CALF MORTALITY SURVEY

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SUMMARY

On request of the Ministry of Agriculture, the Animal Health Regional Services from the Secretariat of the Pacific Community conducted a survey on calf mortality in collaboration with Fiji Animal Health and Production Service. The purpose of this survey was to identify the origins of the lack of replacement stock. Thirty dairy farms were randomly selected and surveyed for one year. A recording system was implemented for each calf present on the farm. Farmers' practices were assessed with a questionnaire at the beginning and at the end of the survey. Farmers were asked to contact the survey officers when a calf died so that a post mortem examination could be performed.

The farmers' collaboration varied, especially concerning the death notices. Death was most of the time preceded by parasitic diarrheas and pneumonias and autopsied carcasses were emaciated and highly dehydrated. As an average, mortality was 17.5% (confidence interval 13.4% to 21.6% at the 95% level of probability), with a maximum mortality of 50% on some farms.

The monthly distribution of mortality suggested that high temperatures had a harmful impact on the livestock. The questionnaire revealed a connection in between the livestock farming practices and mortality. In most of the cases, farmers' monitoring on the livestock was revealed to be insufficient. Lack of record-keeping led farmers to make mistakes with livestock and finance management. The combination of lack of drinking water, heat-stress due to high temperatures and parasitic diarrheas account for high mortality rates.

Recommendations addressed to the Fiji Animal Health and Production Service and to the farmers consisted in improving skills in livestock management and promoting a regular livestock monitoring.

RÉSUMÉ

Une enquête sur la mortalité des veaux dans le secteur laitier de Fidji a été mise en place à la demande du Ministère de l'Agriculture fidjien afin d'élucider l'une des possibles causes au manque d'animaux de renouvellement. L'enquête a été conduite en collaboration entre le Service Régional de Santé Animale du Secrétariat général de la Communauté du Pacifique et les Services de l'Élevage fidjiens. Trente exploitations laitières ont été sélectionnées au hasard et suivies pendant un an. Un système d'enregistrement des données individuelles des veaux a été mis en place pour la période d'étude et les paramètres d'élevage ont été évalués au moyen de questionnaires en début et en fin d'enquête. À la mort d'un veau les éleveurs devaient prévenir les enquêteurs pour que l'animal soit autopsié.

La collaboration des éleveurs a été très variable, notamment s'agissant de la notification des décès. Les principales entités pathologiques impliquées dans les décès consistaient en diarrhées parasitaires et en pneumonies, la plupart des carcasses étaient émaciées et fortement déshydratées. La mortalité moyenne par ferme était de 17.5% (intervalle de confiance de 13.4% à 21.6% avec un niveau de probabilité de 95%) et pouvait s'élever jusqu'à 50% dans certaines exploitations.

Les variations mensuelles de la mortalité suggéraient une influence climatique avec un effet délétère des fortes températures. L'analyse des questionnaires a révélé une importante association entre les pratiques d'élevage et la mortalité. Le suivi des animaux par les éleveurs était insuffisant dans la plupart des cas et l'absence de tenu d'un cahier d'élevage conduisait les éleveurs à des erreurs de gestion zootechnique et financière. L'association entre l'abreuvement insuffisant des animaux, les conditions de stress thermique dans lesquelles ils se trouvaient et les diarrhées parasitaires expliquaient les taux de mortalité élevés.

Les recommandations adressées aux Service de l'Élevage fidjiens et aux éleveurs visent à améliorer les compétences en gestion zootechnique et à promouvoir un suivi plus régulier des élevages.

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Introduction

Dairy cattle in Fiji were first introduced in 1835 to supply milk and meat for the domestic market. In 1949 there were 132 registered dairy farms with 12,300 cows (ANON, 2000). At the end of the year 2001, there were 197 suppliers with 15,100 cows producing approximately twelve million litres of milk to the Rewa Dairy Co-operative (VERESA, 2001).

The dairy commodity profile of Fiji shows that the national milk production is 6L/cow/day and constraints to production are attributed to high rain fall, weed infested paddocks, mastitis, lameness, poor replacements, poor stockman ship, and poor management.

The Agricultural Development Programme (ADP) has been put in place for the years 2000 to 2005 with the focus on food security and self-sufficiency. The Governments direct involvement with the dairy farmers is through the Animal Health and Production, Division of the Ministry of Agriculture, Sugar, and Land Resettlement (MASLR). It provides services such as technology transfer, regulatory activities, disease control, treatment of clinical cases and advices. The government also has a dairy research station at Koronivia where experiments are carried out to improve dairy production. They are also involved in genetic improvement through artificial breeding, pasture research, and herd recording.

In November 2000 at the Livestock Industry Conference organised by AHP, some dairy farmers expressed concerns about low productivity and lake of replacement stock on farms. The Animal Health and Production Division sought the assistance and expertise of Secretariat of the Pacific Community (SPC). This prompted an investigation by SPC/MASLR to find the possible reasons for the problem. It had long been thought that calf mortality is an important factor contributing to the lack of replacement stock. A dairy farm should have should have sufficient replacement stock to enable a good selection and culling programme.

A survey was carried out to determine the calf mortality rate and to what extent this is a problem in the dairy industry.

Objectives

The survey targeted 3 different objectives:

- To assess the global calf mortality rate in the dairy industry of the Central Division, Viti Levu, Fiji;
- To investigate the causes of death of calves;
- To relate these deaths to the management practices of farmers.

I Method

1.1 General presentation of the method

The study of calf mortality in Fiji had to be prospective as farm records are usually very poor. A transversal survey was designed, as it was compatible with descriptive and etiologic studies.

The method chosen to select a representative sample of dairy farms, and monitor calf rearing during a period of one year in order to observe the influence of climatic factors. The monitoring included the assessment of the farmer practices at the beginning and the end of the survey, the recording of birth, sales and deaths of calves and the determination of the cause of death through post mortem examination.

1.2 Selection of farms, calves and duration of the survey

The surveyed zone was the Central Division of Viti Levu as this the area where most of the dairy farms are concentrated and it is also the most accessible region from Suva and Nausori.
The sample frame was an exhaustive listing of the 129 dairy farms registered in the Central Division, the records have been computerized on Microsoft Excel ©. The number of farms selected was a compromise between the accuracy of the results desired and the monitoring limits imposed by a two-people team. A sample of 30 farms was eventually selected, using the random selection function proposed by Excel ©.

Final inclusion of farms in the survey was decided after a first visit. Reasons for exclusion of farms were:

- Closure or change of production (no more calves present): 2 cases;

- Inaccessibility (more than 3 hours from Suva): 6 cases.

In addition to that four farms appeared to be uncooperative, although they manifested an interest at the beginning of the survey. It has been decided to exclude these farms and to replace them with four farms presenting the same main characteristics in order to keep the same sample pattern (Rumeau-Rouquette *et al.*, 1985). These farms were included during the survey and therefore presented a shorter period of surveillance.

An animal is considered as a calf up to the age of six months. All calves born during the survey period have been included, plus all calves less than 1 month old at the beginning of the survey, as farmers were able to remember information about animals born one month or less before the first meeting. Reciprocally, calves born 15 days before the end of the survey have not been included.

1.3 Collection of data

1.3.1 Assessment of farmer's practices

The assessment of farmer's practices was done on the basis of interview (Martin W. *et al.*, 1975 (1)). Two questionnaires (Appendix 1 and 2) were submitted to the farmers. The first questionnaire was submitted when farms were included in the survey, the second questionnaire, at the end of the survey. According to farmer linguistic level, interviews were made in English, Hindi or Fijian.

The first questionnaire, which was targeted to assess the farming system and management practices, had questions organised into nine groups:

- Identification of the farm;
- The farmer: sociologic characteristics, manpower and experience in dairy farming;
- Production: stock present, milk production, land characteristics and other production;
- Outlets for calves: destination, age and price of calves sold;
- Reproduction: practices and results of reproduction;
- Housing calves: type and management of calf sheds;

- Nutrition of calves: management and quality of calf nutrition from birth to weaning;
- Growth: parameters to estimate growth rate of calves and cost of rearing;
- Health: disease concerns in the farm and management of diseases, perception of calf mortality and possible improvements in the farm.

The closing questionnaire aimed to identify the main changes that could have occurred during the survey period and identify some points that were not clearly defined with the first questionnaire:

- Farmer: modification of manpower and work management;
- Production: stock present, milk production, land characteristics;
- Stock changes: details of death, theft, sales and acquisition of the different kind of animals;
- Reproduction: parameters of reproduction campaign;
- Housing calves: changes which occurred during the survey;
- Nutrition of calves: management and quality of calf nutrition from birth to weaning;
- Health concerns: management of calf's diseases, help from livestock officers;
- Record keeping, compliance to the survey and comments about the survey.

The number of questions was reduced, compared to the first questionnaire, because the answers to some questions at the first interview were not susceptible to change and the answers to some questions were completely unknown by farmers.

1.3.2 Monitoring of farms

The monitoring of farms consisted of regular visits and the provision of assistance with record keeping.

In order to assist and standardize records, record forms (Appendix 3) were distributed to farmers.

These forms were individual calf record sheets, which contained all information about the calf required to produce a satisfactory history.

Data can be summarized in 4 categories.

- Calf identification: farm number, date of birth, sex, breed, calf number and dam number;
- Growth history: with quantitative and qualitative parameters as all the farmers were unable to weigh or measure their calves. In case the calf died or was sold, the date of removal was to be recorded accurately;
- Health events: reports of disease observed and treatments given to the calf;
- Observation: blank box to let farmers put any observations about the calf that did not match one of the previous fields.

In order to assist smaller farms with the identification of their calves, ear tags were distributed, to encourage a good cooperation in record keeping.

1.3.3 Post mortem examinations

Following the discovery of a dead calf in the farm, owners were asked to contact the survey team as quickly as possible, by direct call to the office or via the nearest livestock officer. This enabled the survey team to go and to pick up the carcass and obtain the history of the animal.

Post mortem examinations (PME) were performed at the Veterinary Pathology Laboratory at Koronivia (VPL). Bacterial identification, faecal eggs count and coccidiosis counts were available for most of the carcasses submitted. Results were sent by mail to submitters.

The number of dead calves submitted for post-mortem which demonstrated a degree of decomposition during the examination, was very low (23) and it was not possible to use the data from these animals for etiologic analysis. In addition, reports of post-mortem examination of dead calves submitted to the VPL during 2001 and 2000 were analysed in order to summarize the principal causes of deaths found.

1.3.4 Climatic factors

Climatic data were collected from the Fiji Meteorological Service. Data included daily rainfall and temperature (minimum and maximum) recorded at the Nausori station for the period January 2001-February 2002.

1.4 Management and analysis of data

A database was created on Microsoft Access© to record all the results coming from the two questionnaires, individual calf records and PME reports.

Farmers' names were replaced by a numeric key in order to assure the confidentiality of the results. Open questions were entered verbatim and then recoded into individual variables according to keywords found in the answer.

The database Tables were exported to SPSS 10.0 for Windows © for recoding and statistical analysis. Two Tables were created, one relative to the description of farms, the other relative to the description of calves.

The questionnaires provided a total of 400 variables. Variables, without variation or with more than 5 (# 25 %) missing records, have been deleted.

In order to analyse farmer's practices, the following synthetic variables have been computed using the descriptive variables of both questionnaires (see Appendix 4 for details of coding).

- Complementation, paddock, milk feeding,

Food = paddock + complementation + milk feeding,

- Watering,
- Calf housing, protection,

Housing = calf housing + protection,

- Health, workers, recording, ownership,

Management = workers + recording + ownership,

- Reproduction,
- Land management, land tenure,

Land = land tenure + land management,

- Variation of income, milk production, selling,

Production = selling + milk production + variation of income,

Global note = sum of all the factors.

Comparing results of individual records, questionnaires and responses to related questions enabled the investigation to check consistency of the data. In the case of doubtful results, verification was done with the farmer. In a few cases, a sensible answer was not found and the variable was either considered as missing or calculated with an alternative method.

Consistent records of individual calves were collected from 17 farms. These records include date of birth, date of sale or death, sex, breed, and observed symptoms or reason of death.

Five farms returned inaccurate answers, in that case the number of calves born has been deducted from the number of pregnant cows minus the number of abortions. The number of dead calves recorded was compared to the number of calculated calves born minus the number of calves sold plus the animals still present on the farm. If an important distortion existed, the number of dead calves used for analysis was an average between the two values.

The calf mortality rate (CMR), is defined as the ratio of dead calves during the survey period compared with the number of births during the same period, and was calculated for each farm using individual records when available.

The average calf mortality rate was calculated for the 22 farms of the Central Division. Farms have been weighted (Falissard, 1998) according to the fraction of duration of survey (duration in day/365) and the ratio of the number of calves monitored by the number of calves expected.

The global mortality rate (GMR) has also been calculated for the region, using the total number of calves died over the total number of calves born.

Similarly a calf sale rate and calf exit rate were calculated for each farm and for the region.

The monthly calf mortality rate has been calculated for each farm as the number of calves dead per month divided by the number of calves present for that month (total born minus previously dead or sold, minus calves over 6 months). A global monthly calf mortality rate was calculated for all farms.

Correlations between monthly calf mortality rates and quantitative factors used the coefficient of Pearson; correlation between CMR and qualitative variables used the coefficient of Spearman. All correlations were explored by a two-tailed test with alpha 5 %. Correlations and partial correlations have been explored using the Pearson correlation coefficient and a two-tailed test. Comparisons of independent samples were done by a two-tailed Chi-square test and comparisons of means by a two-tailed ANOVA test, both at 5% level of significance (Bouyer *et al*. 1995, Falissard, 1998).

The economics of calf rearing are calculated for a minimum cost. Usual costs of rearing found in the literature (Crawford, 1998) take into account the milk and supplementary food given to calves according to quantity given and prices practiced (Appendix 5). In addition to that cost of drenching has been calculated. Three costs of rearing were calculated for three key ages: 2 weeks, 3 months and 6 months. The costs represent the minimum rearing cost, as fixed factors (sheds, labour, use of pasture) are not taken into account. The direct cost of mortality is modified from those usually found in the literature (Toma *et al.* 1996) and is defined as sum of the values of calves dead at an age plus the cost to rear them up to this age. When the age of death is unknown, the cost is calculated as for all deaths occurring at 2 weeks.

II Results

2.1 Calf mortality rate

The average calf mortality rate (CMR) for the region was 18.2 % and the mean of average calf mortality per farm was 17.5 % [13.4; 21.6] $_{5\ \%}$. It presented an important deviation (standard deviation = 0.124) and the distribution of CMR per farm, as shown in Table 1, indicates an interesting heterogeneity.

IDsurvey	*1*	*2*	*4*	*5*	*6*	*10*	*11*	*12*	*13*	*14*	*15*
Deaths	1	26	1	2	1	2	6	18	15	2	2
Births	97	86	23	16	19	32	125	69	117	18	51
CMR	1%	30%	4%	13%	5%	6%	5%	26%	13%	11%	4%
IDsurvey	*16*	*17*	*20*	*21*	*22*	*28*	*30*	*31*	*32*	*33*	*34*
Deaths	22	34	4	15	6	120	24	5	9	1	6
Births	101	187	15	43	19	332	337	17	44	9	12
CMR	22%	18%	27%	35%	32%	36%	7%	29%	20%	11%	50%

Table 1: births, deaths and CMR calculated per farm

2.1.1 Characteristics of Calf mortality

The CMR between farms from which individual records were available and from those farms where only yearly records were available were not found significantly different (comparison of 2 independent samples, $p>0.3$) so that findings resulting from the analysis of individual records were generalised.

There was no difference in mortality between males and females.

The repartition of age at death, shown in Figure 2, indicates that, in this survey, less calves died between 3 months and 6 months than at an earlier age and this is comparable for the period 2 weeks

to 3 months and before 2weeks. The differences in the distribution of age of death are statistically significant (Chi-square = 11.2; p=0.004) for deaths after 3 months but are not different for the others (before 2 weeks compared to 2 weeks to 3 months).

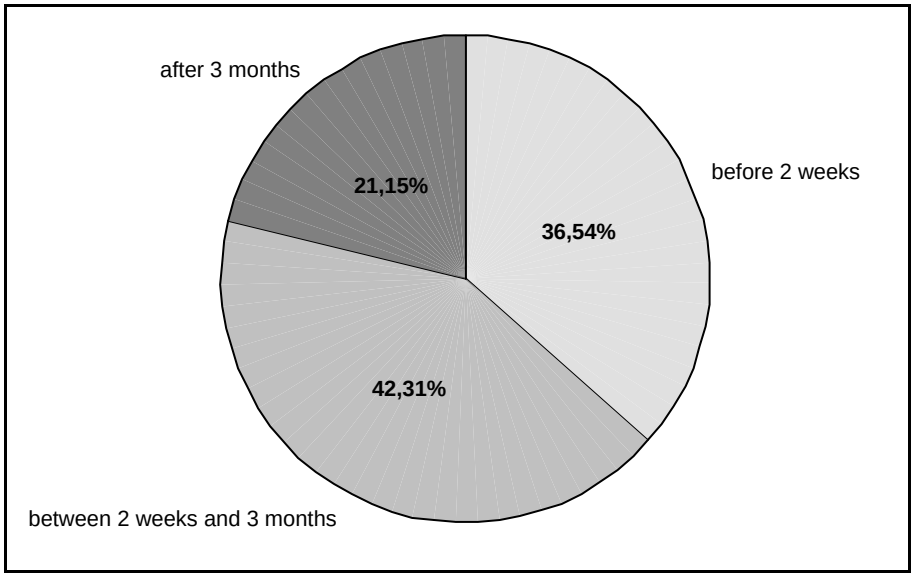

Figure 1: Distribution of age of death

The period from birth to 2 weeks also corresponds to the maximum number of calves sold as shown in Figure 2. The differences in the distribution of age when sold is significant (Chi-square = 126.4; p< 0.001).

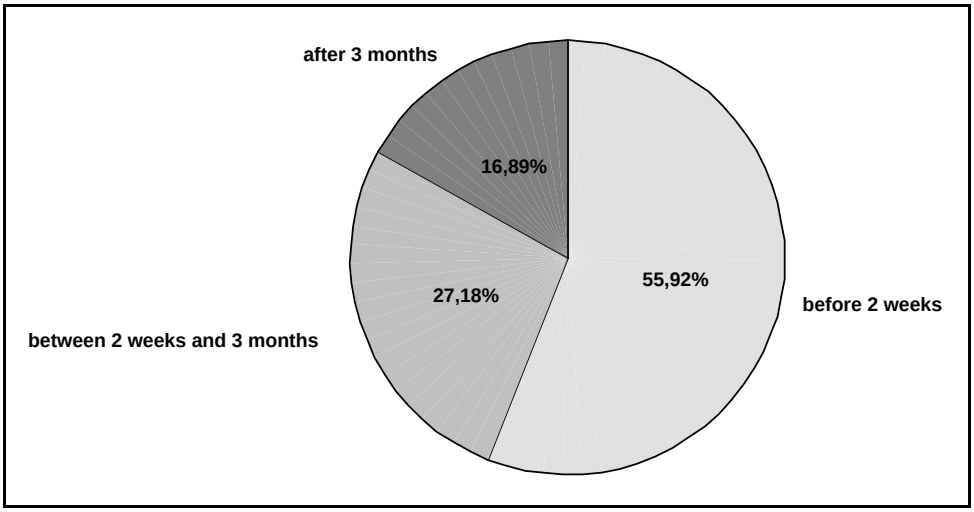

Figure 2: distribution of age when sold

Therefore it is interesting to reconsider the calf mortality rate by category of age, adjusted on the number of calves present, which is defined as the number of death at this age divided by the number of calves born minus calves sold or death at the previous class of age.

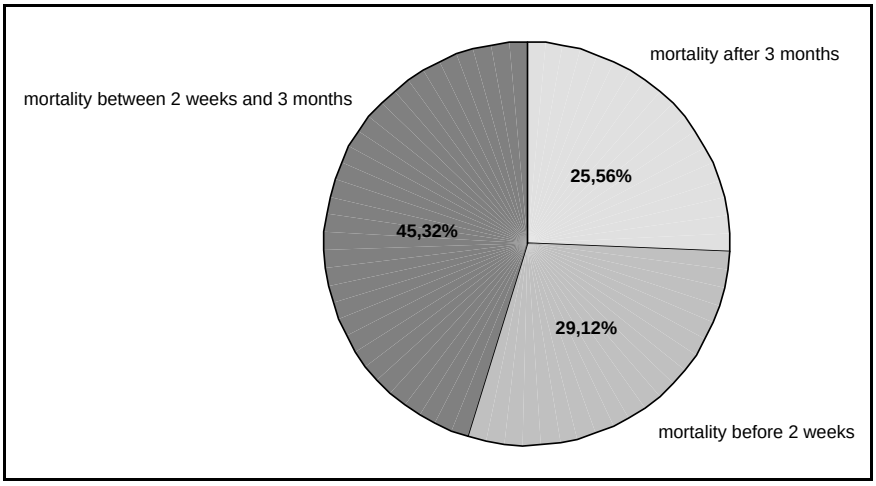

Figure 3: distribution of adjusted calf Mortality rate by age

The distribution, represented in Figure 3, shows that the adjusted calf mortality between 2 weeks and 3 months is the highest, meaning that 45.32 % of the mortality (and not the number of deaths) is represented by this class of age.

2.1.2 Seasonal patterns and climatic factors

Figure 4 shows the distribution of the monthly percentage of deaths and births over the full period of survey. The maximums deaths were observed in April and July but were not found significantly different from the rest. The monthly distribution of the number of births and deaths does not present any significant variation.

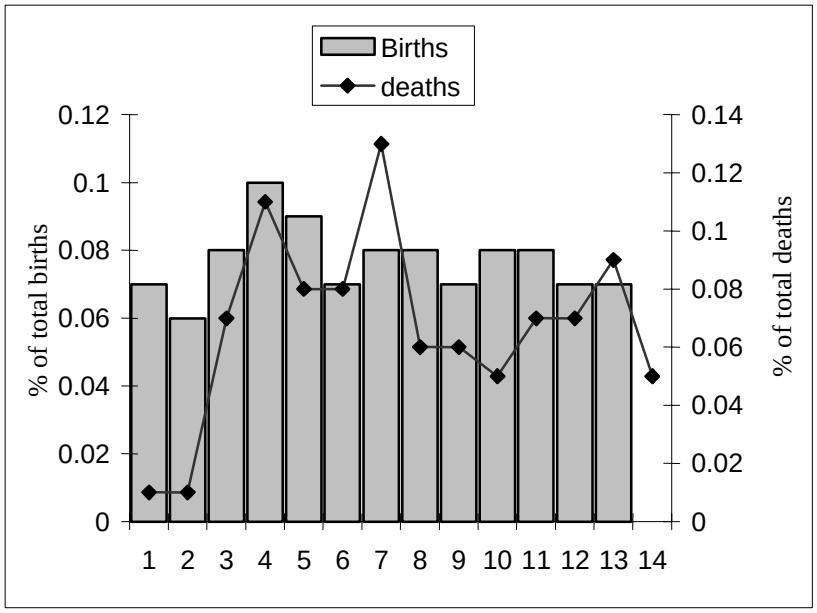

Figure 4: Distribution of percentage of births and deaths according to month of birth

The monthly calf mortality rate must not be confused with the percentage of total calf deaths and is given in Table 2.

	janv-01	févr-01	mars-01	avr-01	mai-01	juin-01	juil-01	août-01	sept-01	oct-01	nov-01	déc-01	janv-02	févr-02
Rainfall (mm)	329	208	237	295	73,9	146	82,1	191	76,9	330	211	448	611	428
Maximum Temperature (average in °C)	31,7	32,2	30,8	31	29,4	27	26,6	27,4	27,6	28,3	29,9	30,4	31,5	31,8
Minimum Temperature (average in °C)	23,4	23,6	23,5	23,6	22	20,5	20,4	19,7	20,6	20,5	21,9	23,2	23,8	24
Monthly CMR	2%	1%	4%	14%	7%	4%	3%	4%	5%	4%	5%	3%	6%	15%

Table 2: Monthly CMR, Min, Max temperatures and monthly rainfall during the survey period

There is a positive correlation between temperatures (average of minimum, maximum) and the monthly CMR. The highest correlation is found for the average of minimum temperatures ($r=0.405$, $p<1\%$). There is also a correlation between the rainfall and the monthly CMR but this one disappears on a partial correlation controlled by the temperature.

This aspect can be graphically represented by a histogram (Figure 5), where it is clear that CMR is higher when minimum temperatures are higher.

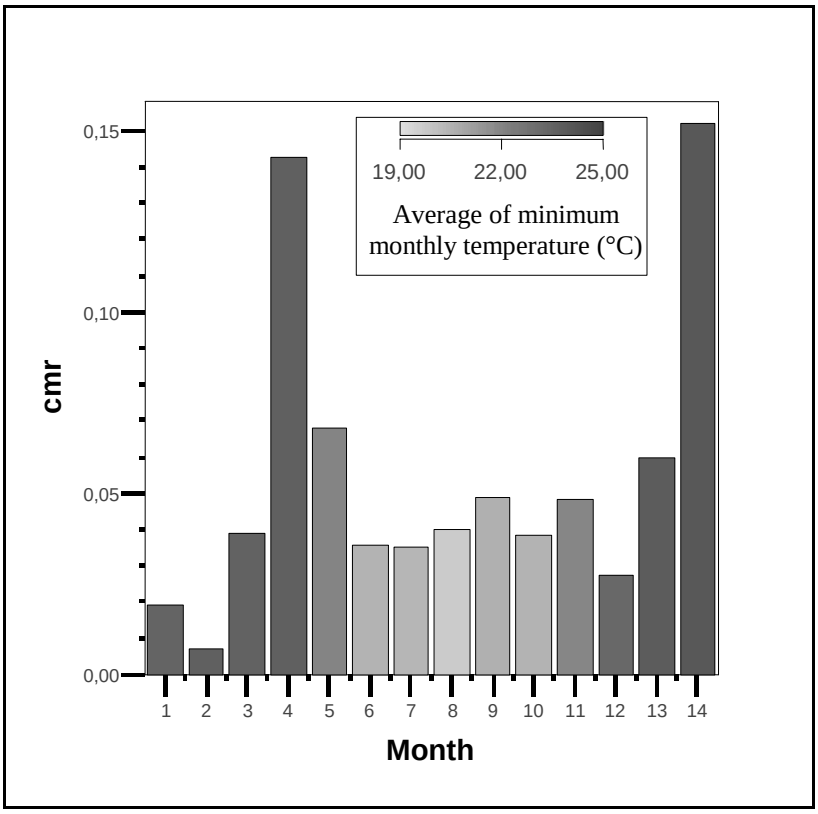

Figure 5: Distribution of monthly CMR with reference to monthly average of minimum temperatures.

There is a seasonal influence on death with a higher number of deaths occuring during the wet season (October to April). The correlation between the season and the CMR is not an effect of the difference of temperature as the partial correlation controlled by temperature is still significant (p=0.021) but when considering the rainfall, the partial correlation is no more significant. Therefore it appears that there is an effect of rainfall in the monthly calf mortality rate that acts through the seasonal pattern.

2.2 Farming practice

The scores of farmer's practices previously calculated are given in Appendix 3.

Correlations with CMR were found significant for the management score (Spearman coefficient = -0.423, p= 0.06), the housing score (Spearman coefficient = -0.518, p= 0.001), the watering score

(Spearman coefficient = 0.379, p=0.19), the health score (r=-0.396, p=0.14) and the global score (Spearman coefficient =-0.310, p=0.49). Correlations tested with control from the other factors were also found significant.

No effect on the CMR was found from the total number of births, neither the total number of cows.

The effect of housing type on CMR, described in Table 3, stresses the side effect of bad housing conditions comparing to a proper shed or no sheds at all.

Housing type	Number of cases	Mean of CMR		
calf shed overcrowded, or not maintained	12	24,92	Chi-Square	4,713
no calves shed	15	20,20	df	2
proper calf shed	12	14,83	p	0,095

Table 3: Effect of housing type on CMR

The farmer's practices showed a correlation between the management score and the CMR and between the housing score and the CMR. The management score and the housing score are also correlated (Spearman coefficient = 0.515, p= 0.001

The costs of rearing calves up to three key ages are given in Table 4.

Minimum cost of rearing from birth to:	Mean	95% Confidence		Min	Max	market price
		Lower	Upper			
to 2 weeks	10	8	12	3	20	25 to 30
to 3 months	134	109	158	50	220	80 to100
to 6 months	200	155	245	75	375	125 to 170

all prices in Fiji dollars

Table 4: Minimum cost of rearing and common market price of calves at key age

The actual benefit of selling a calf, which is actually a maximum benefit as the rearing cost is a minimum, was found negative for 9 farms.

There was no link between cost of rearing and CMR, and as was expected, there is a positive correlation between the food score and the cost of rearing (Spearman coefficient between CMR and Cost of rearing at 6 months: r= 0.492, p= 0.002).

The cost of mortality depends on the number of deaths, and therefore the size of the farm, however the Figures calculated as minimum values are over 3,000 for 6 farms and the average cost of calf mortality is FJ$ 1,780 (Table 5).

	Mean	95% Confidence		Min	Max
		Lower	Upper		
cost of death	1780	773	2788	73	7776
all prices in Fiji dollars					

Table 5: Minimum cost of calf mortality

The cost of mortality was superior to the benefit from selling calves in 14 farms. A positive correlation (Spearman coefficient = 0.406, p= 0.14) was found between the character positive or negative of the difference (benefit from selling - cost of mortality) the score of food, meaning that a maximum profit was done with a higher quality of the food.

The global sale rate for the region was 31.46 % and sale rate per farm was 20.6 % [14.2; 21.7] $_{5\,\%}$.

These two values are the main component of the calf exit rate, which was found equal to 38.1 % [31.0; 45.1] $_{5\,\%}$

2.3 Causes of death

Only a few farmers reported a cause of death on the individual records. Reported causes are given, in Table 6, for the 168 dead calves that had an individual record.

Total death	Stillbirth	Accident	Scour	Dog attack	Heavy rain	Unknown
168	19	3	32	30	6	78
	11.31%	1.79%	19.05%	17.86%	3.57%	46.43%

Table 6: Reported cause of death

There is no significant link between deaths reported as related to rain by the farmers and the monthly or weekly rainfall recorded by Fiji meteorological service.

Dog attacks occurred on 5 farms causing large losses.

III Discussion

3.1 Biasis and compliance difficulties

The following biasis are discussed for the questionnaire part of the survey.

Regarding the selection biasis, the sample frame was the exhaustive list of dairy farms of the surveyed region and the selection procedure was randomised. The cancelled farms were replaced by equivalent ones, therefore biasis of selection is minimal in this survey.

Biasis of assessment could have been avoided by using standardized scores for the different facts under consideration. A biasis could have been introduced through the language (as three different languages were spoke by farmers) but in that case it would have occurred in the same way for every farmers and the biasis would have not influence the results. Another biasis is due to the different quality of records available. The analysis of record quality revealed no difference for individual and global records, therefore the biasis did not influence the results in a specific way. Finally the number of dead calves could have been underestimated due to some missing records; in that case results are minima and recommendations given are de facto valid for a higher mortality. This biasis does not concern management factors as only individual records were kept for these analyses. Maybe for some farmers the need to fill records lead to an increased attention to calves and may have lead to lower mortality. Once again if such a phenomena occurred, the mortality found is a minimum and the recommendations are still valid.

Biasis of confusion was avoided by using controlled tests of correlation.

Post mortem which is sometimes described as a message from the dead to the living did not find the positive echo that was expected. Biasis are very important as the compliance of farmers has been generally very disappointing despite efforts made to increase and to grateful their involvement.

The poor number of dead calves examined was due to several factors:

Lack of farmer access to communication: six farms do not have their no own phone contact but three of them managed to contact the survey team on calves' death.

Lack of cooperation: some farmers did not notice the death of calves in time, some argued that calves were mainly dying on weekends or holydays, in that case it indicates a lack of farmer conscience and work management failure as there is no valid reason for calves to die more during weekends.

Lack of availability of the survey team: two calves were missed due to other tasks and three calves were collected at an advanced stage of decomposition.

Many attempts have been made during the survey to improve the situation: frequent visits to farmers (an average of five visits per farm and a total of 135 visits) during which ear tags were provided free with a few results. The lack of cooperation seemed to be greater among middle to large-scale farms. In some extent the lack of cooperation is a result in itself, demonstrating inconsistency from the farmers who submitted the request for this survey to the Fiji Ministry of Agriculture. The position of small farmers is more easily understandood as deaths are more perceptible at a smaller scale (although impacts are the same).

3.2 Examination of Calf Mortality

3.2.1 Value of Calf Mortality Rate(s)

Different calf mortality rates have been calculated, as there are different levels of understanding.

The global CMR describes what is happening in the region regardless of farm variations, it is not an average but an indicator of the regional stock mortality and it should be considered as an estimate of growth of stock. The value found is equal to 18.2 % and is a minimal estimate as explained before.

Such a mortality rate prevents the increase of dairy cattle numbers in the Central Division both in terms of quantity and quality.

The farm CMR describes the average mortality at farmer level, it takes into account variations from farm to farm, which is why it slightly differs from the global CMR. The value of 17.5 % is very highed, usually it is considered that calf mortality is an issue over 6% (RADOSTITS, 1997). Some farms are presenting CMR up to 50% and 8 farms are over 20%. Despite this some farms are limiting their calf mortality to below 5 %, thus calf mortality is not unavoidable and could be reduced. As the causes of deaths shows, good management can prevent deaths.

The calf mortality rates found in this survey are actually very similar to the levels found in developed dairy countries thirty years ago (Oxender, 1973; Martin, 1975) which is very encouraging in terms of implementing improvements. Causes of deaths in these studies were very close to the current findings in Fiji and deal more with management than actual animal health.

3.2.2 Explanation of death

3.2.2.1 Age of death

As diseases affect calves preferentially at certain stages of life, the age pattern of mortality is an indicator of the pathogen environment of the calves and must be carefully considered.

The distribution of age of death is subdivided into three categories: category one is during the first two weeks of life (29.12%), category two is from two weeks to three months (45.32%) and category three is from 3 to 6 months where fewer claves are dying than during the earlier stage (25.56%). The distribution of mortality shows that the problem is present at every stage of calves' life, meaning that different pathogens are present in the environment. Usually the critical period for calves are the first two weeks (RADOSTITS, 1997) with a high prevalence of septicaemia and enteritis, however in this survey the highest CMR is found for the period 2 weeks to 3 months. It is linked with the management practices, as this is the period where calves are the most dependent on humans in a management system where young calves are commonly kept with the mother for about ten days and

are partially protected by colostrum and following which they are less dependant on milk and indoor conditions.

The number of stillbirths or calves dying on their first day of life is relatively high in some farms. It does not seem to be due to specific diseases (such as BVD, Brucellosis, Leptospirosis…), as these more usually cause abortions and occasionally stillbirths. It is certainly related to the dam's conditions and to some extent to the calving by itself. Old cows or young heifers are more likely to give birth to weak calves and this is increased when the nutritional requirements are not properly covered (WARRINGTON, 1985). Calving difficulties may also be associated especially in animals in poor conditions.

The survivability of animals passed the age of 6 months has not been considered in this survey as the definition of calf goes up to 6 months. Nonetheless discussions with farmers revealed that the mortality after 6 months is not negligible, especially if weak calves are weaned.

According to the different periods of life many pathogens can be involved in calf mortality.

3.2.2.2 Pathogenic factors

Even if the post mortem examinations performed during the survey were not numerous, it is still possible to rely on the veterinary laboratory records to give a fair idea of diseases occurring among calves. The records consist of all dead calves from agricultural stations and calves submitted by private farmers on a voluntary basis from 1998 to 2001. These records are subject to quarterly and annual reports to which refer in need (Singh, 1998-2000).

The findings are the common diseases of calves and do not involve epizootic disease of national importance. In fact Fiji seems to be free from or infected at a very low level with a number of contagious diseases that cause major mortality problems elsewhere such as BVD or IBR.

The pathogenic process involved in calf mortality are typical and include diarrhoea, pneumonia and septicaemia, due to various causes.

The causes of diarrhoea include bacterial infection (E. coli enteritis; salmonellosis, campylobacteriosis) viral infection (rotaviruses and coronaviruses, the first is suspected to be circulating at a high level) and parasitism (cryptosporidies, coccidiosis, nematodes such as *Haemonchus sp., Cooperia sp., Bunostomum sp., Trichostrongylus sp. , Oesophagostomum sp.*). As calves are very sensitive to dehydration, diarrhoea can be quickly disastrous and lethal. It is also sometimes associated with pneumonia and/or septicaemia. Bacterial and viral enteritis are occurring during the first weeks of life, parasitism start to occur after a few weeks and there is a progression of species according to the physiologic maturation of ruminants from a mono-gastric to a poly-gastric behaviour.

Pneumonia can be due to bacteria (*Pasteurella haemolytica* or *P. multocida, Staphilococcus aureus, Corynebacterium pyogenes*) viruses (PI-3, BRSV, Herpes virus) or parasites (*Dictyocaulus viviparous*). Most of the time, it occurs within a multi-etiologic complex known as “enzootic pneumonia of calves”. Respiratory problems usually occur after the second week of life; verminous bronchitis usually affects older animals.

Septicemia usually occurs at earlier stage of life and leads to quick death. Bacteria involved are commonly *E. coli haemorragiae* but also *Klebsiella sp., Staphilococcus sp., Streptococcus sp.* Sources of septicaemia are usually existing infections, primarily localised in the lungs, the liver or the joints. Skin and navel (navel ill) are maybe the most common source of infection. For instance dermatophilosis (Figure 6) is wide spread in Fiji and contributes to make calves weaker and eases the penetration of opportunist’s germs through the skin.

Figure 6 : Dermatophilosis contributes to weake calves

During the survey, serology of leptospirosis was not systematically investigated and no clinical case was identified. Nonetheless it is possible that a high level of prevalence of the disease among cows lead to weak newborn calve, more susceptible to other diseases.

Some deaths are also accidental and include dog attacks and strangulation with ropes. Dog attack is a real issue as the dog population is not controlled and has potential to cause serious losses to farmers.

3.2.2.3 Climatic factors

The monthly calf mortality rate is higher during summer, independent of the seasonal calving rate. Two parameters are susceptible to significant change during the summer: the rainfall and the temperatures. Statistical analysis showed that the main effect is due to temperature. More particularly,

the highest calf mortality is found when the average of minimum temperatures is highest and simultaneously averages of maximal temperatures are over 30°C.

The main impact of high temperature is to increase the risk of dehydration in calves (Martin, 1975(3)), as in high temperatures and increased humidity heat loss is more difficult. The thermal neutrality of newborn calves ranges from 12 to 20 °C, after a few weeks it increases to a wider range of 5 to 25 °C (SHERAER, 1999). With a relative humidity which exists in the Central Division of Fiji (80 to 100%) moderate to severe heat stress is expectable when temperatures reach 30 °C. In cases of heat stress, calves will (COMBS, 1996) loose more body water, reduce feed intake, stand rather than lie down, increase respiration rate, increase body temperature, increase saliva production and increase water intake. Holsteins are also known to be more susceptible to heat stress than Jerseys (COMBS, 1996).

The consequences of heat stress on an already sick animal (dehydrated and underfed because of diarrhoea for instance) will be a major factor in the risk of mortality.

3.2.2.4 Management factors

Analysis showed that poor housing, insufficient watering, inappropriate health management are factors linked to the mortality. It has also been demonstrated that these elements work together when associated, and act like pathogens. Some of the management factors are:

- ***Housing factors***

Poor housing management was found linked to higher calf mortality. In fact poor housing can be resultant of different causes and acts in different ways which are all known to be mortality risks factors (MOSS, 1991).

Sheds with broken roof, improper drainage, improper lateral protection from rain, are found to be permanently wet. Humid sheds favour the persistence of pathogens in the environment and contribute

to heat stress. Humidity also helps the development of skin diseases, such as dermatophilosis, that contribute to reduce the natural defences and general condition of calves.

Overcrowding facilitates germs transmission (by air portage, urine or feaces), increases the humidity and temperature of sheds, and is a common cause of fights especially when calves of different ages are mixed, furthermore it reduces access of weaker animals to food and water.

Sheds with low or poor maintenance levels soon become detrimental to calves, as dirty floors extend the survival of germs, and broken fittings like broken slats can be a source of injuries (Figure 7).

Figure 7: Accident in calf shed where the slat-floor is broken

In the absence of a calf shed the direct exposure to solar radiation can further increase the adverse effect of high environmental temperatures (MARTIN, 1975 (3)). ***Humidity is increased and effective surveillance is more difficult.***

- ***Availability of water***

In a number of farms calves appear not to have proper access to water, leading to increased mortality, as the statistical association shows.

Access to water may be improper for several reasons, i.e. either there is no water at all or the drinking-troughs are not regularly filled, or it is inconvenient for calves to use creeks or rivers which are only accessible to adults. Lack of drinking water reduces food intake and contributes to dehydration.

- ***Health management***

This factor, which takes into account drenching and treatment of sick animals, is related to calf mortality. Health management includes two major aspects: prevention and treatment measures.

Only two preventive measures appeared to be applied: colostrum feeding and drenching.

The colostrum is routinely given to calves, which is positive, but the protective quality of the colostrum may vary considerably according to the dam's condition. In developed dairy countries it is recommended that the mothers are vaccinated in order to increase the immunological capacity of colostrum (Selk, 1997). Many factors also contribute to a lower immunoglobulin concentration of colostrum (RADOSTITS, 1997) such as:

- Poor nutrition of cow at the end of gestation,
- Milking rank as lower concentration is found in heifers than in older cows (the maximum is found at the third lactation),
- Holstein's breed is known to have lower concentration,
- Moment of milking as the concentration of colostrum is the highest just before calving.

Without studying the colostrum composition of dairy cows in Fiji we can assume that the existence of the above factors contribute to reduce the protection of calves by colostrum and increase their susceptibility to infection.

Drenching can be considered to be both a preventive measure and a curative treatment. Nonetheless it seems to be more used as a treatment in Fiji as large numbers of farmer don't practice regular drenching. Success of drenching depends on the right periodicity at the right dosage with the right drug. The generally observed tendency of farmers to always use the same drench, can lead to drug resistance. Furthermore some farmers give low doses to save money on the drug; as a result the drug is not efficient and simply wasted.

Many other preventive measures exist that are not practiced by Fijian farmers and are subject to recommendations.

Regarding treatment, it appeared that calves with diarrhoea were, most often only treated with a drench or anticoccidial solution. This therapy would be sufficient to reduce the cause of sickness (in cases of good diagnostic) but will not help the calf to recover from the loss of body fluid (dehydration) which leads to death in many cases. As many factors (heat stress, insufficient watering, diarrhoea) are contributing to calves' dehydration, the absence of rehydration (parenteral or even oral) is a major factor of calf mortality. Other infections, such as pneumonia, septicaemia and skin diseases seem to be not treated or underestimated. Treatment prescription and administration should be done under the livestock officer's responsibility as they have the knowledge to choose the best health management for farmers. Unfortunately, in a too-important number of farms, livestock officers were reported not to come as requested (not coming in 45% of the farms surveyed or coming only sometimes in 36% of the farms surveyed).

Poor preventive measures, miss-use of drugs, lack of appropriate medication and advice contribute, in an environment favourable to many germs, to increase calf mortality.

- ***General Management***

In the survey, general management component includes workers, recording system and ownership of the farm.

Manpower is known to be a factor in calf mortality. Usually calf mortality is higher with external workers (MARTIN, 1975 (1)), calf rearing requires a lot of attention and should be under the owner's responsibility as he is more sensitive to the needs of replacement stock. It has been also said that women are significantly better than men at calf rearing (CRAWFORD, 1999). The situation observed in research station or cooperative farms clearly illustrates that involvement is much higher when people own their dairy farm and have all the benefit of improvements done.

Record keeping is the best way to monitor calf rearing and helps in making cost/benefit decisions (CADY, 1996). Unfortunately many farmers are not keeping records at all or are keeping records badly. Recording comes with proper cattle identification. In the absence of records, many mistakes occur through inbreeding which leads to weaker calves, and various management errors on feeding, drug administration, reproduction… There was only a few farmers who kept adequate records and they generally had fewer calf mortality problems. As record keeping is part of good management, it was not possible, within this survey to isolate the effect of record keeping from the rest of good management practices, but some farmers recognised the benefits of the use of records and the increased monitoring on calves since they began keeping records for the use of the survey.

- ***Other management factors.***

Although no statistically significant correlation was found with the other factors, it is likely that they influence with calf mortality at a general level. The other main factors influencing calf mortality are feeding and reproduction.

Feeding has an influence on calf mortality before calving (fitness of newborn calf and quality of colostrum) and during the development of the calves by determining its fitness and resistance. Many different feeding systems exist among farmers and generally the low level of knowledge leads them to continue familiar practices without trying improvements even if some obvious problem exist.

The fertility did not seem to be particularly low in the survey, most of the farmer are using natural breeding without problem. Some are using artificial insemination, with variable success, notably when unsuccessful artificial insemination leads to a loss of fertility and delay of the production

calendar. It follows that AI should only be practiced where good controls are available. Furthermore the genetic improvement provided by AI only occurs when the potential of cows is fully expressed. When feeding, health, and management conditions are already preventing cows from giving their best. Genetic improvement may only produce weaker animals and the production benefits will not appear.
The general tendency of keeping cows for a long period (over 10 years) is also a factor of mortality as old cows give birth to weaker calves. This condition is linked to cultural aspects and to the lack of replacements.

The calf mortality problem in the dairy industry of Fiji is not due to one single factor but is due to the association of local conditions and bad management practices. It is also the result of bad economic decisions and leads to loss of benefits.

3.3 Economic factors

The minimum cost of calf mortality averaged at 1,780 FJD and exceeded 3,000 FJD in 6 farms (Table 5). In a farm economy it may considerably affect the profit, and it has been shown (MARTIN, 1975 (2), RADOSTITS, 1997) that a calf mortality rate of 20% can reduce net profit by 38%.

The two component of the cost of mortality are the cost of rearing and the price of the calf.

From the data available, calf selling seems to be an important source of income and the selling rate per farm averaged 20.6%. Nonetheless this income is not necessarily a benefit. The figures calculated in this survey, show that the average costs of rearing calves over two weeks are lower than the market price of calves at the same age (Table 4). So, the older the calf is, the less benefit is made on the sale, especially when they are weaned after 4 months. Despite this market distortion, 44% (Figure 2) of calves are sold after 2 weeks, at a loss in most cases. The low value of calves is actually very surprising in the context of lack of replacements stock may be due to a perception that they are unproductive mouths to feed.

The cost of rearing appears not to be linked with the CMR but there is a relation between cost of rearing and the net profit of calf selling (sales- cost of mortality). Some farmers are reducing the number of calves at an early stage, by selecting females and potentially good males. These farmers sell animals before spending money on them, making a maximum of profit, and then focus their resources on rearing the selected animals with better standard of food and management in order to have minimal mortality. Good record keeping and a long-term view of the farm economy are the keys to this wise practice.

The high calf mortality found in the dairy industry of Fiji includes many aspects of livestock production. Technically, the problem is due to the association of an environment favourable to the pathogen's resistance and proliferation, and the risk of heat stress plus poor management practices. The lack of good monitoring of farm among a large part of the farmers lead to management mistakes and increases the economical impact of calf mortality. The loss of profit contributes to narrower profit margins and a common feeling that improvements cannot be implemented without direct help from the government. Sustainable improvements will not occur from financial assistance but through capacity building of the farmers to adopt rational management.

IV Recommendations

4.1 Recommendations to MASLR

4.1.1 Education on calf rearing

The major issues of calf mortality are related to management. On the assumption that if farmers understood the consequences of their mistakes they would certainly not commit them, the main recommendations to be addressed regard education programs and the promotion of better techniques.

Among the different area for improvement, the following topics should be considered:

- Watering of animals,
- Proper use of calve sheds (and promotion of the economical thatched roof),
- Disease control (diarrhoea, worm control, navel cleaning),
- Interests and methods of identification and recording,
- Surveillance of calving,
- Better feeding system for pregnant cows and calves from two weeks to weaning,
- Advantages of Lucinia, Glycidia and legumes creeping, techniques for maintenance of pasture.

As dairy farming is a very absorbing activity, most of the farmers do not have time for researching and implementing new techniques and the easiest way for them is to reproduce what they have been always doing, sometimes for generations. For similar reasons, old farmers are also less susceptible to change their habits, so that messages should be preferentially addressed to the younger generations of farmers. The main people in contact with farmers are the livestock officers and as they are best to advice on the implementation of new practices, they should benefit also from good education programs.

Education can be divided into two groups:

- Active teaching which includes workshop, farm visits, training and scholarship
- Passive teaching which includes manual, leaflets, posters and radio programs.

Active teaching is probably most effective when it is targeted to the right audience. Workshops are usually very popular but their impact is difficult to assess as afterwards people go back to their farms and there is no monitoring of changes. In addition, as older farmers tend to be the main participants, messages have less impact and sometimes workshops turn to be more about old friends meeting than teaching improvement. Therefore a successful educational program will not rely only on workshops.

The more active way of teaching is on the farm itself at the time of visits. Livestock officers can identify problems and propose practical solutions and the effect can be assessed by farm monitoring. This practice has been conducted for years in developed dairying countries with success, leading to large improvements. It should involve veterinarians and livestock officers, as well as representatives from dairy and food industries for diversity of advice, as long as they are not contradictory, is of benefit to the farmer. In order to convince farmers of the relevance of the messages, the competence of livestock officers should be maintained by continuous education.

Eventually the education of tomorrow's farmers should be considered cautiously. Only a few students from the agricultural college will become private farmers. Most of the young people who will become dairy farmers do not receive any specific education is dairy farming and only learn from their parents. To increase their educational level, farm visits and short training courses could be organised at the agricultural research station. As most of them are already working in their parent's farms, they are already aware of many aspects of dairy farming so their educational level could be improved quickly. It is also possible that collaboration with the Ministry of Education would permit the involvement of extension officers and the diffusion of technical information in rural secondary schools.

These education programs involve the active participation of people; they can be supported by extension material such as manuals, leaflets, posters and radio programs. Such media or documents

carry technical references that farmers can use to complement personal advice and reinforce awareness messages which have been received elsewhere.

4.1.2 Incentives to improve monitoring and management

4.1.2.1. Individual monitoring of farms

Incentives apply to both farmers and livestock officers. Continuous monitoring of farms should be the best way to ensure that improvements are done. Monitoring involves the establishment of good records. It is difficult for some farmers to keep records, mainly because of a low level of writing and reading and livestock officers could assist them in keeping and updating record books and periodically help farmers to make an evaluation of their farm (by calculating production, reproduction and economic data).

The promotion of such practices is not easy as they require more work and results are obvious only after sometime, which is sometimes discouraging. The direct help from government to farmers is usually much appreciated but rarely leads to sustainable improvements once the subsidies are finished. An alternative way of helping farmers is to distribute breeding animals to those farmers achieving a certain goal in terms of production and/or calf mortality.

Assistance to farmers is also provided through the services of the livestock officers. Unfortunately farmers complain that they are not coming as regularly as they used to do in previous years. The apparent lack of concern has direct consequences on the recovery of sick animals and indirect consequences on government prestige. To increase the motivation of livestock officers for their work, they could be rewarded by salary bonuses if they can justify farm monitoring and alternative transport facilities could be promoted (mountain bike, horses) for close farms, leaving vehicles for the visit of remote farms.

Ways of increasing the economic value of calves should be considered by the government. Bull calves that are not selected for reproduction, should be used to promote beef farms. The government could coordinate the project by facilitating transport, assessing the tuberculosis status of farms and mediating between dairy and beef farmers.

As demonstrations are known to be an incentive, the use of model farms can be promoted. Small or medium-scale farms could be used as models, however two problems may arise: the creation of a climate of jealousy among farmers and the promotion of both good and bad techniques as it is not possible to control every practice in a private farm.
Finally, the research station should be the benchmark used as the model during workshops and training. Currently KRS is suffering from management problems like many farms (calf mortality of 13%) and only averages at 5 litres of milk per cow done with *ad-lib* feeding. Therefore if research stations are to be used as model farms, they will have to increase their performances with resources that are also accessible to farmers.

Small research projects conducted on research stations can also benefit to farmers. For instance it would be of benefit to farmers to have a handy means of weight estimation to monitor calf's growth and adjust food and drug administration. It could be provided by adapting a girth measuring tape to dairy cattle as measuring tapes from developed dairy countries are not suitable.

4.1.2.2. National surveys

To follow up the calf mortality problem, low budget surveys that cost less than 5,000 FJD (Appendix 6) could be implemented in the future to assess progress. The main constraint of this survey is the time required but if records are properly kept in farms, a following survey could be completed within a few months.

Another area that could be investigated is the prevalence of leptospirosis in dairy cattle. Although no clinical case of leptospirosis was identified during the survey, this disease is known to induce weak calves, more susceptible to die, and to reduce the milk yield of cows. The low national average of milk production per cow and the high calf mortality rate could be partially due to leptospirosis with potential consequences on farmers' health. Such investigation could be done in collaboration with SPC RAHS, which already has programme on leptospirosis and the farms already monitored for that survey could be used as a sampling frame.

4.2 Recommendations to dairy farmers

any sources of advices are available from the Agriculture Station, Fiji College of Agriculture, library and Internet, and from people working with farmers like veterinarians and livestock officers. It is very important for farmers with a calf mortality problem to ask for early advice instead of suffering from a chronic situation of calf mortality, which once established in the farm can be devastating.

As there is no unique solution, and all situations are different, the best advice would be provided on the farm in regard to each particular conditions. However, a partial list of general advice can be provided on the basis of practices observed during the survey.

4.2.1 General Management

Good management is a key of successful calf rearing.

4.2.1.1 Workers and minimised stress

The owner of the farm is the best person to realise the importance of replacement stock, and he or she should always be involved in calf rearing and avoid delegating it to outside workers. Calves need constant and cautious care, as soon as they are separated from their mother because they are totally dependant on human care and if things go wrong it is the farmer's responsibility.

They are extremely sensitive to all kind of stresses and stressed animals are more likely to get diseases. When animals are fearful of people, their welfare and productivity can be reduced. Studies show long-term stress and reduced productivity in farm animals where they show fear of people (e.g. shying away or vigorous avoidance) compared to farms where the animals approach people confidently. The way calves are handled will affect how fearful they become. Scientific studies show that calves can tell differentiate between people and will be frightened of people who handle them roughly (CARC, 1998). Therefore, people in charge of calves should be always skilled people, patient and cautious. As change is another source of stress, routine in calf rearing is very important, once they are accustomed to somebody they are simpler to handle and the person in charge of them would easily notice if something goes wrong (CRAWFORD, 1999).

4.2.1.2 Record keeping and identification

Many farmers are relying only on their memory and as it is almost impossible to remember all the events occurring, many facts (e.g. calf mortality, production, cost and benefits) are forgotten or underestimated, leading to management errors.

- ***Why keep records***

Record keeping is essential for good management, not only for the information it gives but also for the process. Records by themselves do not provide much information, but once summarised they are very helpful. The information of good records helps when taking rational decisions (CADY, 1996) on topics such as day-to-day management decisions, financial accounting, progress measurement, problem solving, genetic evaluation and planning future actions.
Updating of records can appear to be a constraint but it ensures constant monitoring of the situation as some farmers experienced during the survey.

Recording requires identification of animals and this should be done with ear-tags in the first day of life of the calf. Identification of cattle helps to prevent stealing and inbreeding (CASSELL, 1997).

- ***How to keep useful records***

There are different steps of record keeping, namely:

- Temporary records
- Individual permanent records
- Summarization of records.

The first step can be done on a board (like Figure 8) in the calf shed or in the dairy, or better, in a note book that the farmer keeps in his pocket. Temporary records consist of daily events like cow's heat, injuries, disease symptoms, calving, breeding, treatments, change of paddock and other miscellaneous information.

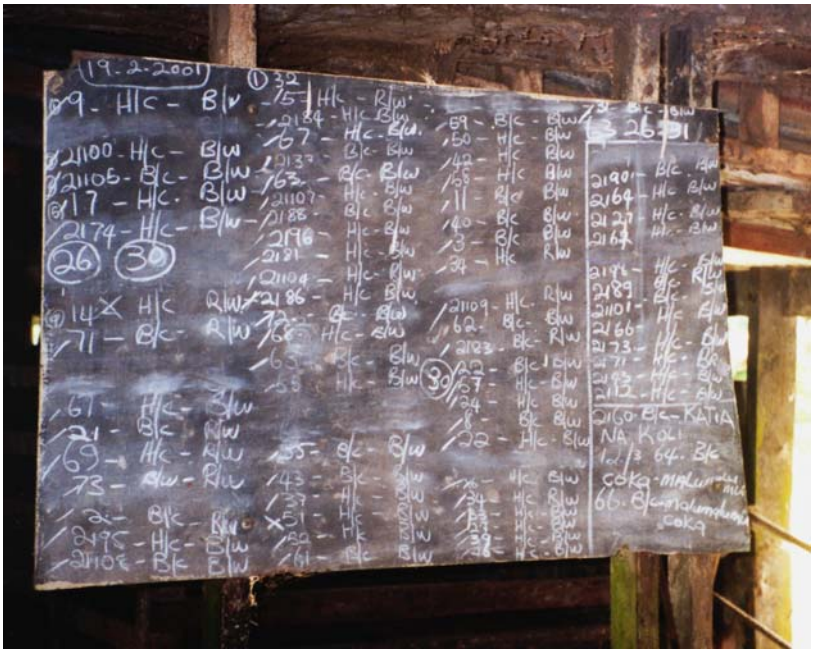

Figure 8: Temporary records on a black board at the calf sheds entry

Temporary records must be transferred to permanent records before they are lost. Permanent records may vary from farm to farm but as a general rule, each animal from the herd should have its individual record, whether there is herd records or not.

Individual records include:

- Identification of the animal,
- Birth date,
- Sire and dam information,
- Sex,
- Birth weight or at least body condition at birth,
- Calving difficulty.

Health records are very useful to track health problems in a herd and they can be used as criteria of culling. They should include:

- Apparition of symptoms (date and nature),
- Treatments given (date, nature, cost).

Breeding records, feeding and production records and oestrous detection history are other important categories of records which come under the general rules of dairy farm managing.

Eventually summarization of records should be done annually to assess achievements and progress from year to year.

For some people record keeping can be a very difficult exercise as they have limited education, in which case family members and livestock officers should participate and asist in record keeping. The livestock officers would be very helpful in advising on summarizing records and analysing them with farmers.

4.2.2 Housing

4.2.2.1 Advantage and inconvenient of calf sheds

Rearing calves in sheds contributes to success but only if the sheds are appropriate as a poor calf shed is worse than nothing at all. The purpose of rearing calves in sheds is to facilitate monitoring, group animals, to control food intake and to protect calves from adverse climatic conditions and from parasites on pasture.

The main inconvenience of rearing calves in sheds is the extra work of calf feeding and shed maintenance. As explained previously, unsuitable calf sheds lead to a higher occurrence of diseases, heat stress and accidents.

4.2.2.2 Choice of calf sheds

Many options are possible for calves housing. They all have advantages and disadvantages and the choice must be taken in relation to local conditions. Individual hutches are a very interesting option as they reduce disease transmission, solve overcrowding problems and hutches are inexpensive but they require more labour and restrict the social behaviour of calves. Loose pens are an inexpensive and efficient solution, they can be installed in a paddock and are easy to monitor. Transformation of a pre-existing building (like a dairy or a piggery) can be a practical and cheap solution. Eventually, a purpose built shed is an expensive but interesting option as it provides an opportunity to look for the best design and gives possibility to install a nursery.

Regarding materials, a thatched roof is a good alterative to the more expensive iron roof as it has a good water-tightness and gives better temperature control. Nonetheless they have to be changed regularly. The floor can be just made of earth but it becomes muddy quickly and unhealthy. Slatted floors are easy to clean but they need replacement of broken slates and the elimination of under floor draughts, or pneumonia and scour will be constant problems (Crawford, 1998 (2)). The slates should be spaced by 3,2 cm. Deep litter covered with straw is probably the best option but is not readily available in Fiji. Concrete floors are convenient to clean and to maintain but the drainage has to be seriously considered to avoid draughts and constant humidity.

In order to minimize heat stress ventilation of the shed is very important and natural cooling will involve open sheds with high roofs and if possible the calf shed will be built in a windy and shaded area. Air inlets should be above the calf and about 0,5 square feet per calf (ANONYM, 1999)

4.2.2.3 Managing of calves in shed

Calves will be kept in sheds for different period of times from farm to farm. There is no unique formula as it will depend on the fitness of calves, the age at weaning, the pasture resources, and the space in sheds.

Calves should be grouped according to age, whether they are kept inside or outside. Inside, groups should be limited to a maximum of 12 calves as it is easier to identify sick animals in small groups. Groups are set according to age and also size, for if a calf is too small it is better to keep it with younger animals as long as it is not sick. The best way to optimise grouping is to sort animals by feed requirements. Sick animals should always be isolated from the group and kept in a “nursery” where they receive treatment.

Overcrowding must be avoided to reduce disease transmission, stress (including heat stress), accidents and feeding/watering difficulties. It is recommended that groups of calves should have a minimum of 1,5 m² of unobstructed floor space (ANONYM, 1999) and air space should of 6 m^3 for each baby calf to 12m^3 for each 12 weeks calf.

Calves in small sheds should never be tethered and, when tethered in large stalls or outside, the tether must be long enough to allow movement, loose enough to prevent strangulation and wounds. Examination for injuries should be carried out regularly as tethering is sometimes responsible for fatal accidents.

Control of flies in the sheds is also necessary to reduce heat stress (JONES, 1999) and it is done by eliminating breeding areas such as manure or wet spilled feed.

When animals are kept outside, sufficient and effective shade trees should be provided, if there is not enough shade in the paddock, the animals will group and the shade area will be muddy and wasted. If necessary a shade shelter should also be installed in the paddocks.

4.2.3 Proper and sufficient watering

Calves (like cows) should always have fresh water available. In hot weather a calf is expected to drink from 16 to 40 L of water (WELLS, 1995). If water is not available, calves eat less, they are unhealthy and the consequences of diarrhoea and heat stress are greater. For calves, a trough can be easily made from a half-drum or a large plastic basin. A creek is not always convenient for young calves in terms of access, and it can also be a source of infection.

In order to facilitate watering the trough should be put in the shade and there should be at least one trough for 20 animals (JONES, 1999). It is also useful to clean it regularly and to ensure that the water is not contaminated. It is recommended that water for animals contains less than 50 coliforms per millilitres (WELLS, 1995) and on request the veterinary laboratory can analyse it.

4.2.4 Disease prevention and management

4.2.4.1 Management of the new born calf

- ***At calving***

Cows about to give birth should be kept in a paddock that is not too wet and where surveillance is easy. So that way it is possible to manage calving difficulties, provide care to the newborn calf and properly identify it.

- ***Just after calving***

After calving it is particularly important that the calves are put in a clean and dry place (ANONYM, 1999). Cleaning the navel with iodine or even with soap and hot water prevents navel abscess, which is a common source of septicaemia.

- ***Colostrum feeding***

Colostrum is the orange/pink first milk that cows produce at calving. It is produced by the dam from the first hours before calving and the first three to four days after calving. It is a very valuable food for calf and it also gives them protection against many diseases. The protection part of the colostrum is higher at calving; therefore if the colostrum is not immediately given to calves it will be less protective. A 45 kg newborn calve should drink 2,25 L of colostrum in its first hours of life and a total of 6 to 8 L during the first day.

It is a good idea to freeze some colostrum if possible to give to calves in case the mother dies or for some reasons she does not produce enough colostrum.

The colostrum of heifers is less protective than of that older cows (third lactation is considered to be very good). If the cow is not in good nutritional condition before calving its colostrum is also less protective. Cows should always receive good food before calving (flushing). If colostrum is to be frozen, it is better to choose it from a 5 to 8 years old cow in good conditions (score 3).

4.2.4.2 General issues on health management

Calves should always be kept in a dry place, with sufficient water and food, in on environment that protects from stress.

Surveillance of animals is an essential factor for disease prevention, because when symptoms are detected early, treatment is easier and efficient; moreover it is possible to isolate the calf and prevent the spread of the disease.

Diseases should always be recorded on individual calf records in order to have an overview of how they occur in the herd and which treatment and control measure are efficient.

4.2.4.3 Drenching for parasites

Drenching is both a preventive and a curative measure. It is always better and cheaper to prevent a disease than to treat it and assume for the consequences of it. Drenching programmes should be systematic as in Fiji conditions are favourable to worms throughout the year. Good drenching programmes involve the use of the right drug at the right dose and with the right frequency. The right dose means that it is must correspond to the calf's size, if under-dosed the drug is less effective. It is also recommended that the drugs are rotated. If the same drench is used every time, worms become used to it and it will develop resistance and the drench is no longer effective. Alternating drugs like Nilverm © and Fencare© will prevent most resistance developing.

The quantity to give is dependent on the bodyweight of the animal and the farmer should have a mean of weight estimation, such as measuring tape. The dosage for the two most commonly used drenches are Nilverm™: 10mL/45kg of body weight and Fencare™: 13 mL/ 45 kg of body weight.
Calves should be drenched monthly from one-month old to six months of age and then drenched again at 9 months, 12 months and 15 months because as they mature, they become more resistant to worm infection.

4.2.4.4 Treatment

Treatment of sick animals should be prescribed and administered by a veterinarian or a livestock officer. However some measures can be taken in order to limit the severity and spread of the disease. As mentioned before, it is very important to isolate sick animals to limit the spread of the disease and at the same time, other animals should be checked for clinical signs. The "nursery" should be a dry and quiet place to facilitate calf' recovery.

In cases of scouring, oral rehydration is an important measure to help calves recover. Different formulation can be recommended:

→1 can beef consommé, 1 package fruit pectin (Sure Jell or Pen Jel), 2 teaspoons low sodium salt (Morton Lite Salt), 2 teaspoons baking soda, and enough warm water to total 2 quarts;

→1 can beef consommé, 3 cans warm water, and 1 heaping Tablespoon baking soda;

→1 Tablespoon baking soda, 1 teaspoon salt, and 250 cc (8 ounces) 50% dextrose or 8 ounces light Karo syrup, and add enough warm water to total 1 gallon;

→1 Liter of warm water, 6 tea spoons of sugar, 1 tea spoon of salt.

One liter of any of these solutions should be given every 4 hours for a period of 24 to 48 hours.
The first three solutions provide the calf with enough nutrients and enable the farmer to stop giving milk or milk replacer during this period, as milk in the intestinal tract makes an ideal medium for bacteria such as *E. coli* to multiply.

4.2.5 Other management issues

4.2.5.1 Dam's conditions

The cow's condition has great impact on the calves condition and survivability.
The age of calving should be from two and half years to a maximum of twelve years. Outside this range the risk of having a stillbirth or a weak calf is very high.
Cows should be particularly well fed during the last three months of pregnancy, but not overfed to avoid calving difficulties. The ideal body condition is a score of 3 (ANONYM, 1999). Good mineral coverage is particularly important.

4.2.5.2 Feeding

The feeding has great consequences on calves' health as weaker calves are more susceptible to disease and will be less resistant. Moreover improper food can lead to disease, particularly diarrhoea in young calves which is often due to misuse of milk replacer. Milk replacer has to be carefully mixed with warm water, according to the recommendations of the supplier.

Among the problems associated with digestion, chronic indigestion maybe under estimated as it could be hidden by more apparent disorders such as parasitism. Chronic indigestion occurs when milk is deposited into the rumen as a result of failure of the reticular groove reflex during drinking. Calves that 'gulp' rather than sip milk are at greatest risk. The milk in the rumen ferments and produces acids that damage the rumen. Affected calves show lack of appetite, abdominal distention and poor growth.

They pass sticky, clay-like feces that may adhere to the tail and hind legs. Chronically affected calves are small for their age and have a poor prognosis.

A way to avoid this problem is to induce reticular groove closure by inducing vigorous sucking activity with the fingers before feeding milk. Calves that relapse should be fed by nipple-bottle or weaned. A rubber nipple floating on the surface of bucket fed milk may prevent the syndrome.

Conclusion

The calf mortality in the dairy industry of Fiji, averaging at 18,2 % per farm is a great concern. It leads to economic loss in the farms, lack of replacement stock and poor selection capabilities. It cannot be explained by a single factor but results from the association of disease environment, hot and wet climatic conditions and poor management practices. The relationship between scouring, heat stress and lack of water is the major contributing factor. The cooperation difficulties encountered during the survey with some farmers who had high calf mortality is an indication of the low concern they have for this problem, however some farmers are successful in calf rearing and demonstrate to others that management is a key issue.

To improve the situation, the general knowledge of dairy farmers has to improve through education programs and workshops. In future, similar surveys should be organised to monitor the progress, with implementation of recording systems. The length of surveys would be shorter and mortality monitoring could be extended to include older animals.

Calf mortality is, unfortunately, not the only constraint to the dairy industry in Fiji and further projects should seek ways to improve production, weed control, nutrition and health management, all issues which contribute to the low level of production of cows.

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Appendixes

Appendix 1: Opening questionnaire

Date: …/…./…. **ID Survey**: …..

Identification

Farm No: …….. Farm name: …… District: ……Locality: …….
First name: ……. Last name: ……. Phone number: ……

The farmer

Farmer's age: ……. Race: …… Level of education: …… No of Generation of farming: ……
Family size: …… Manpower: …… Family manpower: ……. Is there enough manpower? …..
How many people are in charge of calves? …… Average time spent per day for calves (h)? ……
Calves staff 1: identification: ……. qualification: ……
Other tasks in charge?……
Calves staff 2: identification:…… qualification: ……
Other tasks in charge?……

The production

Total livestock: ……. Milking cows: ……. Dry cows: ……. Bulls: …….
Total Heifers: ……. Heifers 2-3 years:……. Heifers 1-2 years:…….. Heifers ½-1 year:……...
Steers: ……. Milking calves: ……. Weaners: …….
Average quantity of milk per cow (L):…… Min: …… Max: ……
Milk production per year (L): …… Bacteriological quality of milk: ……..
Evolution of production over 5 past years: ……. Evolution of the number of livestock: ……
Desired evolution for the number of livestock: ……..
Type of land: ……. Total pasture (ha): …….
Improved pasture (ha): ……. Native pasture (ha): …….. Bush (ha): ……..
Companion crops: …….. Land under cultivation (ha): ……..
Other production in farm? ☐ Animal production: Vegetal production:
Part of self-consummation (milk, meat, vegeTable…): ……

Outlets for calves

Destination 1: …… No of calves sold: ……..……
Age at sale: ……. Price: …… Average weight at sale: …….
Destination 2: …… No of calves sold: ……..……
Age at sale: ……. Price: …… Average weight at sale: …….
Destination 3: …… No of calves sold: ……..……
Age at sale: ……. Price: …… Average weight at sale: …….
Total estimated returns from calves: …….

The reproduction

Breed(s) used on the farm: ……

Self replacement ☐ Heifers integrated last year: …… Bulls: …….
At what age do you select replacement calves? ……..
What are your criteria of selection? ……..
What are your targets of selection? ……..
Do you buy animals for replacement? ☐ How much: …….. From where: …… Are they upgrading? ☐
Natural mating ☐ Use of AI ☐ Synchronization of estrus? ☐
Number of non pregnant cows during the last year? ……. Number of abortion: …… Stillbirth: …….
Number of births last year? …… Births during the dry season? :…… during the wet season? :……
Number of dead calves last year? ..…… Before one week: ……. Between 1week and 3 months: ……..
Average age of cows at first calving: …… Average age of cows at last calving: ……
Culled cow last year: …….

Housing calves

Number of sheds: …….. Calves grouped by class of age ☐
Type of floor: ……..…… Is it easy to clean? ☐ How often do you clean? ……..
Slope ☐ Drainage ☐ Roof ☐ Cleanliness ☐ Risk of flooding ☐
Exposure to wind ☐ Exposure to sun ☐ Exposure to rain ☐ Power supply at proximity ☐
Proximity to farm ☐ Grouping calves by age ☐ Do you think you have enough space for calves? ☐
Water supply different from feeder ☐ How often do you fill? ……
Quality of water: …….. Level of water observed: …….

Pen	1	2	3	4	5	6	7
Size (m^2)							
No of calves							
Range of age							
Observation							

General state of calves pens: ……...
General comments on calves housing

Nutrition of calves

Colostrum? ☐ How many days? …….. Kind of milk for calves …….
Slow introduction of milk powder ☐ Temperature of distribution …… Mode of distribution ……
Number of distribution per day ……... Who feeds the calves? …… Is it always the same person (y/n)
Dilution (g/L): ……. Volume given (L):……..
Total of milk powder bought during last year: ……
Price of milk powder per kg: …….. Where do you buy it? ……..
Age at weaning: ……. Weaning weight: …… Age when supplementation starts: ……
Turn out to graze before weaning ☐
Method of weaning:……..
Are weaning calves in the same paddock than weaners? ☐ If not, why (any differences between the paddocks)?
……..
……..
Number of paddocks …… Size of paddocks (ha) ……
Quality of pastures for weaners? …….. Quantity of improved pasture for weaners ..…….
Proximity to farm ☐ Fences ☐ Humidity in pasture ☐ Shadow in paddocks ☐ Shelter in paddocks ☐
Mud/Swamp ☐ ☐ important slope of field ☐ Association with adults ☐
Min and maximum age of animals in the same paddock……..Rotation of pasture ☐
Method of rotation:……
Water in paddocks ☐ Water in the same time that supplementation ☐
Quality of water: …… Quantity of water: …… How often do you change it? ……..
Supplementation in paddocks ☐ Supplementation after grazing ☐

Supplement	Copra	Molasses	Urea	Grain	Grass	Coconut meal	Mill mix	Others	
Presence									
Quantity									
No of animals									

Observations concerning feeding system

Do you separate and manage calves that you want to keep in a different way, if yes in which extent?

:……
:……
:……
:……

Growth

Average weight of calves at 1 week (kg) …….. Average weight of calves at 1 month (kg) …….
Average weight of calves at 3 month (kg) …… Average weight of calves at 6 month (kg) …….

Estimated cost to rear a calf up to 1 month: ……. Estimated price: ……..
Estimated cost to rear a calf up to 3 months: ……. Estimated price: ……..
Estimated cost to rear a calf up to 6 months: ……. Estimated price: ……..

Health concerns

Disinfection of navel ☐ Vaccination of dams ☐ Vaccination of calves ☐ TB free ☐
Drenching calves ☐ Age at first drench: …… Periodicity of drench: ……
Drugs used: ……. Drug rotation ☐
Who administrate drugs?…….. Treatments administrated to calves: ……
……..
How much did you spent for drugs last year?…… For calf's drugs:…….
Drugs available on the farm: …….
……..
Drugs used without external advice: ……
Most common diseases on the farm:……..
……..
Diseases found during abattoir examination: …….
……..
Perception of calf mortality problem: ……Farmer's estimation of calf mortality rate: ……
3 points that could be improved for calves:
……
……..
Limits of improvements according to manpower, cost, time, place:
……
……

Appendix 2: Closing questionnaire

Identification

Farm No: …….. Farm name: …… District: ……Locality: …….

Farmer and manpower

How many people are working in the farm? ..... Is it enough? …..
How many people are in charge of calves? ..... Average time spent per day for calves (h)? ……

Change in manager or workers, if yes why and how?.....
.....
.....
.....

Production

Total livestock:..... ..... Milking cows:..... ..... Dry cows:..... Bulls: .....
Working B:..... Mature or immature? .....
Total Heifers:..... ..... Heifers 2-3 years:..... ..... Heifers 1-2 years:..... Heifers ½-1 year:.....
Steers:..... ..... Milking calves:..... ..... Weaners: .....

Average quantity of milk per cow (L):..... Min: ..... Max: .....
Milk production per year (L): ..... Bacteriological quality of milk;.....
Number of non milking cows this year.....

Evolution of production since last year: ..... Evolution of the number of livestock:.....
Desired evolution for the number of livestock;.....

Type of land:..... If lease when does it expire? ..... Do you think it will be renewed?.....
Did you improve your pasture?..... If yes how many Ha, with which species and which funding?.....
.....
Did you crop any complementation food?..... If yes how many Ha, with which species and which funding?.....
.....
Did you gain or loose some pasture? (details) :.....
Companion crops:..... ..... Land under cultivation (ha):.....

Stock changes:

	Dead	From dog attacks	Stolen	Stolen last year	Magiti	Culled	Sold	To farmers	Born/ Bought	Present
? Calves										
? Calves										
Heiffers										
Steers										
Cow										
Bull										

What is your estimation of your return from calves sells?.....

Reproduction

Heifers integrated last year: ..... Bulls: .....
Number of non pregnant cows during the last year..... Number of abortion:..... Stillbirth: .....

Housing calves

Did you change your housing system? ..... If yes how: .....

.....

.....

Nutrition of calves

Age						
Morning						
Afternoon						

Kind of milk: P (powder); M (Mixed); F(whole); S (Skim); C (cow) and volume in L

Paddock: Size: ..... Species: ..... Size of grass: .....

Supplement	Copra	Molasses	Urea	Grain	Grass	Mill mix	Others	
Presence								
Quantity								
No of animals								

Watering: How: ..... Frequency: .....

Did you change your feeding system for calves? ..... If yes how: .....

.....

.....

Health concerns

Last TB testing: ..... Result (F/I): .....

Disinfection of navel ☐ Drenching calves ☐ Age at first drench: ..... Periodicity of drench: .....

Drench used: ..... Cost of drench: .....

Treatments administrated to calves: .....

In case of scouring did you give oral rehydration? ..... Did you notice any improvement? .....

Did you get help from the L.O. as requested? .....

Do you think you had less disease this year/why? .....

Did you submit your dead calves for post mortem? ..... If not, why? .....

Did you give more care to the calves this year and how? .....

.....

.....

.....

.....

Did you change your recording system and how? .....

.....

.....

How do you use your records? .....

.....

.....

.....

What are your comments about this survey? .....

.....

.....

.....

.....

Appendix 3: Calf records

Dates and identification of calf

Sex: …… Breed: …… Ear tag: …… No of dam: ……

Event	Date	Weight or Body Circumference[1]	Unit[2]	Body condition[3]	Observation
Birth	__ / __ / __				
1 week	__ / __ / __				
1 month	__ / __ / __				
3 month	__ / __ / __				
6 month	__ / __ / __				
Weaning	__ / __ / __				
Sale	__ / __ / __				
Death	__ / __ / __				

[1] To take the chest circumference place the tape around animal at smallest heart girth just back of front l legs and pull tight enough to lay hair flat
[2] Unit for weight could be kg or pounds, unit for circumference could be cm or inches
[3] For Body condition choose one of the followings: thin, medium, fat, extra fat

Health events

Did it get scour? ☐ Date of scour apparition: __ / __/ __ Did it get better? ☐
When did it stop? __ / __ / __ Did you treat? ☐ If yes, which drug? ……
Did you isolate it? ☐ Did other calves have scour? ☐ Did the disease come again? ☐

Did it get breathing problems? ☐ Date of apparition: __ / __/ __ Did it get better? ☐
When did it stop? __ / __ / __ Did you treat? ☐ If yes, which drug? ……
Did you isolate it? ☐ Did other calves have the same problem? ☐ Did the disease come again? ☐

Did you notice some of the following points?
Skin disease ☐ ; Wet hair ☐ ; Weight loss ☐ ; Lack of appetite ☐ ; Weakness ☐ ; Lameness ☐

Observations (complete with all important events or observations of the calf life for each period)
From birth to weaning:

From weaning up to 3 months:

From 3 months up to 6 months:

Appendix 4: Synthetic variables and scores

Management		Workers + Recording + Ownership
Ownership	-1	The farm manager is not the owner
	0	The farm manager is the owner
Recording	0	None or useless records
	1	Records kept
Workers	-1	Calf management is relegated to external workers
	0	Calf management if done by family member or farmer himself
Housing		Calf housing + Protection
Calf housing	-1	Improper calf sheds (overcrowded, wet, not maintained)
	0	No calf sheds
	1	Proper calf sheds
Protection	-1	Dog attacks and stealing reported
	0	Calves protected from dogs and thieves
Watering	-1	Water is unavailable or in a creek inaccessible to calves
	0	Water is only available sometimes
	1	Water is always available to calves (*ad lib*)
Health management	0	No treatment of sick calves or improper drenching programme
	1	Treatment of sick calves and proper drenching programme
Feeding		Pastures + Complementation + Milk feeding
Pastures	-1	Pastures are consisting of weeds and not enough numerous
	0	Pastures are not improved but are in sufficient number
	1	Pastures are improved
Milk feeding	-1	Improper quantity or for a too short period
	0	AccepTable quantity but no variation with age
	1	Right quantity which varies with age
Complementation	-1	No complementation
	0	Poor complementation: unbalanced or insufficient
	1	Good complementation: balanced and sufficient

Production		Sale + Milk production + Variation of income
Sale	-1	Calves sold without profit
	0	Calves not sold
	1	Calves sold with profit
Milk production	0	Average per cow lower than 4,5
	1	Average per cow greater than 4,5
Variation of income	-1	Another commercial production
	0	Dairy farm is the only income
Land management	0	No improvement of pasture
	1	Improvement of pasture
Lease	-1	Expiring lease
	0	No lease concern
Reproduction	-1	Calving rate lower than 95% or old cows not culled, or IA used with poor results
	0	Calving rate greater than 95%, old cows culled
Global note		Sum of all precedents scores

Appendix 4 bis: Score and stock of farms

	ID	*1*	*2*	*4*	*5*	*6*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*20*	*21*	*22*	*28*	*30*	*31*	*32*	*33*	*34*
	time of survey in days	329	320	342	342	342	269	365	313	350	358	356	358	350	336	336	354	364	342	264	264	264	212
number of	cows	114	164	22	18	21	48	129	113	97	15	67	75	272	22	56	25	332	370	26	53	23	31
	births	97	86	23	16	19	32	125	69	117	18	51	101	187	15	43	19	332	337	17	44	9	12
	calves sold	1	16	0	2	4	2	80	2	36	3	7	13	13	0	11	7	50	255	4	7	3	1
	calves dead	**1**	**26**	**1**	**2**	**1**	**2**	**6**	**18**	**15**	**2**	**2**	**22**	**34**	**4**	**15**	**6**	**120**	**24**	**5**	**9**	**1**	**6**
score of	management	0	-1	0	1	1	-2	1	-1	-1	0	1	-1	-1	0	-1	0	-1	1	0	1	0	0
	ownership	0	-1	0	0	0	-1	0	-1	-1	0	0	-1	-1	0	-1	0	0	0	0	0	0	0
	recording	0	0	0	1	1	0	1	1	1	0	1	1	1	0	0	0	0	1	0	1	0	0
	workers	0	0	0	0	0	-1	0	-1	-1	0	0	-1	-1	0	0	0	-1	0	0	0	0	0
	calf housing	-1	2	0	-1	0	0	-1	1	-2	1	-1	-1	1	0	1	0	0	1	0	0	0	0
	housing	1	-2	0	1	0	-1	1	-2	1	-1	1	0	-2	0	-1	0	-1	-1	0	0	0	0
	protection	0	-1	0	0	0	0	0	-1	0	-1	0	-1	-1	0	-1	-1	0	-1	0	0	0	0
	watering	0	0	-1	0	0	0	-1	1	1	0	-1	1	0	-1	-1	0	0	0	0	0	-1	0
	health management	1	1	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0	1	0	1	1	1
	feeding	-1	-2	-2	0	-1	-1	2	1	2	-1	2	3	-1	-2	-2	1	2	1	-2	1	-2	1
	pasture	-1	-1	0	0	-1	-1	1	0	0	0	1	1	-1	0	1	0	1	0	-1	1	-1	0
	milk feeding	1	0	-1	0	-1	0	1	0	0	-1	1	1	0	0	-1	0	0	0	-1	-1	0	0
	complementation	-1	-1	0	0	1	0	1	0	1	0	1	0	0	-1	-1	1	1	1	0	1	0	1
	production	-1	1	1	2	-1	0	1	1	1	-1	1	0	1	0	0	0	2	1	0	1	0	1
	sale	0	1	0	1	-1	1	0	1	1	-1	1	-1	1	0	-1	-1	1	1	1	1	-1	0
	milk production	0	0	1	1	0	0	1	1	1	1	0	1	1	0	1	1	1	1	0	1	1	1
	variation of income	-1	0	0	0	0	-1	0	-1	-1	-1	0	0	-1	0	0	0	0	-1	-1	-1	0	0
	land management	0	1	0	1	1	0	1	1	1	0	1	1	0	0	0	1	1	1	0	1	0	0
	lease	0	0	0	0	0	0	-1	0	0	0	0	-1	0	0	-1	0	0	0	0	0	-1	0
	reproduction	0	-1	-1	-1	0	0	0	-1	0	-1	0	-1	0	-1	-1	-1	0	0	0	0	0	0
	global	0	-3	-2	4	1	-4	6	0	5	-3	7	2	-3	-3	-6	1	3	4	-2	5	-2	3

Appendix 5: Details of cost of rearing calculation

	1	*2*	*4*	*5*	*6*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*20*	*21*	*22*	*28*	*30*	*31*	*32*	*33*	*34*
milk	4	1	2	3	2	1	2	2	1	2	1	1	1	3	2	2	1	2	2	2	2	3
milk (L) up to 2 weeks	35	21	14	14	14	28	28	28	.	21	28	42	28	21	7	28	56	28	14	14	14	28
milk (L) up to 3 months	460	276	84	112	184	282	368	295	.	276	368	252	368	204	92	368	238	368	184	184	252	368
milk (L) up to 6 months	875	329	84	112	350	308	546	308	.	441	448	252	742	189	154	700	364	336	203	217	336	560
cost of copra up to 3 months	0.0	0.0	13.2	17.6	0.0	13.2	0.0	17.6	0.0	8.8	6.2	13.2	0.0	0.0	0.0	5.5	17.6	0.0	0.0	17.6	0.0	8.8
cost of copra up to 6 months	0.0	0.0	33.0	37.4	0.0	13.2	0.0	37.4	0.0	26.4	23.1	33.0	0.0	0.0	0.0	15.4	37.4	0.0	0.0	37.4	0.0	19.8
cost of molasses up to 3 months	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.3	1.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3	1.8	1.6	0.0
cost of molasses up to 6 months	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	3.7	3.9	3.1	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.7	4.0	3.9	0.0
cost of mill mix up to 3 months	0.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	37.5	37.5	0.0	0.0	0.0	35.0
cost of mill mix up to 6 months	0.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	60.0	0.0	0.0	0.0	0.0	0.0	87.5	87.5	0.0	0.0	0.0	85.0
cost of crest mash up to 3 months	0	0	0	0	0	0	43	0	27	0	0	0	43	0	0	0	0	0	0	0	0	0
cost of crest mash up to 6 months	0	0	0	0	0	0	108	0	81	0	0	0	108	0	0	0	0	0	0	0	0	0
cost of drench up to 3 months	2.9	3.6	0.0	2.1	6.3	2.0	0.0	1.8	0.0	3.3	3.9	2.0	0.6	1.6	3.3	2.6	2.6	0.0	3.6	2.6	0.0	2.3
cost of drench up to 6 months	9.5	10.4	4.2	6.2	16.9	6.8	1.7	5.7	3.1	10.0	13.7	6.8	2.1	5.5	10.0	9.1	9.1	1.3	10.4	9.1	1.7	6.5
Age at weaning (m)	7.5	4.0	3.0	2.0	3.0	3.0	3.5	3.0	3.0	8.0	6.0	1.8	6.0	3.0	6.0	6.0	2.5	3.0	3.5	2.0	3.0	4.5

milk category is: 1: powder 2: fresh mi 3: from mother 4: fresh milk then skim milk

Appendix 5 bis: Prices practiced

Product designation	Unit	Price (FJD)
Fresh milk (average)	1 L	0.47
Milk powder	25 kg	41.3
Coconut meal	40 kg	8.8
Molasses	44 gal	39.38
Mill mix	35 kg	17.7
Crest calf meal	26 kg	13.92
Fencare 2.5	1 L	11
Nilverm Oral	1 L	6.5
Ivomec Cattle	1 mL	0.88
Coccee Solution	1 L	23.6
Scourban	1 L	27.5
Ear tag	1 pair	1.35
Ear tag applicator	1 unit	37
Calf shed	10 places	3000

Appendix 6: Budget of the calf mortality survey

Item	**Cost**
Protective clothing	60
Transport	1548,14
- fuel	821,14
- maintenance	727
Ear tags and applicators	1304
Drugs	350
Laboratory stationary	1043,98
Total	**4306,12**

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