-weaning period. The results indicate that the type of housing had no effect on feed intake. This agreed with the findings of Quigley III *et al* (1995) who observed that calf starter meal intake was not different between calves housed in calf hutches and those housed in calf pens.

Table 4: Least-square means (± standard error) for daily feed intake of heifer calf per housing type during pre- and post-weaning period at ARS, Botswana

Variable	Type of housing					
	Mobile calf hutch Weaning age (weeks)			Conventional calf pen Weaning age (weeks)		
	6	9	12	6	9	12
Pre-weaning						
Starter meal intake (kg)	0.22 ±0.18^{a}	0.44±0.25^{ab}	0.57± .20^{ab}	0.28 ± 0.14^{a}	0.57± .24^{ab}	0.71 ± 0.21^{b}
Lablab hay intake (kg)	0.11 ± 0.06^{a}	0.13 ± 0.05^{a}	0.21 ± 0.07^{a}	0.12 ± 0.07^{a}	0.14 ± 0.05^{a}	0.17 ± 0.07^{a}
Post-weaning						
Starter meal intake (kg)	3.16 ± 1.15^{a}	3.96 ± 0.91^{a}	4.08 ± 0.59^{a}	3.67 ± 0.89^{a}	4.46 ± 0.40^{a}	4.51 ± 0.57^{a}
Lablab hay intake (kg)	0.44 ± 0.18^{a}	0.52 ± 0.14^{a}	0.69 ± 0.17^{a}	0.43 ± 0.11^{a}	0.47 ± 0.16^{a}	0.65 ± 0.09^{a}

^{a,b} Means within rows with different superscripts differ significantly ($p<0.05$)

Table 5: Least square means for temperature (°C) and relative humidity (%) inside the housing structure of heifer calf during the pre-weaning period at ARS, Botswana

Variable	Type of housing					
	Mobile calf hutch Weaning age (weeks)			Conventional calf pen Weaning age (weeks)		
	6	9	12	6	9	12
Mean temperature (°C)	28.2 ± 2.1	31.1 ± 3.0	30.0 ± 3.0	29.5 ± 3.8	29.4 ± 3.5	28.2 ± 3.1
Mean relative humidity (%)	30.6 ± 9.2	25.8 ± 7.6	25.4 ± 11. 6	30.3 ± 10.9	26.3 ± 6.2	26.7 ± 9.3

Mean temperature and relative humidity inside the mobile calf hutches and the conventional calf pens were similar ($p=0.05$) during the pre-weaning period, indicating that heifer calves in different types of housing experienced similar environmental conditions (Table 5).

Heifer calves weaned at 12 weeks of age were significantly heavier ($P<0.05$) than those weaned at 6 and 9 weeks of age in both mobile calf hutches and conventional calf pens (Table 6). These results are similar to those of Khalili *et al.* (1992) who reported increased live weight gains for calves weaned at 12 weeks compared to those

weaned at 8 weeks of age. Ogundola (1981) also observed low weight gains during pre-weaning period for calves weaned at 3 weeks, mainly because of limited time to feed before weaning. However average daily gains (ADG) of heifer calves were not significantly different ($P<0.05$) across the three weaning ages and the two housing types (Table 6), although heifer calves weaned at 12 weeks showed some observable advantage compared to the other 2. The trend of a low ADG for early-weaned (weaned at 6 weeks of age) heifer calves continued even post-weaning (until the 22 week period when the study ended) because of limited solid feed intake as their rumen was still not fully developed for efficient utilisation of dry feed.

There were no significant differences ($p<0.05$) between the performances of heifer calves raised in mobile calf hutches and conventional calf pens especially during pre-weaning, corroborating with findings of Chua *et al.* (2002) who found cleanliness and adequate ventilation to be important instead of the type of calf housing system used. Heifer calves also experienced similar environmental conditions in the two calf housing systems.

Time devoted to taking care of heifer calves in conventional calf pens was significantly longer ($P<0.05$) compared to the time devoted to taking care of heifer calves in mobile calf hutches during the pre-weaning period and post-weaning period (Table 6 and 7). This was mainly because conventional calf pens had to be cleaned and bedded daily, an activity which took a lot of time, while moving of the mobile calf hutches from the soiled areas was not done on daily basis. The use of mobile calf hutches saved time and labour expenses.

Average daily gains (ADG) of heifer calves weaned at 9 weeks of age and housed in both the mobile calf hutches and conventional calf pens were significantly higher ($P < 0.05$) during the post-weaning period (Table 7). The heifers weaned at 9 weeks of age were also significantly heavier ($P < 0.05$) at 22 weeks of age compared to those weaned at 6 and 12 weeks of age. Post-weaning ADG of 1.06 kg/day registered for 9 weeks weaned heifer calves housed in conventional calf pens should, if maintained, enable Holstein-Friesian heifer calves to reach required breeding weight of about 320 kg early in life.

The estimated cost of material to construct a conventional calf pen was almost seven times more compared to a mobile calf hutch (Table 8). In addition, grass hay for bedding, water and detergents used daily for cleaning the calf pens increased the cost.

Table 8: Cost for construction material of the two calf housing types at ARS, Botswana

Type of housing	Cost in Pula [1,a]
Mobile calf hutch	204.00
Conventional calf pen	1 388.00

[1] One Pula (Botswana currency) was equal to US $0.21 on January, 2005

[a] The figures do not include labour costs

Construction costs of conventional calf pens were higher than that of mobile calf hutches. In addition, conventional calf pens needed regular cleaning and change of bedding materials, which increased their maintenance costs. Mobile calf hutches are much cheaper and can be constructed from local materials (such as reeds, used empty feed bags) hence, they are more attractive to resource poor farmers.

Table 6: Least square means (± standard error) for birth weight, weight at weaning, daily live weight gain and daily amount of time devoted to taking care of heifer calf per housing type during the pre-weaning period at ARS, Botswana

Variable	Type of housing					
	Mobile calf hutch Weaning age (weeks)			Conventional calf pen Weaning age (weeks)		
	6	9	12	6	9	12
Birth weight (kg)	34.2 ± 3.5	38.3 ± 5.7	31.7 ± 4.5	33.4 ± 4.4	35.3 ± 7.0	36.6 ± 4.5
Weight at weaning (kg)	45.6 ± 5.3^{a}	60.7±11.2^{ab}	64.7 ± 7.8^{b}	46.4 ± 5.2^{a}	60.2±9.9^{ab}	74.6 ± 7.7^{b}
Daily live weight gain (kg/day)	0.33±0.12^{a}	0.40±0.16^{a}	0.4 ±0.10^{a}	0.37±0.11^{a}	0.44±0.10^{a}	0.49±0.11^{a}
Daily time devoted to taking care of calf (minutes)	8.9 ±2.6	9.9 ±2.3	8.8 ±2.0	15.7 ±2.4	16.3 ±3.5	15.1 ±1.9

^{a,b} Means within rows with different superscripts differ significantly ($p<0.05$)

Table 7: Least square means (± standard error) for weight at weaning, daily live weight gain and daily amount of time devoted to taking care of heifer calf per housing type during the post-weaning period at ARS, Botswana

Variable	Type of housing					
	Mobile calf hutch Weaning age (weeks)			Conventional calf pen Weaning age (weeks)		
	6	9	12	6	9	12
Weight at 22 weeks of age (kg)	128.2± 3.5^{a}	140.5± 5.7^{b}	131.0±3.7^{ab}	134.5±4.8^{ab}	150.0± 7.0^{b}	142.4±4.5^{ab}
Daily live weight gain (kg/day)	0.74± 0.12^{a}	0.98±0.31^{ab}	0.84±0.18^{ab}	0.78± 0.11^{a}	1.06±0.17^{ab}	0.94±0.25^{ab}
Daily time devoted to taking care of calf (minutes)	5.9 ±1.1	6.8 ±1.2	6.4 ±1.3	13.9 ±2.4	14.5 ±2.4	15.6 ±2.3

^{a,b} Means within rows with different superscripts differ significantly ($p<0.05$)

CONCLUSIONS

The results of this study demonstrated that early weaning at 6 weeks of age compromised subsequent performance of heifer calves. The study also demonstrated that dairy farmers can successfully wean their heifer calves early at 9 weeks of age instead of 12 weeks in order to reduce the total milk consumed by the calf. The study further demonstrated that performance of heifer calves housed in mobile calf hutches or in conventional calf pens was similar during the pre-weaning period, although the penned calves were heavier at 22 weeks. The cost of constructing conventional calf pens and expenses of frequent cleaning and changing of bedding, places these calf pens beyond the financial means of most Botswana dairy farmers. Therefore the use of mobile calf hutches is proposed as an appropriate calf housing alternative within the conditions prevailing in Botswana.

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REFERENCES

Chua, B.E., Coenen, J. van Delen and Weary, D.M., 2002. Effects of pair versus individual housing or the behaviour and performance of dairy calves. J. Dairy Sci 85, 360-364.

Berhane, G.Y., Kurwijila, L.R and Kimambo, A. E., 1998. The effect of early feeding of soybean and fish meal based calf starter ration on feed utilisation and growth performance by dairy calves. Tanzania Journal of Agricultural Science (1998) Volume 1, 42-49.

Fallon, R.J. and Harte, F.J., 1986. Effects of giving three different levels of milk replacer on calf performance. Irish J. Agric. Res. 25, 23-29.

Heinrichs, A.J., Swartz, L.A., Drake, T.R and Travis, P.A., 1990. Influence of Decoquinate fed to neonatal dairy calves on early and conventional weaning systems. Journal of Dairy Science 73: 1851-1856.

H.O. de Waal, W.J. Combrinck and F.J.L. Burger Tweespruit, South Africa; personal communication, 2000.

Khalili H., Crosse, S. and Varvikko, T., 1992. The performance of crossbreed dairy calves given different levels of whole milk and weaned at different ages. Anim. Prod 54, 191-195.

Kung, L., Demarco, S., Siebenson, L.N., Joyner, E., Haenlein, G.F.W and Morris, R.M., 1997. An evaluation of two management systems for rearing calves fed milk replacer. J. Dairy Sci. 80, 2529-2533.

Lance, S.E., Miller, G.Y., Hancock, D.D., Bartlett, P.C., Lawrence, E.H. and Moeshberger, M.L., 1992. Effects of environment and management on mortality in pre-weaned dairy calves. J. Am. Vet. Med. Assoc. 201, 1197-1202.

Mathewman, R.J., 1993. Calf rearing. Dairying. The Tropical Agriculture p. 32-48. The Macmillan Press Ltd. London and Basingstoke.

Moeller, N.J. and Friday, W.H., 1973. Considerations in selecting dairy calf housing ID - 93 Cooperative Extension Service. Purdue University. Accessed 6 August 2002: *http_dir/b_save/acsonline/ID - 93 – 15k.*

Morrill, J.L., 1999. The calf: Birth to 12 weeks. In: Large Dairy Herd Management. Eds. Van Horn, H.H. and Wilcox, C.J., pp. 401. American Dairy Science Association, 1111 N. Dunlap Avenue, Savoy, Illinois. 61874.

Ogundola, F.I., 1981. Performance of white Fulani calves weaned at different ages. Trop. Anim. Prod. 6, 336-337.

Quigley, J.D. III, Martin, K.R., Bemis, D.A., Potgieter, L.N.D., Reinemeyer, C.R., Rohrbach, B.W., Dowlen, H.H. and Lamar, K.C., 1995. Effects of housing and colostrums feeding on serum immunoglobulins, growth and fecal scores. J. Dairy Sci. 79, 2255-2260.

SAS Institute Inc., 1991. SAS/STAT^R Software: Usage and reference, Version 6.04. Cary NC: SAS Institute Inc., 1991.

TAHAL-NAMPAADD, 2000. National Master Plan for Arable Agriculture and Dairy Development, Ministry of Agriculture, Botswana.

Waltner-Toews, D., Martin, S.W. and Meek, A.H., 1986. Dairy calf management, morbidity and mortality in Ontario Holstein herds, II: age and seasonal patterns. Prev. Vet. Med. 4, 125-135.