Asian-Aust. J. Anim. Sci.
Vol. 24, No. 9 : 1318 - 1328
September 2011

www.ajas.info
http://dx.doi.org/10.5713/ajas.2011.11099

Factors Affecting High Mortality Rates of Dairy Replacement Calves and Heifers in the Tropics and Strategies for Their Reduction

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ABSTRACT : The tropics is not an ideal location for calf rearing as the high temperatures and humidities introduce many potential disease problems to milk fed calves. In addition, the type of dairy farming (generally poorly resourced small holder farming) and the general lack of awareness of the long term implications of poorly reared stock do not encourage farmers to pay close attention to their calf and heifer rearing systems. Surveys of calf rearing systems in Asia, tropical Africa and South America highlight the high calf and heifer mortalities. A range of 15 to 25% pre-weaning calf mortality is typical on many tropical dairy farms. It is often as high as 50%, indicating very poor calf management. This contrasts with US findings of less than 8% mortality from birth to 6 months while surveys of Australian farmers report only 3% losses. Simple extension programs on farms in Sri Lanka and Kenya have drastically reduced calf mortalities and improved pre-weaning growth rates. Improved management strategies leading to lower calving intervals, higher calving rates, reduced still born and pre-weaned calf mortalities and fewer non pregnant heifers can supply many more dairy herd replacements than currently occurs. Such strategies can increase the number of replacement heifer calves in the herd from 15 to over 35%, thus allowing farmers to increase their herd sizes through natural increases. Simple management procedures such as ensuring adequate intake of good quality colostrum within the first 12 hours of life, housing and good hygiene to minimise disease transfer, providing clean drinking water, developing appropriate feeding protocols to encourage early rumen development and paying closer attention to climate control and animal health can all lead to improved calf vigour and performance. Good record keeping is also important so farmers can more easily identify susceptible calves and quickly treat potential problems. (**Key Words :** Pre-weaning, Calf Mortality, Tropics, Small Holder Dairy Systems)

INTRODUCTION

The tropics is not an ideal place to rear young dairy stock. The harsh tropical climate introduces many animal health issues to dairy stock, particularly young calves (Aiumlamai, 1999). Furthermore in many countries, the type of dairy farming, generally poorly resourced small holder production systems (Moran, 2009), and the lack of awareness of the long term implications of poorly reared young stock (Moran and McLean, 2001), does not encourage farmers to pay close attention to their calf rearing systems.

This review documents the published data on current mortality rates of calves and heifers on tropical dairy farms, summarises the major reasons behind these high levels and reports on the success of farmer extension programs designed to reduce such mortalities to more acceptable levels. A series of Key Performance Indicators (KPI) are presented to provide quantitative guidelines to more acceptable levels of young stock management.

With increasing numbers of temperate, hence poorly adapted, dairy stock being imported into tropical countries, there is an urgent need for well planned and conducted farmer extension programs into young stock management (Moran, 2005). The progeny of such high grade Friesian cows are more susceptible to environmental and managerial stresses of tropical small holder dairy farming than local, more adapted calves (Vaccaro, 1990). Certainly, their high investment costs justify greater attention than they currently receive.

Considering the above, it is not surprising that the performance of young stock on most tropical and subtropical dairy farms is below that observed on temperate farms. Not only is the performance of young stock suboptimal, but such documentation is often difficult to find, particularly from Asia. This is evident in Table 1 in which

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Received April 11, 2011; Accepted May 27, 2011

most of the reported studies originate from Africa and South America.

PUBLISHED SURVEYS OF CALF AND HEIFER MORTALITIES IN THE TROPICS

The results of recent published surveys on mortality during calf rearing undertaken in tropical dairying areas are presented in Table 1. Altogether there are 17 tropical studies reported, many from Africa and South America, but several from Asia. The surveys covered a wide range of dairy production systems, from large scale grazing and feedlots to small holder systems. The highest pre-weaning mortality reported was 81%, from a survey of various Indian dairy systems (Tiwari et al., 2007) in which it was found that over half the 90 farmers ceased rearing any calves because they considered it uneconomic and it was cheaper for them to purchase all their herd replacements. This was an extreme

Table 1. Details of studies documenting calf mortalities in tropical dairy farming areas, listed in decreasing level of pre weaning calf mortality rates

Location and year	Farms surveyed	Calf mortality (%)	Further details	Reference
1. Uttar Pradesh, India 2005?	90 farms; 30 with 1-10 cows, 30 with 11-20 cows and 30 with >20 cows Restricted suckling Data to weaning?	68% in small herds 82% in medium herds 84% in large herds 81% pre-weaning	Only 22% farms reared dairy calves Only 33% farms reared buffalo calves Important causes are scours, endo and ecto parasites, navel ill and pneumonia Only 17% farms dewormed calves Only 17% farmers call veterinarian if calf became sick Farmers consider calf rearing uneconomic so only purchased mature stock	Tiwari et al. (2007)
2. Chikwaka, Zimbabwe 1996	50 small holder farms 261 dairy stock, various sire breeds	4.7% still births 35.0% mortality to 12 m	Female mortalities; 25.3% to 12 m, 6.1% from 1 to 2 yr, 11.4% from 2 to 5 yr Jerseys had higher and Red Danes had lower calf mortalities	French et al. (2001)
3. Addis Ababa, Ethiopia 1997-1999	5 large farms with Friesian and Jersey cows 701 calves	19.7% in 1st year 4.8% from 12-18 m 5.2% from 18-24 m 29.7% from 0-24 m	Higher in Friesians than Jerseys High loss 0-90 d and 5-6 m (post weaning) 1st service at 28 m (22 m Jersey, 30 m Friesian) CCI; 6.4 m Friesian, 4.8 m Jersey	Asseged and Birhanu (2004)
4. Western Province, Sri Lanka 1999	Only documenting "control" or non assisted farms 25 coconut grazing (CG) and 23 peri urban (PU) farms 340 dairy XB cows	50-60% of the mortalities before 3 m 23.4% (CG farms) pre-weaning 28.7% (PU farms) pre-weaning	1st lact peak milk yield; 4.0 (CG) vs. 5.9 (PU) kg/d Calves weaned at 5.9 (CG) vs. 3.3 (PU) m 24 m weight; 233 kg (CG) vs. 221 (PU) kg AFC; 36 (CG) vs. 38 (PU) m	Nettisinghe et al. (2004)
5. Portuguese State, Venezuela 1977-1979	One commercial farm with Friesian and Brown Swiss cows 1,656 observations	2.5% still births 15.6% deaths and culls to 9 m 28% in 1st week, 64% in 1st m, 18% in 2nd m and 17% from 3 to 9 m and 9.9% from 9 m to 1st calving 94% of losses due to deaths 25.5% lost up to1st calving	Major causes are scours, pneumonia and joint ill Losses up to 1st calving; 32% in Brown Swiss and 25% in Friesians	Vaccaro and Vaccaro (1981)
6. Dar es Salaam, Tanzania 2002	125 small holder farms, stall feeding 977 dairy cattle	10% pre weaning mortality 25% annual calf mortality	Average milk yield, 8 L/d AFC, 33 m; CI, 20 m	Kivaria et al. (2006)
7. Kiambu, Kenya 1991-1992	78 farms with 201 calves European×local dairy stock Weaned at 12 weeks of age	26.6% morbidity up to 12 m 21.6% mortality up to 12 m	Scours was major cause of death Older calves had higher morbidity Poor shed hygiene related to higher mortality Clinical illness, low red blood cell count and concentrate feeding associated with higher mortality Mineral feeding associated with lower mortality	Gitau et al. (1994)
8. Bagamoyo and Handeni, Tanzania 1999-2003	2 villages with 269 calves 25% Friesian×75% Boran	20.8% calf mortality	12 m live weight only 88 kg 233 kg at 21 m (first conception) 4 kg/d milk yield during first lactation	Msanga and Bee (2006)
9. Bringakro, Ivory Coast 1997-1999	3 herds of 165 N'Dama cattle with day time grazing and night time yarding Limited milking for home consumption	19% mortality within 7 m	200-250 kg mature weight 250-600 kg milk/lactation 52% annual calving rate	Knopf et al. (2004)

Table 1. Details of studies documenting calf mortalities in tropical dairy farming areas, listed in decreasing level of pre weaning calf mortality rates (Continued)

Location and year	Farms surveyed	Calf mortality (%)	Further details	Reference
10. Kiambu, Kenya 1990-2003	4 large scale farms with Friesian XB cows 3,508 calves	19% mortality before 1st calving Another 6% culled before 1st calving 22% mortality before 48 m Another 12 % culled before 48 m	Most deaths within 1st 12 m AFC 35 m with range 30-45 m Total deaths and culls prior to AFC increased from 5% to 45% over 13 yr of study	Menjo et al. (2009)
11. Debre Zeit, Ethiopia 2003-2004	3 large and 112 small holder farms 236 Friesian cross calves up to 6 mth old	61.5% morbidity 18.0% mortality	Scours was major cause of mortalities Mortality related to calf age, age at 1st colostrum and shed cleanliness	Jemberu (2004)
12. Oromia, Ethiopia 2003?	300 small holder farms Zebu×dairy breeds Calves suckled or bucket fed	1.4% abortions 17.4 % pre-weaning	CCI; 7.8 m	Lobago et al. (2006)
13. Bamako, Mali 2002-2004	38 peri urban dairy herds Zebus and XB dairy breeds 762 calves	3.9% in 1st 10 d 5.4% from 10 d -3 m 4.2% from 3-6 m 3.4% from 6-15 m 16.9% from 0-15 m	Higher in modern and large farms vs. traditional farms Higher in rainy season Important causes were peri natal, accidents, digestive disorders (inc parasites) and starvation	Wymann (2005)
14. Rift Valley, Kenya 1996-1998	5 large scale farms 673 Friesian calves Data to weaning ?	15.6% mortality	Higher in heifers than bull calves Higher in calves born Jul-Sep Highest in 2-4.5 yo dams Pneumonia most important cause Higher in moveable vs. permanent pens	Bebe et al. (2001)
15. Rio de Janeiro, Brazil 1977-1981	One farm 614 Friesian×Guzera heifer calves 6 breed groups Bucket reared to 4 m	Mortality to 12 m 10.1-20.4% range for 6 breed groups 15.5% average mortality	Scours, respiratory and tick borne diseases were major causes of mortality Intermediate crosses had lower mortalities	Madalena et al. (1996)
16. Bahir Dar, Ethiopia 1983-2003	One farm 1,829 Fogera (Zebu)× Friesian calves Suckled dams until 6-8 m of age	Mortality rates 3.6% to 30d, 5.8% to 180 d, 6,5% to 240 d 9.7% mortality to 12 m	-	Amuamuta et al. (2006)
17. Ha Tay, Vietnam 2002-2003	99 smallholder dairy farms (2-3 Zebu XB cows/farm) Data to weaning ?	3.1% pa abortions 2.3% pa peri natal mortality (1st 24 h) 4.7% pa calf mortality 7% pa total calf mortality	3,500 L milk/lactation, 2.5 m dry period, 13.0 m CI Cows calved twice and 60 m old on average	Suzuki (2005)
18. Entire US 2009	"Gold standards " for calf rearing in temperate regions	Mortality: <5% from 1-60 d <2% from 2-4 m <1% from 4-6 m <8% from 0-6 m	Morbidity for scours (S) and pneumonia (P) 1-60 d; <25% (S), <10% (P) 2-4 m; <2% (S), <15% (P) 4-6 m; <1% (S), <2% (P) 0-6 m; <28% (S), 27% (P)	DCHA (2009)

CCI = Calving to conception interval; AFC = Age at first calving; CI = Calving interval.

finding as the calf mortalities from the other reported studies varied from 10% to 35%, with one Vietnamese study reporting only 7% calf mortality.

Unfortunately, the studies documented a wide variety of ages over which calf mortalities were reported, making it difficult to fully interpret the data. However, a range of 15 to 25% pre-weaning and early post-weaning mortality rates would be typical on many tropical dairy farms. De Jong (1996) concluded that typical calf mortalities in the tropics, of 20 to 45%, are much higher than the 7 to 16% found in temperate regions because of high disease incidences and low feeding levels. This was further compounded by the low value of calves reared for meat or as replacement heifers. With regard to its potential economic impact, Amuamutu et al. (2006) calculated that a calf mortality rate of 20% can reduce dairy farm net profits by 38% compared with a target mortality level of 5%.

For comparison, the US Dairy Calf and Heifer Association (2009) present "gold standards" for dairy farms in the US, namely less than 8% mortality from birth to 6 months. Accepted norms are even lower in Australia (Moran, 2002), where a recent survey of 300 dairy farmers

reported mortalities due to illness in calves reared to weaning to be only 3.3% (McNeil, 2009).

In his survey of 112 small holder farms in Ethiopia (Study 11 on Table 1), Jemberu (2004) reported that many of the farmers considered high calf mortality to be their number one herd health problem, compared to mastitis and infertility. On the 3 larger farms he surveyed, calf health problems were generally rated second behind mastitis. The incidence of calf health problems (that is the morbidity, in contrast to mortality) was higher on the 3 large farms, probably due to the greater number of calves being reared hence the potential for transfer of pathogens. However, despite the lower morbidity on small holder farms, mortality rates were higher, which the author interpreted as poorer management of sick calves and lack of easy access to health professionals for calf treatment.

Poor adaptation of imported stock

High calf mortality can also be the result of poor adaptation of exotic stock, for example when unacclimatised temperate or crossbred dairy stock are imported to the tropics, thus adding severe climatic stress to the other hazards of calf life. Vaccaro (1990) reviewed published data on the losses of European dairy breeds in the tropics, compared with European×zebu crossbreds. He separated data for European breeds as to whether the dams of the calves were imported or they originated from local or mixed origin. Approximately 15% of the imported calves failed to reach first calving or survive their first year of life. The published losses for different stages of young stock management for imported stock versus those of local/mixed origin were respectively:

- 12.1 vs. 6.7% for abortions
- 9.2 vs. 6.0% for stillbirths
- 37.6 vs. 19.9% for calf deaths
- 1.4 vs. 1.9% for calf culls

Following weaning, the average wastage rates up to first calving for both groups amounted to 3.9% for heifer deaths and 6.6% for heifer culls. Over their herd life, imported stock only produced 2.6 calves compared with 3.1 for the local cows. Of every 100 females conceived, an average of 56 would have died or been culled before first calving in the case of imported dams, compared to only 39 for local dams.

Clearly, young stock management of exotic dairy stock or their progeny require closer attention than was the case prior to 1990, and possibly even after. Anecdotal stories during the 2000s of high mortalities among imported European dairy heifers, milking cows and their progeny calves and heifers in various Asian countries clearly indicate that their survival, as well as their post calving performance, could still be vastly improved.

The effect of grazing system on calf and heifer mortalities

Table 2 presents the results of a detailed survey, undertaken between 1996 to 1998, in which Bede (2008) and Bebe et al. (2003) documented the dairy herd dynamics of 1755 small holder farms in the highlands of Kenya. Of these farms, 987 had dairying enterprises as part of their mixed farming systems, and these had evolved to diversify the risks from dependence on a single crop or livestock enterprise. There was a large movement of weaned heifers from their home farms to other dairy farms as purchased heifer replacements. This strategy was used by farmers to reduce spending scarce feed resources on raising as yet, unproductive stock.

In the densely populated highlands of Kenya, farmers have had to intensify their dairy systems, by changing from free grazing to zero grazing, due to decreasing farm sizes. This led to changes in herd structure with more emphasis on milk production and increased stocking rates. High stocking rates were maintained through cut and carry feeding of Napier grass and crop residues, as well as sourcing additional fodder from neighbours and communal areas, together with purchasing more concentrates.

Farm sizes and total herd numbers decreased as farms became more intensive. In addition, calves were more likely to be bucket fed, they were fed less milk to 3 months of age, and were weaned earlier. The cows produced more milk. However, the proportion of heifers to cows was reduced because they were younger when sold to other farmers as heifer replacements. To provide sufficient heifers for a more intensive dairy industry, Bede (2008) recommended an increasing need for heifer breeding and growing farms.

Mortality rates of all classes of stock were very high, varying from 7 to 19%, but were not statistically significant across grazing systems for any of the animal classes. Losses due to animal diseases and their interaction with nutritional level were a major constraint to small holder dairying irrespective of grazing system. With 25% of the heifers dying and 22% being sold before breeding, only 53% of the heifers on the zero grazed farms could have become pregnant, produced milk hence generated farm income.

The high mortality and low calving rates then led to very high reproductive wastages, irrespective of the level of farm intensification. Together with the numbers of heifers sold, many of these farms were not able to maintain sufficient heifers for their own herd replacements. Herd sizes could not then increase without an external supply of replacement animals. Constraints to rearing replacement heifers on these farms ranged from high losses due to disease and malnutrition through to inadequate breeding services and credit.

Table 2. The effect of grazing system on heifer rearing and herd dynamics on 987 farms in the Kenyan highlands (study reported by Bede, 2008)

Grazing system	Free grazing	Semi zero grazing	Zero grazing	Average	Sig
Number of farms	227	326	434	-	-
Farm size (ha)	2.4	1.8	0.9	1.7	*
Herd size (number)	4.3	3.1	2.1	3.2	*
Cows (number)	2.2	1.7	1.2	1.7	*
Calves fed milk using buckets (%)	38	61	68	60	*
Milk fed to calves to 3 mth of age (L/calf)	321	230	193	-	*
Average weaning age (mth)	5.5	4.6	3.8	-	*
Proportion of heifers to cows (%)	40	36	29	-	*
Cow milk yield (L/d)	3.8	4.8	5.6	-	*
Stocking rates (TLU/ha)	1.1	1.0	1.4	1.2	*
Proportion of cows in the herd (%)	51	55	62	53	*
Annual calving rate (%)	69	51	52	58	*
Age at first calving (yr)	2.8	2.7	2.5	2.7	*
Heifer calf mortality (%)	15	13	15	14	-
Heifer mortality (%)	8	12	7	9	-
Cow mortality (%)	13	14	12	13	-
Bull calf mortality (%)	21	19	14	18	-
Immature bull mortality (%)	16	16	11	14	-
Mature bull mortality (%)	13	10	13	12	-
Heifers dead before reaching breeding age (%)	27	31	25	28	-
Heifers sold before reaching breeding age (%)	11	15	22	15	*
Heifers reaching breeding age (%)	62	54	53	57	*

Classification of stock. Heifer calf, pre-weaned female; Heifer, post-weaned until first calving; Cow, after first calving; Bull calf, pre-weaned male; Immature bull, post weaned to 3 years old; Bull, older than 3 years.
TLU = Total Livestock Unit; Stocking rate weighted for bulls (1.0), cows (0.7), heifers/young bulls (0.5) and calves (0.2).
Sig, * Significant difference between grazing systems.

REASONS FOR POORLY REARED CALVES IN THE TROPICS

Young stock require greater attention on tropical than temperate farms for a wide variety of reasons. Many of these (documented by Aiumlamai, 1999; Moran, 2005; 2009; 2011) are listed below.

- The tropical environment encourages the proliferation of many disease organisms that can reduce calf and heifer performance. These include some diseases that only occur in the tropics.
- Dairy cows are essentially temperate animals which are most comfortable 6 to 18°C. The high tropical temperatures and humidities introduce specific climatic stresses that adversely affect calf and heifer feed intakes, growth rates and fertility.
- As ambient temperatures approach body temperatures, stock rely more on cutaneous evaporation to remove residual body heat, and this is less efficient than other forms of heat loss, requiring increasing amounts of water and minerals.
- The stock on many small holdings are multi-purpose, being farmed for manure, meat and even draught, in addition to milk. Young stock management is often not a high priority on such farms.
- Many of the dairy farms are small holdings where farmers often lack the resources to develop the most effective rearing systems for young stock, since most of their attention is directed towards income generation, namely through feeding and managing their milking cows.
- The best way to reduce calf mortality is to practice good husbandry. Some common ailments can be treated by the farmer, but once a calf is seriously ill or large numbers are ill, expert veterinary advice should be sought and are not readily available.
- Levels of shed hygiene are often suboptimal and this can have detrimental effects on monogastric animals such as milk-fed calves.
- The nutritive value of tropical forages is generally poorer than that in temperate areas, so weaned heifers cannot grow as fast as they do in temperate regions without continual access to high energy and protein

supplements. As these are generally more expensive than forages, farmers are less likely to provide sufficient amounts.
- Suboptimal feeding regimes, leading to low growth rates, can greatly reduce feed efficiency in replacement heifers.
- In many cases, farmer extension programs place little emphasis on feeding and managing calves and heifers because of the extended time required for such investments to reap rewards.
- Service providers and agribusiness are less able to source the most up to date equipment and farm inputs, such as the latest generations of veterinary drugs or calf milk replacers that are more readily available to farmers in the developed temperate dairy regions.
- Many veterinarians are not fully aware of the most recent treatment and prevention animal health protocols readily adopted by dairy farmers in more developed countries.
- Farmers are not fully aware of the high costs associated with poor management of young stock, arising through firstly, the high wastage rates of calves and heifers and secondly, the detrimental effects on potential milk yields and fertility.
- Delayed calving can greatly increase the total costs of rearing replacement heifers.
- We know less about the constraints to the performance of young stock in the tropics because there has been less research undertaken. Accordingly, there is less relevant extension material available for dissemination to tropical dairy industries. The "bottom line" is fewer resources are devoted to young stock management in the tropics.

EXTENSION PROGRAMS ON CALF AND HEIFER REARING IN THE TROPICS

Clearly there is much to improve on most tropical dairy farms (large scale or small holder) with regards to calf rearing. Several studies have quantified the impacts of simple extension programs on the improved performance of milk fed calves and weaned heifers in the tropics.

Sri Lankan study

To reduce calf mortality and age at first calving of heifers in an artificial insemination heifer calf rearing scheme during the 1990s, the Sri Lankan Ministry of Livestock Development instigated a heifer rearing program which supported smallholders with subsidised calf meal together with free mineral mixtures, drugs and acaricides for 30 months. Nettisinghe et al. (2004) reported the outcome amongst 100 smallholder farmers in the Coconut Triangle grazing and the peri-urban dairy production systems in the wet lowlands of Western Province. About 50 scheme and 50 non-scheme farmers were surveyed in the two production systems three years after the scheme finished and the data are summarised on Table 3. Virtually all the coconut grazers were part-time dairy farmers and

Table 3. The benefits in belonging to an AI heifer rearing scheme in the Western Province of Sri Lanka (study reported by Nettisinghe et al., 2004)

Production system	Coconut grazing		Peri-urban	
	Scheme	Non-scheme	Scheme	Non-scheme
Number of cattle/cows per farm	5.3/2.5	5.7/2.8	8.3/4.4	8.5/4.4
Peak milk yield in 1st lactation (kg/d)	4.2	4.0	5.8	5.9
Conc fed at peak yield (kg/d)	0.8	0.6	2.0	2.1
Calf weaning age (m)	5.7	5.9	3.3	3.2
Weight at 24 m (kg)	273	233	238	221
Age at 1st calving (m)	31.1	36.0	33.5	37.9
Calf mortality (%)	12.5	23.4	14.2	28.7
Young female stock present per cow	0.9	0.6	0.6	0.5
Deworming frequency	2.6	1.5	1.4	1.4
Deticking frequency	5.1	3.7	4.8	4.1
Minerals fed (kg)	2.0	1.2	1.0	1.5
Milk fed (L/calf)	660	572	328	298
Concentrates fed (kg/calf)	646	112	569	66
Concentrate costs (Rs/calf)	847	492	577	518
Total rearing costs (Rs/calf)	14,737	6,432	14,419	6,531
Total returns (Rs/calf)	22,598	12,666	27,482	12,434
Total profit (Rs/calf)	7,861	6,234	13,063	5,903

Rs = Sri Lankan rupee.

supplied the formal milk market (receiving 10 to 11 Rs/L in 1999) whereas the peri-urban farmers supplied the informal milk market (receiving 19 to 20 Rs/L) while about one third of them were full time dairy farmers. About half the coconut grazing farmers stall fed their stock whereas most of the peri-urban farmers employed grazing only.

Live weight at 24 months varied between breeds with Friesians being the heaviest (244-251 kg), followed by Australian Milking Zebus (AMZ, 219-241 kg), then Jersey (220-248 kg) with the lightest being Sahiwal (191-204 kg). Scheme heifers calved five months earlier than non-scheme heifers (32 vs. 37 mth) while coconut grazing herds calved three months earlier than peri-urban herds (33 vs. 36 mth). Across breeds, scheme Jersey and AMZ heifers were the youngest to calve (28 mth) with non-scheme Sahiwal being the oldest (42 mth).

Calf mortalities were lower in the coconut grazing compared to the peri-urban herds (18 vs. 21%) and on former scheme compared to the non-scheme farms (13 vs. 26%), with 50 to 60% of these mortalities occurring in the first three months of age. In coconut grazing herds, scheme farmers had more young female stock present per cow whereas there was no difference with the peri-urban farmers.

Most non-scheme and former scheme farmers applied deworming drugs and fed concentrates, whereas less than half applied deticking, while very few fed minerals. On the coconut grazing farms, former scheme farmers dewormed their calves more frequently and spent more money on concentrate feeding than did non-scheme farmers. There was no difference in these calf management practices in former scheme or non-scheme peri-urban farmers. The former scheme peri-urban farmers had higher costs and, because of their higher unit milk returns, they still achieved higher profits than did the coconut grazing farmers.

Poorer calf housing and low level of health management led to peri urban farmers' herds experiencing higher calf mortalities (see Table 3 for details). The coconut grazing farmers' herds produced more female stock per cow because of reduced calf mortality and younger ages at first calving. As the peri-urban farmers were less motivated to continue the improved calf rearing practices after the scheme was stopped, differences between former scheme and non-scheme farmers was much smaller.

The total production costs per in-calf heifer was considerably cheaper than the production of such animals, either by multiplication on state farms or imports. The authors calculated the cost of importing one exotic heifer to be the same as producing 16 well adapted heifers from this study. As in other countries, importation of exotic stock or multiplication of breeding stock on state farms has a poor record for expanding dairy populations. This study showed that only in certain production systems, in this case grazing under coconuts, were farmers likely to continue their improved heifer management practices after such government-supported schemes had finished.

Kenya study

Lanyasunya et al. (2006) reported on a study of 120 small holder farmers in Kenya. It involved 60 test farmers, each provided with a chest girth tape (to estimate live weight), a spring balance and 10 L bucket (to weigh feed), a graduated jug (to measure milk) and a note book. An additional 60 control farmers continued with their traditional calf rearing practices. Each of the test farmers was also provided with moveable calf pens, compartmentalised with feed and water troughs, a daily heifer feeding schedule and forage planting material (which included improved tropical grasses and legumes). Test farmers regularly dewormed their calves and were visited every fortnight by extension staff. The dairy production systems were categorised as zero grazing, semi zero grazing or free grazing.

Pre-weaning growth rates were higher on the test farms (0.37 vs. 0.31 kg/calf/d) while calves offered legume forages (lucerne, *Desmodium and Leucaena*) grew faster than those only offered sweet potato vines (0.40 vs. 0.34 kg/calf/d). Mortality of heifer calves on zero grazed farms was lower than on semi zero and free grazed farms (6 vs. 15 vs. 20%). Mortality of bull calves was higher than for heifer calves, namely 13 vs. 6% on test zero grazed farms and 11 vs. 9% on control zero grazed farms. Heifer live weight at 24 months was 295 kg for zero grazed, 296 kg for semi zero grazed compared to only 240 kg for free grazed stock.

The key messages from this study included:

- The beneficial impact of legumes enabled calves to more efficiently utilise low quality forages
- Calf survival was improved because individual calf pens reduced disease transfer
- Better performance of zero grazed stock was due to greater attention and improved management

Tanzania study

Lyimo et al. (2004) surveyed calf rearing practices on 60 small holder mixed farmers in Tanzania, with average herd sizes of only 3 cows. The area had fertile soils and a favourable climate, therefore cropping was given greater emphasis than milk production. Most farmers practiced restricted suckling. Calf survival and growth rates were low, but no mortality data were provided. Calves only weighed 96 kg at 6 months of age. Calves stayed with their dams until 4 to 7 days, were only provided with concentrates after 4 weeks and were weaned at 4 to 6 months of age. Calves were then stall fed with limited forages and poorly formulated concentrates. The major constraints to forage supplies were season of year, labour, ease of harvesting and distance to forage supplies. Farmers ranked the problems in

calf rearing (mean score out of 8.0) as follows:

- Labour (7.5)
- Poor calf growth (7.0)
- Diseases (6.5)
- Little milk available (6.5)
- Inadequate knowledge (4.8)
- Mortality (3.4)

They ranked the options for improvement (mean score out of 8.0) as follows:

- Strategic feeding (7.7)
- Provide more supervision and adequate management (6.3)
- Use cheaper concentrates (5.5)
- Farmer's training (5.5)
- Adopt more appropriate housing (5.3)
- Allocate more funds to calf rearing (5.0)
- Accept technical advice (3.8)

Many of their problems were nutritional with strategic feeding of milk, concentrates and forages seen as most important. These can be solved by improved farmer training and supervision to practice more appropriate husbandry.

Philippines study

A study was undertaken in the Philippines in which heifers were reared in different systems from 3 to 12 months of age and their performance was monitored (Payne, 1967). They were raised indoors or at pasture or a combination of the two, with or without strategic drenching for internal parasites (Table 4).

The indoor/outdoor system was used as it provided protection from heat stress during the day while at night, the larvae of most internal parasites would move down the stems of the pasture so the calves could safely select the better quality components of the forages. Calf growth rates were highest in the two drenched groups with access to grazed pasture while mortalities were lowest in the indoor groups. Payne concluded that even allowing for their higher mortality, the overall production was superior in the indoor/outdoor and drenched group. The most dramatic finding was the very high mortality in the outdoor and non-drenched group.

The importance of good colostrum feeding management

Although this has not been well documented in tropical calf rearing extension programs, temperate studies have shown good colostrum feeding management to be one of the keys to low calf mortality (Moran, 2002). In his survey of calf mortalities on small holder farms in Ethiopia, Jemberu (2004) reported a close relationship between calf mortality and hours post birth when calves drink their first colostrums.

KEY PERFORMANCE INDICATORS FOR REARING REPLACEMENT HEIFERS

There are many hidden costs arising from poor management of the replacement dairy herd. The milking potential of small stunted animals that do not calve until three years of age can be markedly reduced (Moran and McLean, 2001), while very high mortality rates in calves during their milk feeding period represent an enormous waste of genetic potential in the dairy herd as well as cash outlay (Moran, 2002).

There are easily quantifiable benefits in having more newly calved heifers available to replace older unprofitable cows, as heifer and reproductive management improve (Morton et al., 2003). These benefits are:

- 1 to 2% more first calf heifers for every month reduction in age at first calving
- 3 to 5% more first calf heifers for every 10% reduction in calf mortality
- 2 to 3% more first calf heifers for every month reduction in inter-calving interval

Replacement heifers are bred to allow for the culling of cows no longer suitable for the milking herd. Good heifer management is then essential to provide sufficient animals for this to occur on a regular basis. The proportion of heifer calves that survive and grow well enough to become

Table 4. Performance of Friesian cross calves from 3 to 12 months of age under various rearing systems (study reported by Payne, 1967)

Management system	Drenched	Growth rate (kg/d)	Mortality (%)
Indoor (day and night)	+	0.38	6.7
	-	0.30	0
	Mean	0.34	3.3
Indoor (day) - outdoor (night)	+	0.40	10.0
	-	0.38	7.7
	Mean	0.39	8.8
Outdoor (day and night)	+	0.40	16.7
	-	0.37	40.0
	Mean	0.38	28.3

replacements depends on the many factors described above. These can be quantified as the proportion of

- Milking cows that actually conceive (the conception rate)
- Those that produce a live calf (namely, do not abort during pregnancy or suffer neonatal death)
- Those that are heifers (usually 50% of the viable calf drop, except when using sexed semen)
- Those that survive until calving (namely, do not die during milk rearing and post weaning)
- Those that conceive as maiden heifers
- Those that are suitable as milking cows in the herd (for example are not culled because of poor temperament or because of lengthy illness)

STOAS (1999) compared reproduction and calf survival in two rearing systems to calculate their relative replacement rates for a dairy herd with stable stock numbers (in Table 5). System A measures could be considered as a set of Key Performance Indicators.

Assuming cows remain in the milking herd for four to five lactations, 20 to 25% should be replaced each year. From Table 5, the supply of 36% heifers from System A allows for the sale of young breeding stock or a higher culling rate to better address genetic improvements in the herd. Only one in every six or seven cows could be replaced annually in System B, which would hardly be enough to maintain herd numbers, let alone allow for much genetic selection.

With high ages at first calving (>30 months) and long inter-calving intervals (>15 months), it is very difficult to increase herd size through natural increases. That is why it is so important to seek the underlying causes of herds with high percentages of dry cows or a high proportion of heifers to cows. The most likely cause is poor feeding management but there could be others, such as disease, heat stress or simply poor reproductive practices.

Farmers should aim to rear 20 to 25% of their milking herd each year as replacements, to calve down for the first time by about two years of age and produce at least five calves during their productive life. Realistic target for tropical dairy systems (Moran and Tranter 2004) are:

Table 5. Measures of reproduction and calf rearing to produce replacements for a stable dairy herd on 2 rearing systems (A and B) in the tropics (data reported by STOAS, 1999)

Rearing system	A	B
Calving interval (m)	12	18
Calving rate (%)	85	65
Still born calves (%)	2	5
Calf mortality from 0-24 m (%)	8	20
Non-pregnant heifers (%)	5	10
Heifer calves born (%)	36	15

- Calf mortality to weaning, 4 to 6%
- Heifer wastage rate from birth to second calving, 20 to 25%
- Live weight at mating, 250 to 300 kg
- Live weight at first calving, 400 to 500 kg (depending on breed type)
- Age at first calving, 28 to 30 months.

STRATEGIES FOR IMPROVING YOUNG STOCK MANAGEMENT

High calf mortalities on tropical dairy farms should not be accepted as “the norm” and need to be addressed by extension programs targeting the following aspects of management:

- Ensuring effective transfer of passive immunity to all new born calves through good colostrum feeding management
- Housing to minimise transfer of disease between calves, such as using individual pens or calf crates
- Good hygiene of calf pens and feeding equipment
- Providing clean drinking water within their first week of life
- Milk feeding regimes to encourage early rumen development through restricting access to limited quantities of raw milk or quality calf milk replacers so calves will seek out solid feeds
- Appropriate feeding management based on formulating palatable calf concentrates to supply adequate energy, protein and fibre
- Close attention to animal health to minimise the incidence of calf scours, pneumonia and other diseases prevalent in many traditional calf rearing systems
- Adequate climate control to reduce the adverse effects of heat stress on calf performance
- Good record keeping so farmers can more easily identify susceptible calves and quickly treat potential problems
- Ensure easy access to veterinarians and other animal health specialists to develop and implement effective animal health programs

Good colostrum feeding management

For each hour delay in colostrum feeding in the first 12 h of life, the chance of a calf becoming ill increases by 10%. The key to ensuring new born calves have adequate transfer of passive immunity, through absorbing sufficient antibodies into their blood stream, during their first day of life, is to follow the principles of the 3 Q’s, namely:

i) Quality; providing good quality colostrum
ii) Quantity; ensuring calves ingest sufficient antibodies

iii) Quickly; timing the first feed to ensure efficient absorption from the gut to the blood.

These principles can be quantified as follows:

- Use colostrum from mature cows that produce less than 8 L during their first milking
- Use only first milking colostrum
- Feed 4 L to large calves and 3 L to smaller calves at first feeding
- Feed colostrum as soon as possible, at least within the first 3 h after birth
- Do not let calves suckle their dams

CONCLUSION

Poor heifer management is a major problem in many (if not most) small holder dairy farms throughout Asia and other tropical countries. Young stock receive insufficient attention because they do not generate income for many months. In addition, their first three months are the most expensive period in the life of any dairy cow and many farmers are just not prepared to invest in the calves' future. A low calf mortality rate indicates that early milk rearing practices are adequate and it provides greater opportunity for economic and genetic improvement in the herd. When a calf or heifer dies, there are fewer opportunities for culling unprofitable cows.

REFERENCES

Aiumlamai, S. 1999. Dairy management and animal health. Chapter 12. p. 225. Small holder dairying in the tropics (Ed. L. Falvey and C. Chantalakhana). ILRI, Kenya.

Amuamuta, A., B. Asseeged and G. Goshu. 2006. Mortality analysis of Fogera calves and their Friesian crosses in Andassa Cattle Breeding and Improvement ranch, north west Ethiopia. Rev. Med. Vet. 157:525-529.

Asseged, B. and M. Birhanu. 2004. Survival analysis of calves and reproductive performance of cows in commercial dairy farms in and around Addis Ababa, Ethiopia. Trop. Anim. Health Prod. 36:663-672.

Bede, B. O. 2008. Dairy heifer rearing under increasing intensification of smallholder dairy systems in the Kenyan highlands. Livestock Research for Rural Development 20(2). http://www.lrrd.org/lrrd20/2/bedea20022.htm

Bebe, B. O., S. A. Abdulrazak, P. O. Ogore, J. O. Ondiek and T. Fujihara. 2001. A note on risk factors for calf mortality in large-scale dairy farms in the tropics: A case study on Rift Valley area of Kenya. Asian-Aust. J. Anim. Sci. 14:855-857.

Bebe, B. O., H. M. Udo, G. J. Rowlands and W. Thorpe. 2003. Smallholder dairy systems in the Kenya highlands: cattle population dynamics under increasing intensification. Livest. Prod. Sci. 82:211-221.

Dairy Calf and Heifer Association. 2009. DCHA gold standards-Part V. Mortality and morbidity, DCHA Tip of the week, Sep 22, 2009.

De Jong, R. 1996. Dairy stock development and milk production with smallholders. Ph D thesis, 303 pp, Wageningen University, Netherland. http://library.wur.nl/WebQuery/wda/abstract/929615

French, N. P., J. Tyrer and W. M. Hirst. 2001. Smallholder dairy farming in the Chikwaka communal land, Zimbabwe: birth, death and demographic trends. Prev. Vet. Med. 48:101-112.

Gitau, G. K., J. J. McDermott, D. Walter-Toews, K. D. Lissemore, J. M. Osumo and D. Muriuki. 1994. Factors influencing calf morbidity and mortality in smallholder dairy farms in Kiambu district of Kenya. Prev. Vet. Med. 21:167-177.

Jemberu, W. T. 2004. Calf morbidity and mortality in dairy farms in Dedre Zeit and its environs, Ethiopia. M Vet Sci thesis, Addis Ababa, Ethiopia.

Kivaria, F. M., J. P. Noordhuizen and A. M. Kapaga. 2006. Prospects and constraints of small holder dairy husbandry in Dar es Salaam region, Tanzania. Outlook Agric. 35:209-215.

Knopf, L., C. Komoin-Oka, B. Betschart, B. Gottstein and J. Zinsstag. 2004. Production and health parameters of N'Dama village cattle in relation to parasitism in the Guinea savannah of Cote D' Ivoire. Rev. Elev. Med. Vet. Pays. Trop. 57:95-100.

Lanyasunya, T. P., W. H. Rong, S. A. Abdulrazak and E. A. Mukisira. 2006. Effect of supplementation on performance of calves on small holder dairy farms in Bahati Division of Nakura District, Kenya. Pakistan J. Nutr. 5:141-146.

Lobago, F., M. Bekana, H. Gustafsson and H. Kindahl. 2006. Reproductive performances of dairy cows in smallholder production system in Selalle, Central Ethiopia. Trop. Anim. Health Prod. 38:333-342.

Lyimo, H. L., L. A. Mtenga, A. E. Kimambo, T. Hvelplund, G. H. Laswai and M. R. Weisbjerg. 2004. A survey on calf rearing systems, problems and improvement options available for the small holder dairy farmers on Turiani in Tanzania. Livestock Research for Rural Development 16(4). http://www.cipav.org.co/lrrd/lrrd16/4/lyim16023.htm

McNeil, J. 2009. Program to maintain calf rearing standards. Aust. Dairy Farmer, pp. 95-98, Sep/Oct 2009.

Madalena, F. E., R. L. Teodoro, A. M. Lemos and R. T. Barbosa. 1996. Comparative performance of six Holstein-Friesian× Guzera crossbred groups in Brazil. 8. Calf mortality. Rev. Brasil Genet. 18:215-220.

Menjo, D. K., B. O. Bebe, A. M. Okeyo and J. M. K. Ojango. 2009. Analysis of early survival of Holstein-Friesian heifers of diverse sire origins on commercial dairy farms in Kenya. Trop. Anim. Health Prod. 41:171-181.

Moran, J. B. 2002. Calf rearing: A practical guide (2nd Ed). 210 pp. LandLinks, CSIRO, Melbourne. http://publish.csiro.au/pid/3164.htm

Moran, J. B. 2005. Tropical dairy farming. Feeding management for small holder dairy farmers in the humid tropics. 290 pp. CSIRO Publications, Melbourne. http://www.publish.csiro.au/nid/197/issue/3363.htm

Moran, J. B. 2009. Business management for tropical dairy farmers. 280 pp. CSIRO Publications, Melbourne. http://www.publish.csiro.au/nid/220/issue/5522.htm

Moran, J. B. 2011. Rearing young stock on tropical dairy farms in Asia. CSIRO Publications, Melbourne (in press).

Moran, J. and D. McLean. 2001. Heifer rearing. A guide to rearing

dairy replacement heifers in Australia. 135 pp. Bolworth Press, Vic. http://publish.csiro.au/pid/2947.htm

Moran, J. and B. Tranter. 2004. Reproductive management of smallholder farmers in Vietnam. F & N Vietnam Foods & DPI Kyabram, Apr 2004.

Morton, J., M. Larcombe and S. Little. 2003. The InCalf book for dairy farmers. Dairy Australia, Melbourne.

Msanga, N. Y. and J. K. A. Bee. 2006. The performance of Friesian×Boran managed extensively under agropastoralism with indigenous Tanzanian Zebu. Livestock Research for Rural Development 18 (2). http://www.lrrd.org/lrrd18/2/msan18020.htm

Nettisinghe, A. M., H. M. Udo and F. A. Steenstra. 2004. Impact of an AI heifer calf rearing scheme on dairy stock development in the Western Province of Sri Lanka. Asian-Aust. J. Anim. Sci. 17:18-26.

Payne, W. J. A. 1967. Cited in http://www.most.gov.mm/techuni/media/BioT_04042_p1_4.pdf

Suzuki, K. 2005. Investigation into the constraints to dairy cattle health and production in north Vietnam. Ph D Thesis, Royal Veterinary College, University of London.

STOAS. 1999. Reproduction in dairy cattle. Book 1. STOAS, Wageningen, Netherlands.

Tiwari, R., M. C. Sharma and S. P. Singh. 2007. Buffalo calf health care in commercial dairy farms: a field study in Uttar Pradesh (India). Livestock Research for Rural Development 19 (3). http://www.cipav.org.co/lrrd/lrrd19/3/tiwa19038.htm

Vaccaro, L. 1990. Survival of European dairy breeds and their crosses with Zebus in the tropics. Anim. Breed. Abstracts 58: 475-493.

Vaccaro, L. D. and R. Vaccaro. 1981. Losses up to first calving in Brown Swiss×Zebu and Holstein Friesian×Zebu heifers in an intensive system of milk production in the tropics. Trop. Anim. Prod. 6:308-317.

Wymann, M. N. 2005. Calf mortality and parasitism in periurban livestock production in Mali. Ph D thesis. University of Basel, Germany.