Epidemiology of Lameness in Dairy Cows

by

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Table of Contents

List of tables x

List of figures xii

Abbreviations xv

Acknowledgements xvi

Declaration xvii

Dedication xviii

Thesis Summary 1

Chapter 1: Introduction 2

General introduction 2

Incidence and prevalence of lameness 2

Costs associated with lameness 4

Economic losses resulting from lameness 4

Welfare implications 7

Defining lameness: automatic detection, visual scoring of locomotion and records of claw lesions 8

The bovine claw 11

Diseases causing lameness 13

Risk factors for lameness 16

Lying comfort 16

Floor surfaces and hygiene 17

Track surfaces 18

Claw trimming 18

Nutrition 19

Role of epidemiology in studies of lameness 19

Observational studies 20

Controlled trials 23

Conclusions 24

Aims 25

Chapter 2: Materials and methods 27

Introduction 27

Recruiting farmers 27

Sample size 29

Training events 30

Data collection 30

Locomotion scoring by researchers 32

Recording or claw lesions causing lameness by the farmer 34

Recording of hock lesions by researchers 34

Agreement between researchers for locomotion, hock and cleanliness scores 35

Risk factors for lameness 36

Cow Exposures 36

COW CLEANLINESS 36

Exposures 36

STATIC RISK FACTORS 36

VARIABLE RISK FACTORS 37

Milk yield and milk quality data 38

Data management and handling 39

Results 39

Farmer participation 39

Repeatability of scoring systems 40

Farmer records of lesions causing lameness 41

Management and farmer attitudes questionnaires 42

Training events 42

Discussions of methods 43

Visit logistics 43

Data collection 43

Locomotion scoring 44

Hock lesion scoring 47

Cow cleanliness scoring 47

Lesions causing lameness recording forms 49

Training events 49

Conclusions 50

Chapter 3: Descriptive summary of individual cow measures 51

Materials and methods 51

Case definitions for the incidence of lesions 51

Results 52

Cow specific measures made during visits to farms:
locomotion, cleanliness and hock scores 52
Lesion causing lameness 57
Location of lesions causing lameness 59
Associations between locomotion, hock lesions,
cow cleanliness and lesion causing lameness 63
Discussions 65
Case definitions of lameness 65
Variation with time in milk 66
Seasonal variation 68
Hock damage 69
Location of lesion 70
Conclusions 73
Chapter 4: Risk factors for poor locomotion in
dairy cattle 74
Introduction 74
Materials and methods 75
Data collection 75
Linear modelling 75
Outcome variable: mean farm locomotion score 75
Dependent variables 76
Screening variables 77
Multivariable general linear model 77
Results 77
Multivariable linear regression analysis 79
Discussions 85

Conclusions 91

Chapter 5: Risk factors for increased rates of sole ulcer, white line disease and digital dermatitis 92

Introduction 92

Materials and methods 93

Data collection 93

Monthly milk data 93

Lesion data 93

Risk factor data 93

Data management and analysis 93

Data handling 93

Multi-level modelling 95

Results 96

Summary data 96

Multi-level models 98

Sole ulcers 100

White line disease 100

Digital dermatitis 100

Discussions 103

Bedding quantity 103

Floor surfaces in houses and yards 104

Track surfaces 106

Parity 106

Herd size 107

Variation between herds and between cows 107

Conclusions 108

Chapter 6: Interventions for lameness reduction on commercial dairy farms 109

Introduction 109

Materials and methods 110

Allocation of farms to control or intervention groups 110

Study design and recording considerations 114

Analysing farm specific interventions 114

The presentation of recommendations to study farmers 122

Data collection 123

Pre-intervention visit 124

Monitoring interventions 125

Recording risk factors 126

Individual cow, housing and management data 126

Exit Questionnaire 126

Post-intervention visit 127

Analysis of intervention data 127

Farm mean locomotion scores 127

Individual cow locomotion score 127

Rates of lesions 127

Results 128

Participation 128

Uptake of interventions 129

Comparison of control and intervention group 132

Incidence of claw lesions 132

Locomotion score 136

Discussions 142

Methodology 142

Logistical constraints 142

Using an expert 143

Uptake of interventions 143

Farm variation 144

Effect of intervention on lameness and rates of lesions 145

Conclusions 148

Chapter 7: General discussion 149

Introduction 149

Interrelations of lameness, lesions and risk factors 149

Intervening to reduce lameness 150

Possible shortcomings of the study 152

Conclusions 153

Future work 156

References 157

Appendicies 166

Appendix A: First farmer recruitment letter 166

Appendix B: Second letter to farmers & training event information 169

Appendix C: Lesion recording form 171

Appendix D: Colour atlas 172

Appendix E: Farmer interview 174

Appendix F: Exit questionnaire 185

Appendix G: Winter observations recording form 187

Appendix H: Summer observation recording form 193

Appendix I: Letter to vet 195

Appendix J: Pre-intervention visit information 196

Appendix K: Overall impressions of visit 197

Appendix L: Intervention visit report 198

Appendix M: Recommendations summary sheet 200

Appendix N: Summer and winter Risks 201

List of Tables

Table 1.1	Summary of some frequently used locomotion scoring techniques	9
Table 1.2	Summary of frequently reported lesions	14
Table 2.1	Time and grazing season visits to farms for locomotion scoring	31
Table 2.2	Summary of data collected for the risk factor study (Feb 03-Mar 04)	32
Table 2.3	Locomotion score	33
Table 2.4	Hock lesion score	35
Table 2.5	Cow cleanliness score	36
Table 2.6	Bedding cleanliness and depth scores	37
Table 2.7	Faecal scoring system	38
Table 2.8	Percentage agreement and Pearson's correlation for the locomotion, hock lesion and cow cleanliness scores of 20 cows by two researchers	41
Table 2.9	Location, date and attendance at 5 training events held for study farmers	42
Table 3.1	Mean of the percent (range) of cows in each score category (1-3) for locomotion, cow cleanliness and hock damage for study years 1 and 3	53
Table 3.2	Median (range) of the farm rates of sole ulcer, white line disease and digital dermatitis	58
Table 3.3	Percentage of sole ulcer lesion on each claw for all cows	60
Table 3.4	Percentage of sole ulcer lesion on each claw for first lactation cows	60
Table 3.5	Percentage of sole ulcer lesion on each claw for second lactation or older cows	60
Table 3.6	Percentage of white line disease lesion on each claw for all cows	61
Table 3.7	Percentage of white line disease lesion on each claw for first lactation cows	61
Table 3.8	Percentage of white line disease lesion on each claw for	

second lactation or older cows 61
Table 3.9 Percentage of digital dermatitis lesion on each claw for all cows 62
Table 3.10 Percentage of digital dermatitis lesion on each claw for first lactation cows 62
Table 3.11 Percentage of digital dermatitis lesion on each claw for second lactation or older cows 62
Table 3.12 The percentage of treatments by the farmer of the same lesion type on the same claw in the same lactation 63
Table 4.1 Number and percentage exposure, difference in mean locomotion score for management and housing variables For 49 farms in England and Wales 78
Table 4.2 Summary of 7 sub-models of mean locomotion score for 50 farms 80
Table 4.3a Overall multivariable linear regression model of mean farm locomotion score for 44 cubicle housed dairy herds 81
Table 4.3b Overall multivariable linear regression model of mean farm locomotion score for 44 cubicle housed dairy herds with inclusion of mean herd size and milk yield to investigate confounding effects 82
Table 4.4 Summary of variables included in multivariable analysis which correlated with variables in the final model 84

Table 5.1 Number and percentage of sole ulcer, white line disease and digital dermatitis lesions treated for different cow and farm characteristics 97
Table 5.2 Mixed effects models of risk factors for sole ulcer, white line disease and digital dermatitis lesions 101

Table 6.1 Allocation of farms to control or intervention groups 112
Table 6.2 Intervention and control group means for final farm allocation 114
Table 6.3 Summary of five target areas for intervention and hypotheses and aims for reducing lameness 122
Table 6.4 Time and grazing season of farm visits 123
Table 6.5 Farm visits and data collected between November 2004 and February 2006 124

Table 6.6 Uptake of recommendations within 5 target areas 129
Table 6.7 Summary of recommendations made to farmers 131
Table 6.8 Mean locomotion scores and rates of claw lesions for control and intervention farms in three study years 133

List of Figures

Figure 1.1	Structure of the bovine claw	11
Figure 1.2	Sole surface of the bovine claw	13
Figure 2.1	Locations of participating farms and training events	29
Figure 2.2	Roger Blowey training farmers in lesion recognition	30
Figure 3.1	Mean and s.e.m.of the farm mean locomotion score by time of visit and location of cattle	54
Figure 3.2	Mean and s.e.m of the percentages of cows scored as locomotion scores 1-3 on each farm	54
Figure 3.3	Mean and s.e.m.of the farm mean hock lesion score by time of visit and location of cattle	55
Figure 3.4	Mean and s.e.m of the percentages of cows scored as hock lesion scores 1-3 on each farm	55
Figure 3.5	Mean and s.e.m.of the farm mean cleanliness score by time of visit and location of cattle	56
Figure 3.6	Mean and s.e.m of the percentages of cows scored as cleanliness scores 1-3 on each farm	56
Figure 3.7	Percentage of 16 most frequent lesion types recorded as the primary cause of lameness at claw trimming sessions	57
Figure 3.8	Rate of sole ulcer, white line disease and digital dermatitis lesions per study month as recorded by farmers	58
Figure 3.9	Rate of sole ulcer, white line disease and digital dermatitis by month in milk	59
Figure 3.10	Scatter diagrams of farm means for locomotion, hock lesion and cow cleanliness scores with regression line	64
Figure 3.11	Scatter diagrams of farm means for locomotion and lesions causing lameness	64
Figure 4.1a	Mean proportion of cows within all herds with locomotion score 1 to 3	75
Figure 4.1b	Histogram of mean farm locomotion score	76
Figure 4.2	Plot of residuals versus fit	83

Figure 5.1	Model fit for multi-level model of risk factors for sole ulcer	98
Figure 5.2	Model fit for multi-level model of risk factors for white line disease	99
Figure 5.3	Model fit for multi-level model of digital dermatitis	99
Figure 6.1	Interventions recording form	115
Figure 6.2	Improvements of track surface on hilly terrain from hardcore/ mud used by tractor and cows to separate cow track with pine peelings over reclaimed railway sleepers	130
Figure 6.3	Rubber at parlour exit	130
Figure 6.4	Access to concrete for heifers and dry cows	130
Figure 6.5	Rate of sole ulcer per quarter in control and intervention groups	134
Figure 6.6	Rate of white line disease per quarter in control and intervention groups	134
Figure 6.7	Rate of digital dermatitis per quarter in control and intervention groups	134
Figure 6.8	Differences in rate of sole ulcer per farm between study years	135
Figure 6.9	Differences in rate of white line disease per farm between study years	135
Figure 6.10	Differences in rate of digital dermatitis per farm between study years	135
Figure 6.11	Mean score of locomotion for control and intervention groups	137
Figure 6.12	Percent of cows with locomotion score 1 in control and intervention groups	137
Figure 6.13	Percent of cows with locomotion score 2 in control and intervention groups	138
Figure 6.14	Percent of cows with locomotion score 3 in control and intervention groups	139
Figure 6.15	Percentage of cows per farm with each locomotion score combination between visits 5 and 6	140
Figure 6.16	Percentage of cows per farm with each locomotion	

	score combination between visits 5 and 6	141
Figure 6.17	Percentage of cows per farm with each locomotion score combination between visits 5 and 6	142
Figure 7.1	Schematic diagram of measured and hypothesised risks for locomotion and lesions	154
Figure 7.2	Schematic diagram of measured and hypothesised risks for locomotion and lesions and target areas for intervention	155

Abreviations

CS&ST	Cow comfort and standing time
DD	Digital dermatitis
FQ&CF	Floor quality and cow flow
JW	Joanne Wright
MC	Month from calving
NMR	National milk records
RB	Roger Blowey
s.e.m	Standard error of the mean
SU	Sole ulcer
WLD	White line disease

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Declaration

All the work in this thesis is my own, is original and has not been presented previously for another degree.

The contents of Chapter Four have been accepted for publication (Barker et al., 2007 in press, J.Dairy Sci)

Dedication

I dedicate this work to Donkey with whom this adventure has been shared.

"That'll do Donkey, that'll do!"

Summary

Four visits were made to 50 dairy farms in England and Wales between February 2003 and February 2004 and a further three visits to 42 of these farms between February 2005 and February 2006. At each visit the locomotion of all cows was scored (15,597 cows, 34,643 measures). Multivariable regression analyses were preformed to identify risk factors associated with increased lameness (poor locomotion). Factors associated with mean herd poor locomotion were dry cows kept in straw yards compared with cubicle houses, pregnant heifers kept with milking cows compared with dry cows in winter, passage way widths <3m compared with ≥3m, a kerb height of ≤15cm compared with >15cm, routine trimming of claws of all cows by a claw trimmer or by the farmer compared with no routine claw trimming, feeding maize silage to milking cows compared with other forage types, and the use of automatic scrapers compared with tractor scrapers in the cubicle house.

Farmers recorded the lesions they observed while treating lame cows. Sole ulcer, white line disease and digital dermatitis were the three most frequently recorded lesions. The occurrence of sole ulcer, white line disease or digital dermatitis compared with having no lesion was used as the outcome variable in three multi-level binomial logistic regression models with month from calving nested within cow nested within farm. Risk factors associated with increased risk of sole ulcer were being housed on sparse bedding for four months or more, having grooved concrete floors on the farm, large herd sizes and parity numbers of four and above. Risk factors associated with increased white line disease were grooved concrete floors increasing parity number. Risk factors associated with increased digital dermatitis were grooved concrete floors and large herd sizes.

A large clinical trial was used to assess the effect of intervening on known risk factors associated with lameness. Farmers in the treatment group received farm specific recommendations grouped under five targets areas which reflected the hypothesised aetiologies of sole ulcer, white line disease and digital dermatitis. There were small reductions in locomotion score and sole ulcer rate on treatment farms compared with control. These suggested that the hypotheses that reduced standing time and encouraged increased lying time through improved cow comfort may reduce sole ulcer were, at least in part, correct. There was no clear effect of treatment on the rate white line disease and digital dermatitis. It is likely that more than one of the following factors explain the lack of significant results from these initial investigations; poor recognition of lameness by farmers, insufficient uptake of recommendations, predisposition to lameness from previous lameness event and insufficiently specific lesion definitions.

Chapter 1

Introduction

General introduction

Lameness is a term used to describe impaired locomotion resulting from painful diseases and conditions of the back, legs and feet (O'Callaghan, 2002). Painful conditions causing lameness not only impair the welfare (Whay et al., 1997) of the individual but also result in economic losses to the farmer or herdsperson (Kossaibati and Esslemont, 1997). Lameness is currently one of the three largest disease syndromes the UK dairy herd alongside mastitis and infertility (Esslemont and Kossaibati, 1996).

Incidence and prevalence of lameness

Reported estimates for lameness in the UK vary due to both the recorder and the method of measurement. Eddy and Scott (1980) and Russell et al. (1982) reported the incidence of lameness cases treated by veterinarians to be 7.3% and 5.5% respectively. However, the incidence of lameness recorded at small veterinary practice in Cheshire was 30.0% (Prentice and Neal, 1972). In a study by Whitaker et al. (1983) the annual incidence of lameness treated by veterinarians was 6.3% compared with 18.7% treated by farmers. Therefore 72.0% of lameness treatments are carried out by farmers. This is similar to the figures reported by Clarkson et al. (1996) where, with the exception of farms in one region, between 70% and 78% of lameness was treated by farmers.

When the incidence of lameness in the UK includes the number of cases treated by stockmen and foot trimmers the estimates of incidence range from 17%, (Collick et al., 1989) and (Esslemont and Kossaibati, 1996), through 55% (Clarkson et al., 1996) to 70% (Hedges et al., 2001; Green et al., 2002). Outwith the UK the incidence of lameness has been estimated as 7.0% in Southwest Victoria, Austrailia (Harris et al., 1988) and 17.5% in Kenya (Gitau et al., 1996).

Clarkson et al. (1996) reported the prevalence of lameness across 37 dairy farms was 21%. Huxley et al. (2004) reported a similar prevalence of 24% for 15 organic dairy farms. In Sweden and The Czech Republic the prevalence of lameness were 5% (Manske et al., 2002a) and 22% (Dembele et al., 2006) respectively. The prevalence of lameness in the USA lameness was 14% in summer and 17% in spring (Wells et al., 1993), 21% in summer and 24% in winter (Cook, 2003) and 65% (Sprecher et al., 1997).

Eighty-eight percent of reported lameness cases are associated with disorders of the feet with the remaining 12% attributed to the leg or other sites (Russell et al., 1982). Of the cases affecting the feet of dairy cattle 92% are in the hind feet and 65% of these are in the lateral claw (Murray et al., 1996).

Costs associated with lameness

Economic losses resulting from lameness

Most farmers are aware of the potential financial losses associated with treating lame cows such as medicines, use of a contract claw trimmer and the cost of veterinary treatments. However, numerous other factors exist which may produce additional financial losses for example fertility problems, increased culling rates and poor production.

Increased calving to conception intervals were reported for lame cows when compared with non-lame cows (Collick et al., 1989; Sprecher et al., 1997; Hernandez et al., 2001; Hernandez et al., 2005). Hernandez et al. (2005) also reported that the calving to conception was longer for cows with high (worse) cumulative locomotion scores than those with low cumulative locomotion scores. In lame cows the odds of conceiving were almost half than that of non-lame cows (Hernandez et al., 2001). Collick et al. (1989) also reported a reduction in pregnancy rate at first service in lame cows compared with non-lame cows. However, Barkema et al. (1994) found no such association between lameness and conception rates at first service. There was an increase in the interval from calving to first service and from first service to conception where the first service did not hold (Barkema et al 1994). Milk production in the previous lactation was a confounder for calving to first service interval and first service to conception interval. Garbarino et al. (2004) reported lame cows were 3.5 times more likely to have delayed ovarian cyclicity compared with non-lame cows. Increased

number services per conception were reported for lame cows compared with non-lame cows (Collick et al., 1989; Sprecher et al., 1997).

Lameness has been associated with an increased risk of culling (Rajala-Schultz and Grohn, 1999). In a French herd, 3.9% of cows were culled primarily because of lameness or foot/leg defects (Seegers et al., 1998). Lame cows were 8.4 times more likely to be culled than non-lame cows (Sprecher et al., 1997). Lameness diagnosis in early to mid lactation was most significantly associated with culling between 121-240 days in milk (Booth et al., 2004). Lameness in late lactation is associated with culling to a lesser extent because the effects on production are less (Rajala-Schultz and Grohn, 1999; Booth et al., 2004). Farmers may also consider the impending dry period an opportunity for lame cows to recover. Barkema et al. (1994) reported lower culling rates in lame cows then non-lame cows. However, milk production in the previous lactation was also higher in lame cows and the authors suggest that farmers are more likely to tolerate lameness in high yielding cows.

A number of studies have reported decreases in milk production associated with lameness. Losses of 1.1kg/d in Friesian, Ayrshire, and Holstein crossbreeds and 2.6kg/d in predominantly Holstein herds in America were reported by Lucey et al. (1986) and Warnick et al. (2001). A reduction in 305 day milk yield of 856kg was reported for cows lame with interdigital necrobacilosis compared with non-lame cows (Hernandez et al., 2002). Hernandez et al. (2005) reported a reduction in milk yield of 874kg for cows with high cumulative locomotion scores compared with non-lame cows. However there was no difference in milk

production between moderately lame cows and non-lame cows. In a study by Rajala-Schultz and Grohn (1999) reductions in milk yield were recorded for up to two weeks before diagnosis and persisted for up to six weeks or longer after diagnosis, in first parity animals. For animals in parity four or greater the milk yield of non-lame cows was lower compared to the yield of lame cows greater than 28 days before diagnosis. Green et al. (2002) reported that lame cows had a greater potential yield than that of non-lame cows. It is estimated that over one lactation cows which were lame could had produced an additional 400kg of milk had they not been lame.

Esslemont and Kossaibati (2002) calculated the health costs associated with the average case of lameness is £171.56. On average each cow has 1.4 cases of lameness therefore the cost per cow is £178.23. The calculation included both direct costs and indirect costs of lameness. Direct costs were treatment cost including farmers' time and veterinary intervention, cost of milk withdrawal and cost of reduction in milk yield. Indirect costs were increased culling, longer calving interval and extra services. When taking into account only the direct costs of the main production diseases of dairy cattle lameness accounts for 25% (Esslemont and Kossaibati, 2002). Enting et al. (1997) estimated the cost of lameness in The Netherlands to be £18.10 per cow per year, accounting for 4-5% of the average income on a Dutch dairy farm (Enting et al., 1997). However, excluding cost of fertility problems, a similar value of around £17.82 ($42.90 Australian Dollars) was estimated for Australian dairy farms Harris et al. (1988). Lameness accounted for only 5% of disease cost on dairy farms in Ohio, USA (Miller and Dorn, 1990). Of the cost associated with lameness the majority are

associated with reactive treatment and culling. Only 13% of costs are associated with lameness prevention of which the main costs are a contract claw trimmer (Miller and Dorn, 1990).

Welfare implications

The costs of lameness extend beyond financial considerations. The cost of lameness to an individual cow should also be considered in terms of the welfare of that animal.

O'Callaghan et al. (2003) demonstrated that higher posture scores i.e. deviations from a level spine, even pace and feet pointing in the direction of travel (considered to be the normal walk of a sound cow), were associated with chronic claw lesions and that the severity of the lesion affected the daily activity levels of the cow. This implies that such lesions not only cause pain but also impair the ability of the cow to perform normal behaviours. Treatment of lame cows initially depends on the ability of the farmer to identify lame cows. A recent paper reported that most UK farmers underestimate the prevalence of lameness on their farms (Whay, 2002). Wells et al. (1993) also reported that locomotion scores recorded by farmers were 2.5 times lower than those recorded by researchers. This suggests that a number of lame cows are not treated until the lameness becomes severe enough to be recognised by the farmer or recover without receiving treatment. The perceived pain associated with lameness varies between cattle practitioners (Huxley and Whay, 2006). The median pain scores for practitioners who used analgesics for the treatment of sole ulcer and digital

dermatitis were significantly higher than for practitioners who never used analgesics for the treatment of sole ulcer and digital dermatitis. Despite the high pain scores associated with sole ulcer and digital dermatitis 43.2% and 43.6% of practitioners stated that they never used analgesics for the treatment of these conditions (Huxley and Whay, 2006). Improving the ability of those working with dairy cattle to perceive the pain is essential to improving the detection and treatment and aftercare of lame cows.

Cows show considerable signs of discomfort when lame yet tend to remain in the herd until later in lactation than those culled for disorders of the udder (Seegers et al., 1998; Booth et al., 2004), because they continue to breed and produce milk (O'Callaghan, 2002). This demonstrates that even with signs of severe discomfort and, by inference, pain in many cases the decision-making process regarding whether a cow remains in a herd is driven largely by economics.

Defining lameness: automatic detection, visual scoring of locomotion and records of claw lesions

Lameness detection systems have been developed which measure ground reaction forces and their use has been trialled in a commercial farm situation (Tasch and Rajkondawar, 2004). However, it will still be some time before the use of such systems become affordable and widespread.

Until such a time as automated systems are available visual assessments of locomotion remains the usual approach. A number of scoring systems have been reported in the literature, which assess the locomotion of cows based on any

number of attributes of their gait (Table 1.1). Visual assessments of locomotion may be carried out live where whole herds can be rapidly assessed or using videos where the number in a study may be restricted by the logistics of acquiring good quality videos of individual animals. Videos do however provide the opportunity for independent assessment by many observers in a randomised viewing sequence.

Table 1.1 Locomotion scoring techniques

Author	Score	Description
Manson and Leaver (1988)	1	Minimal abduction/ adduction, no unevenness of gait, no tenderness
	1.5	Slight abduction/ adduction, no unevenness of gait, no tenderness
	2	Abduction/ adduction present, uneven gait, perhaps tenderness
	2.5	Abduction/ adduction present, uneven gait and tenderness
	3	Slight lameness not affecting behaviour
	3.5	Obvious lameness, some difficulty turning, not affecting behaviour
	4	Obvious lameness, difficulty turning, behaviour affected
	4.5	Some difficulty rising, difficulty walking, behaviour affected
	5	Extreme difficulty in rising, difficulty walking adverse effects on behaviour
Tranter and Morris (1991)	0	No abnormality of gait
	1	Lameness hardly noticeable
	2	Slightly lame
	3	Markedly lame
	4	Affected limb not weight bearing
Whay et al. (1997)	1	Sound
	2	Imperfect locomotion
	3	Mild lameness
	4	Moderate lameness
	5	Severe lameness
	6	As lame as possible while upright

Table 1.1 continued Locomotion scoring techniques

Author	Score	Description
Wells et al. (1993)	0	None - Gait abnormality not visible at walk; not reluctant to walk
	1	Mild - Mild variation from normal gait at walk; includes intermittent gait asymmetry or mild bilateral or quadrilateral restriction in free movement
	2	Moderate – Moderate and consistent gait asymmetry or symmetric gait abnormality, but able to walk without continuous stimulation
	3	Severe – Marked gait asymmetry or severe symmetric abnormality
	4	Non ambulatory - Recumbent
Sprecher et al. (1997)	1	Cow stands and walks with a level back posture. Her gait is normal
	2	Stands with level back but arched back when walking. Gait is normal
	3	Arch back while standing and walking. Gait is affected. Shortened strides with one or more limb
	4	Arched back posture always evident. Gait best described as one deliberate step at a time
	5	The cow demonstrates an inability or extreme reluctance to bear weight on one or more limb
Winkler and Willen (2001)	1	Normal gait
	2	Uneven gait
	3	Short striding gait with one limb
	4	Short striding gait with more than one limb or strong reluctance to bear weight on one limb
	5	Does not support on one limb or strong reluctance to put weight on two or more limbs
Cook (2003)	1	No gait abnormality – Walks rapidly and confidently, making long strides with a level back
	2	Mild lameness - Walks more slowly, making shorter strides with an arched back. Stands with a level back and does not appear to favour a limb
	3	Moderate lameness – Often thin. Walks slowly making deliberate short steps with an arched back, may favour a limb. Makes frequent stops. Encounters difficulty turning. Stands with an arched back and frequently lifts affected foot.
	4	Severe lameness – Usually very thin. Moves slowly, making frequent stops to reset affected limb. Only partially weight bearing. Frequently salivates. Encounters extreme difficulty turning. Stands and walks with pronounced arched back.
Whay et al. (2003)	0	Sound
	1	Abnormal locomotion/ perhaps tender
	2	Lame
	3	Severely lame

Reported agreement between observers using locomotion scoring techniques varies. Using a 5 point locomotion scoring system Winkler and Willen (2001) reported 68% exact agreement and 98% agreement where scores differed by one score between 2 observers. This was higher than the agreement reported by Engel et al. (2003) between nine observers and one expert using a 9 point locomotion scoring system. Here the average agreement was 40% and 80% where scores differed by one point. In addition to the effects of observer one must take into account the floor surface on which the cows walk during scoring (Phillips and Morris, 2001; Telezhenko and Bergsten, 2005), recent claw trimming sessions (Aoki et al., 2006) and the time since milking (Flower et al., 2006).

The automatic detection of lameness or the scoring of locomotion allows researchers, veterinarians or farmers to assess the prevalence of lameness in a herd. However, these methods do not identify the cause of the lameness. Identification of specific claw horn lesions or other causes is essential for targeted prevention of lameness. Numerous methods of recording claw lesions have been reported previously. These often record the types of lesion, the position of the lesion on the claw and the severity of lesions (Logue et al., 1994; Clarkson et al., 1996; Smilie et al., 1999).

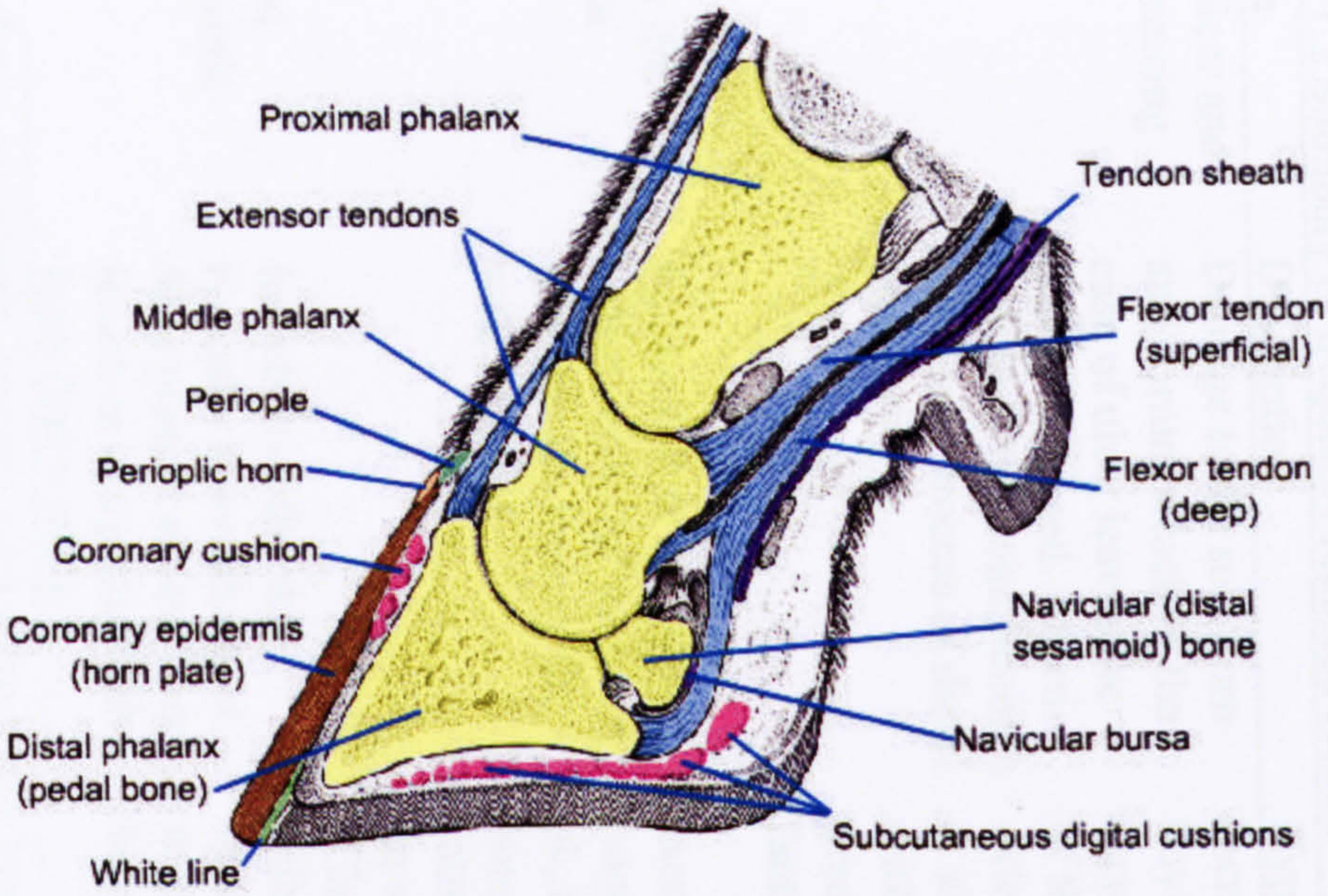
The bovine claw

Figure 1.1 illustrates the gross anatomy of the bovine claw. In the bovine claw the epidermis is specialised and forms a horny capsule around the distal phalanx, middle phalanx and navicular bursa (Leach, 1996). The epidermis forms four

specialised regions of claw horn. A soft layer of perioplic horn (Figure 1.1) covers the coronary band, the junction between the skin and claw horn. The horn of the wall grows down distally from coronary epidermal cells (hoof plate, Figure 1.1). Bulb horn encases the caudal surfaces of the claw (Figure 1.2). Sole horn occupies the remaining surface of the claw between the bulb horn and the white line (Figure 1.2). The white line is the junction between the horn of the sole and the wall (Figure 1.2). The two horn surfaces interdigitate to provide strength (Leach, 1996).

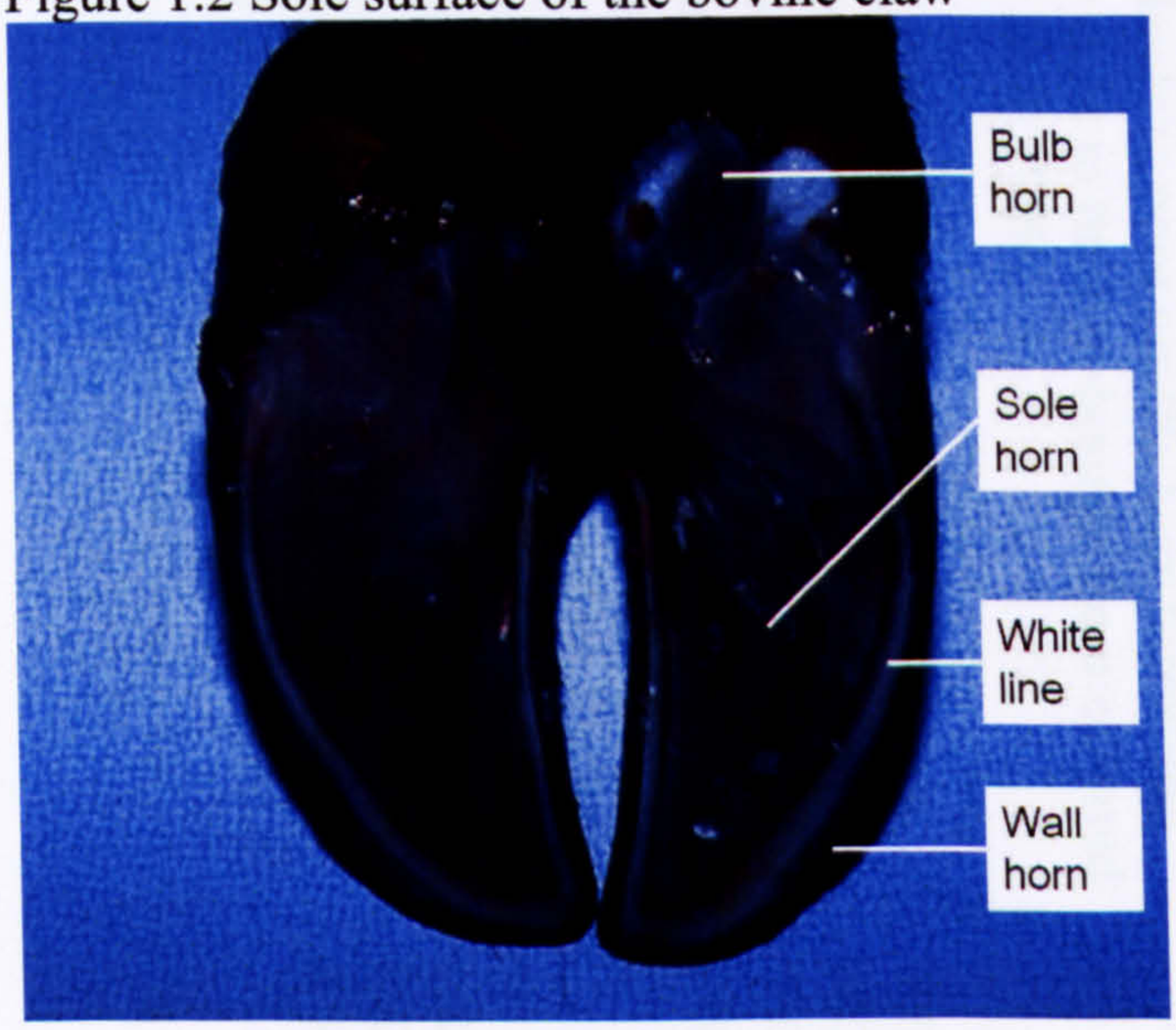
Claw horn is formed when epidermal cells undergo the process of keratinisation. As the epidermal cells migrate away from the basal membrane keratin filaments form keratin masses as keratin associated proteins are cross-linked by disulphide bonds (Bragulla et al.,1994). This process provides physical strength to the horn tissue. The white line does not contain keratin masses and is therefore weaker than both the horn of the wall and sole (Budras et al., 1996). The final stage of keratinisation is cornification during which keratinising epidermal cells produce the intercellular cementing substance. As glycoproteins in the intra cellular cementing substance undergo cell-cell adhesion the outer most layers of epidermal cells form a strong permeable barrier (Mulling et al., 1999). The process of keratinisation depends on an adequate supply of nutrients. A disruption in nutrient supply leads to the formation of poor quality hoof horn because of poor keratinisation (Mulling et al., 1999). The dermis (corium) is a higher vascular and sensitive structure which supplies nutrients to the epidermis (Leach, 1996)

Figure 1.1 Structure of the bovine claw



Courtesy of Ch Mülling (adapted by Judith Brown)

Figure 1.2 Sole surface of the bovine claw



Courtesy of R Blowey

Diseases causing lameness

There are numerous diseases which affect the bovine hoof or surrounding tissues of the foot. The most frequently reported lesions are described and their aetiology and reported incidences are summarised in Table 1.2.

Table 1.2 Summary of frequently reported lesions

Lesion	Description	Hypothesised aetiology	Reported incidence
Sole ulcer and sole bruising	Damage to the sole horn and corium which in the case of ulcer leaves the corium exposed. Often occurs at the point beneath the flexor process of distal phalanx	Increased laxity of the deep flexor tendon within the bovine claw around the time of calving allows increased movement of the distal phalanx and pinching of the corium. This may cause bruising and when external pressures are high lead to ulceration (Tarlton et al.,2002). Disruption to the keratinisation process within the claw leads to poor quality horn formation predisposing the claw to further damage from external factors (Mulling et al.,1999).	*UK 12.2% (Rowlands et al.,1983) UK 19.7% (Clarkson et al.,1996) UK 13.8 cases/100cows/year (Hedges et al.,2001)
White line disease	Penetration or separation of the white line junction between the horn of the wall and sole	Incomplete keratinisation leads to the production of poor quality horn of the in white line (Mulling et al.,1999). This weakened white line is more susceptible to penetration by foreign objects and introduction of infection (Kempson and Logue, 1993) an separation caused by turning and shearing forces (Chesterton, 2004).	*UK 3.8% (Rowlands et al.,1983) UK 12.2% (Clarkson et al.,1996) UK 12.7 cases/100cows/year (Hedges et al.,2001)
Digital Dermatitis	Infection of the skin typically above the heel. May present as raw open lesion or in a proliferative form (hairy wart).	Infection of the digital or interdigital skin by a spirochaete. It is widely agreed that a *Treponeme* is responsible although a number of phylotypes have been isolated (Walker et al.,1995; Trott et al.,2003).	UK 4.5% (Clarkson et al.,1996) UK 12.0 cases/100cows/year (Hedges et al.,2001)

* Incidence of specific lesions causing lameness treated by veterinarian.

Table 1.2 continued

Lesion	Description	Hypothesised aetiology	Reported incidence
Interdigital necrobacilosis ("Foul in the foot")	Infection of the interdigital skin and subcutaneous tissue. Swelling may extend to the coronary band. Foul odour may be present.	Physical damage to the interdigital skin allows infection with *Fusobacterium necrophorum* (Alban et al., 1995). Previous infection by *Bacteroides melaningenicus* also allows infection by *Fusobacterium necrophorum* (Berg and Loan, 1975)	*UK 13.4% (Rowlands et al., 1983) UK 2.8% (Clarkson et al., 1996) UK 7.1 cases/100cows/year (Hedges et al., 2001b)
Laminitis	Diffuse haemorrhage and discolouration of the sole horn. Soft waxy sole.	Reduced rumen pH during sub-clinical acidosis allows the release of vasoactive substances. These substances cause disruption to the blood flow in the corium resulting in the production of poor quality claw horn (Mgassa et al., 1984; Bergsten, 1994).	*UK 3.5% (Rowlands et al.,1983) UK 0.9% (Clarkson et al., 1996)
Heel erosion	Erosion ('pitting') of the heel horn	Structural breakdown of the horn tissue caused by exposure to manure and urine (Mulling & Budras, 1998).	UK 2.3% (Clarkson et al., 1996)
Interdigital growths (Tyloma)	Growth of tissue in the interdigital space	Irritation of the interdigital skin leading to overgrowth (Blowey, 1999).	*UK 5.1% (Rowlands et al.,1983) UK 2.7% (Clarkson et al., 1996)
Hock damage	Swelling scabbing or ulceration over the tarsus joint or carpal	Damage to the skin over the tarsus caused by contact with hard surfaces (Wechsler et al., 2000).	*UK 13.6% (Rowlands et al.,1983)

* Incidence of specific lesions causing lameness treated by veterinarian

Risk factors for lameness

Cows may be predisposed to lesions causing lameness as a result of internal changes within the claw such as those occurring at the time of calving (Tarlton et al., 2002). Aspects of the cow's environment and management have been associated with lesions which cause lameness. Exposure to these potential risk factors cause increased trauma to the claw.

Lying comfort

The base and bedding materials used in cow cubicles (free access stalls) varies across farms and it is not clear which, if any, of the available surfaces is best for the health of legs and claws. Wechsler et al. (2000) reported a significantly higher incidence of leg injuries over the tarsus (hock) in cows housed in cubicles with mats compared with those on cubicles bedded with straw. Given a choice, cows preferred cubicles deeply bedded with sawdust or sand to cow mattresses (Tucker et al., 2003). Cows with cubicles with a thin layer of sawdust and lime on concrete were reported to have decreased lying times, poorer locomotion and increased sole haemorrhage scores compared with those on a thin layer of sawdust on rubber mats however, cubicle size and type differed between these two groups (Leonard et al., 1994). Improved lying times were also reported for straw yards when compared with cubicles (Singh et al., 1993b). Singh et al., (1993a) reported that increased standing times were related to poor locomotion and increased sole lesion scores. Lying times were also increased where cows were housed in cubicles with larger dimensions (Tucker et al., 2004). Faull et al. (1996) reported increased lameness (locomotion scores) in 37 herds associated with limited 'borrowing' space at the front and side of cubicles, low side rails,

kerb heights greater than16cm and low quantities of bedding in cubicles. Bowell et al., (2003) reported that the ratio of cubicles to cows was negatively correlated with locomotion score. Cow comfort and lying times may therefore be important in the development claw lesions.

Floor surfaces and hygiene

The floor surfaces in the winter housing environment may also be important for lameness control. Smooth walking surfaces have been associated with increased locomotion scores (Faull et al.,1996; Dembele et al., 2006). The stride length of cows walking on slippery surfaces is shortened (Phillips and Morris, 2001; (Telezhenko and Bergsten, 2005). Telezhenko and Bergsten, (2006) reported that cows walk with a more natural gait on rubber floors and that lame cows show less asymmetry on rubber floors than on concrete. Cows were less likely to develop heel erosion when housed on rubber floors (Vanegas et al., 2006). However, risk of developing other claw lesions was not affected by floor type. Vokey et al. (2001) failed to find a difference in the amount of clinical lameness in cows housed on rubber floor compared with concrete. Sogstad et al. (2005) reported an increased risk of digital dermatitis for cows housed on solid concrete floors compared with those on slatted floors without scrapers. Slatted floors with scrapers were associated with a decreased risk of digital dermatitis. It was also reported that cows with restricted or zero grazing had an increased risk of digital dermatitis, suggesting both improved cleanliness and reduced stocking may be important factors in reducing digital dermatitis (Somers et al., 2005). Gregory et al. (2006) reported that sole horn exposed to slurry, urine and rainwater was

softer and heel horn exposed to washings from newly laid concrete became swollen. Softer claws are associated with more severe claw lesions (Borderas et al., 2004).

Track surfaces and stockmanship

Poor maintenance of track surfaces on which cows walk to and from pasture is associated with increased lameness (Chesterton et al., 1989; Clackson and Ward, 1991). The walking surface on 'cow walks' created by the repeated use of a specific part of a track, were scored as 'more ideal' than whole track (Clackson and Ward, 1991). If given a choice cows will select the 'cow walks' in preference to other areas of the walking surfaces (Faull et al., 1996). Increased lameness was also associated with impatient handling of cattle while being brought in for milking, for example using a dog or tractor to drive cattle (Chesterton et al., 1989; Clackson and Ward, 1991).

Claw trimming

Claw trimming procedures have been investigated with respect to the spread of digital dermatitis. Wells et al. (1999) reported a decreased risk of digital dermatitis where hoof trimming equipment was washed between cows. Having a hoof trimmer that trimmed cattle feet on other units was also associated with an increased risk of digital dermatitis (Wells et al., 1999).

Nutrition

High starch low fibre diets result in significantly higher incidences of laminitis (inflammation of the corium), sole ulcer, white line lesions and heel erosions (Livesey, 1984; Livesey et al., 1998; Webster, 2001). Faye and Lescourret, (1989) reported an association between feeding maize silage and metabolic claw diseases (laminitis, haemorrhage and ulcers of the sole and horizontal fissures). Greenough and Vermunt, (1991) reported that in a group of heifers those, which had reached the heaviest weights at their first service had the highest haemorrhage scores compared with those with the lowest body weights. It is possible that feeding of high energy rations to growing heifers may result in increased weights at first service and therefore a greater risk of lesions or lameness once they enter the milking herd.

Role of epidemiology in studies of lameness

Epidemiology studies the prevalence, risks and prevention of disease in populations (Dohoo et al., 2003). Consequently, epidemiological studies may be used to define disease, estimate prevalence or incidence, identify risks for disease and establish whether these risks are causal through intervention studies. Designing epidemiological studies of lameness is inherently difficult because lameness is a clinical presentation of many diseases with several aetiologies and pathogeneses. Epidemiological studies where several diseases and exposures can be studied simultaneously in an observational setting are very useful (Dohoo et al., 2003). Such studies are relatively quick and cheap compared with using cows

as experimental animals and studying each disease and possible risk separately (Dohoo et al., 2003).

Early epidemiological studies of lameness primarily reported the incidence of lameness, usually the incidence of the common claw lesions (Prentice and Neal, 1972; Eddy and Scott, 1980). As the number of cattle treated for lameness by farmers increased locomotion scoring techniques were developed used to estimate the prevalence of lameness (Clarkson et al., 1996).

Using multivariable modelling numerous risks for lameness or lesions can be considered together (Gitau et al., 1996; Somers et al., 2005; Amory et al., 2006; Dembele et al., 2006). The effects of confounders and other interrelationships between measured risks factors may therefore be identified. Some risk factor studies have been reported between the incidence of lameness and possible risks, for example season, herd size, housing type and time of calving (Whitaker et al., 1983; Rowlands et al., 1983). Individual risks associated with increased lameness or specific lesions have also been reported (Sogstad et al., 2005; Rodreguiz-Lainz et al., 1999; Weary and Taszkum, 2000).

Observational studies

Whilst epidemiological studies might be most appropriate for understanding lameness in dairy cows there are challenges in study design, data quality and data analysis. Design may be affected by observer bias, case definition, representativeness of data and farmer compliance. One technique to minimise observer bias is to use only one observer e.g. a single researcher measured the

prevalence of digital dermatitis lesions (Somers et al., 2005) and locomotion (Amory et al., 2006). This is probably a better approach than that used by Faull et al. (1996) where farms were visited by one of four veterinarians with no standardisation of recording techniques.

In the UK there is no central or local recording of lameness lesions or even treatment and so there are no historical data readily available from a central source. There are no standard definitions for lameness or lesions. Definitions of claw lesions are often based on the clinical presentation of the lesion at the time of treatment. However, this does not necessarily reflect the degree of pain associated with the lesion. If lesions cases are not followed until they are fully resolved then the case definition of each lesion type must include an arbitrary cut off for when an occurrence of a lesion becomes a new case.

Where estimates of prevalence are made the sample should represent the study population. However, a completely random sample of the study population is often not possible. The cost of visiting farms across a wide area mean that study populations may be selected from smaller geographical regions which may not represent the wider populations (Faull et al., 1996). Selection criteria may also be imposed, such as herd size categories, which may introduce selection bias. The population may also be selected from a specific source, for example a data base of respondents to a previous study (Rodrigeuz-Lainz., 1999) or recording data with an organisation (Sogstad et al., 2005). Again, this may bias the study towards farmers with a certain mind set. Epidemiological studies are usually voluntary and therefore rely on the willingness of farmers to participate. This

may inadvertently introduce selection bias as only farmers tolerant of surveys and research projects will respond positively if invited to participate.

Large studies of lameness often rely on farmers to record cases of lameness because the cost of researchers visiting farms is too great. This too may affect the utility of case definition of lesions and, in addition, compliance of farmers is invariably higher where recording of health records is routine (Alban, 1995). However in the UK routine recording of all cases of lameness is not common place and considerable effort must be made to improve compliance. Regular communication, incentives and feed back may be required to achieve good compliance (Dohoo., 2003).

Questionnaires, interviews or farm observations by a researcher may be used to measure the risks associated with lameness. Completing observations of the farm and interviewing farm staff are time consuming compared with questionnaires sent via the post. However, observations of the farm alone would fail to capture information about management practices just as questionnaires or interviews would not identify all risks in the environment. A combination of methods is therefore likely to provide the most comprehensive data set.

In a study of risk factors for digital dermatitis, lesions were recorded by a researcher using structured case definitions (Somers et al., 2005). Risk factor data were collected using a combination of farmer interview and direct measurements of aspects of the housing. Individual cow data were also collected from computerised records. In another study of risk factors for digital dermatitis

the prevalence of digital dermatitis was estimated by showing pictures and standardized descriptions of digital dermatitis to dairy producers and collecting retrospective data of treatments for digital dermatitis (Wells et al., 1999). On 74.4% of farms lesion estimates were based on records on the remainder of farms accuracy of the data relied upon the ability of the farmer to recall historical treatments. This is likely to be lower than data collected by a researcher. The prevalence of digital dermatitis in these two studies was 19% (Wells et al., 1999) and 30% (Somers et al., 2005). The higher prevalence of digital dermatitis reported by Somers et al. (2005) may have been influenced by the method of measuring digital dermatitis. However, populations represented in these two studies are different. A range of housing types (tie stall and cubicle housing) in the USA were included in the study by Wells et al. (1999). Whereas Somers et al. (2005) reported the prevalence for cubicle housed cattle in the Netherlands.

Controlled trials

Controlled trials (intervention studies) typically investigate the effect of a single exposure on disease. Examples of controlled trails on lameness in diary cattle include the effect of supplemental biotin (Hedges et al., 2001), effect of different footbathing solutions (Manske et al., 2002b) and the effect of rubber flooring (Vengas et al., 2006). Green et al. (2007) recently published the first large farm based mastitis control study in dairy cows. Farmers were given multiple interventions on known risk factors for lesion specific causes of mastitis. Unlike the previous approach to controlled trials this method can control for the associations between different exposures but may be less useful for estimating

the magnitude of effect of any specific intervention. Green et al., (2007) reported a cumulative effect of the number of interventions completed and the reduction in rate of clinical mastitis. In animal health research where financing clinical trials is difficult this approach offers an advantage over controlled trials which investigate a single exposure. In addition, for complex disease presentations several risks may need to be removed before any disease reduction is observed. The above design permitted this hypothesis to be tested, all be it at the expense of elucidating whether individual risks were key to reduction of mastitis.

A quantity of data on risk factors for lameness and claw lesions has now been accrued as presented earlier in this chapter, from many observational studies and small intervention studies. The lessons from the studies above together with generic epidemiology indicate that the time was right in 2002 to investigate lameness in dairy cows using well designed and implemented observational studies and the first multifactorial intervention study.

Conclusions

Evidence for housing and management factors which increase the risk of dairy cattle becoming lame continues to mount. However little evidence is available to suggest that intervening on one or more of these risk factors on a commercial dairy farm can reduce lameness. Previous interventions, successful as small controlled trials, include the use of topical antibiotic treatments and footbath solutions for the treatment of digital dermatitis (Manske et al., 2002b) and biotin supplementation for the prevention of white line disease especially in older

cattle (Hedges et al., 2001a). There are currently no reports of an intervention study across a range of dairy farming systems in the UK.

Aims

In its most simplistic form the overall aim of this study was to reduce lameness in dairy cattle. Many of the studies reporting risks for lameness have concentrated on specific areas of the farming system. Few have attempted to assess the risks across the whole farm. While our knowledge of risk factors for lameness increases there is no apparent decrease in the incidence of the disease. As such, there is a need to develop strategic lameness reduction programmes based on the current knowledge and to assess their impact on the incidence of lameness on commercial farms.

The aims of this study were to:

1. Identify risk factors for increased lameness and lesions causing lameness across commercial dairy cow farming systems (observational study)
2. Investigate lesion specific risks for lameness (observational study)
3. Determine whether the implementation of current knowledge of risk factors for lameness on commercial dairy farms could reduce the incidence of lameness on those units (intervention study)

The study form part of a larger EU funded framework 5 project (OLRT-2001-00969) "A multidisciplinary approach to the reduction of lameness and improvement in diary welfare in the European Community, Lamecow". on lameness in the European dairy herd 'LAMECOW'. The members of the group

at Warwick University were Professor Laura Green, Jonathan Amory (post-doctoral researcher), Zoe Barker (PhD student) and Joanne Wright (research technician). The group was responsible for the epidemiological aspects of the Lamecow project. Collection of data in the UK was completed by ZB and JW. Collection of data in The Netherlands, Germany and Poland was completed by subcontracted claw trimmers. The collection and analysis of these data was coordinated by JA. Additional support and veterinary advice for the UK study was provided by Roger Blowey.

Chapter 2

Materials and methods

Introduction

The data collection occurred in two phases that for the risk factor study in year one and the intervention study in year three. Throughout the whole study the prevalence and incidence of lameness was monitored on all study farms. In this chapter the methods used to monitor lameness prevalence, (locomotion scoring) and incidence (recording of treatments of lesions causing lameness) are described. The methods used to collect data on risk factors for lameness during the first year of the study including, questionnaires and direct observations of potential risk factors are described in this chapter.

During the intervention study the effects of implementing interventions aimed at reducing lameness were investigated. Details of the methods specific to this intervention study are described in Chapter 6.

For the purpose of this thesis the dairy farmers, herdspersons or farm managers representing the farms are called farmers.

Recruiting farms

Four hundred and ninety-eight farmers that had participated in a previous study on mastitis (Peeler et al., 2002) were contacted by letter (Appendix A, Page 166). Farmers were asked whether they would agree to participate in a study to

investigate risks for lameness in dairy cattle. They were specifically asked whether they would record cases of lameness in their cattle. Farmers were also asked if they would allow researchers to visit their farm, to locomotion score their cattle and collect data on management from an interview and direct observations of their farm. Finally, farmers were invited to attend a training day on lesion recognition.

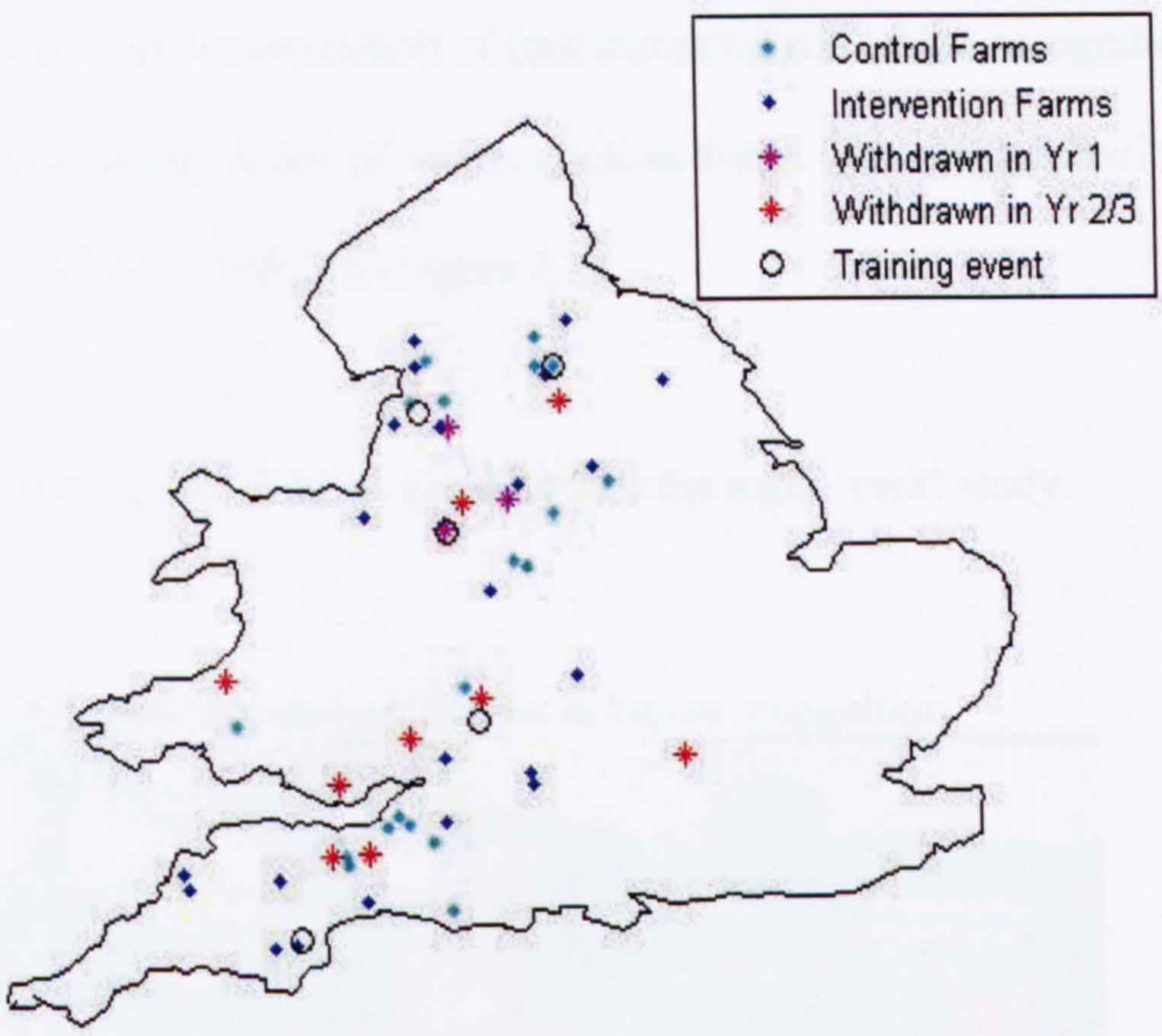
A total of 342 (68.7%) responses were received from farmers of which 170 (49.7%) agreed to participate in the study. A second letter was sent to farmers (Appendix B, Page 169) who had agreed to take part in the project with details of the dates and locations of the training events. Fifty-three farmers (31.2%) indicated that they would attend one of the training events. Evening training events where held in May 2003. These were hosted by four agricultural colleges and one farm, the locations of which are shown on Figure 2.1. The attending farmers represented farms with a range of herd sizes and geographical locations and so they were selected as the 'visit' group i.e. they were later visited by researchers who locomotion scored all cows, made direct observations of the farm buildings and tracks and collected information on the management of the farm in an interview with the farmer.

The remaining farmers, who wished to participate in the study but were not willing to attend a training event, were allocated to the 'postal' group. These farms were not visited by researchers so no direct observations of the farm were made and the cattle were not locomotion scored. Information on the

management of these farms was collected using a questionnaire which was sent by post to the farmers with a prepaid return envelope.

Farmers in both the 'visit' and 'postal' groups were asked to record the lesions observed while trimming the claws of cows using a standard recording form (Appendix C, Page 171).

Figure 2.1 Locations of participating farms and training events



Sample size

We planned to locomotion score all cows on all farms on four occasions so that a range of housing situations were represented (i.e. grazing, the early autumn/winter housing period and late winter housing). The sample size was therefore constrained by the time required for the researchers to visit the farms

four times each year. It was estimated that visiting between 50 and 60 farms would take 25-30 weeks per year therefore representing the maximum sample size.

Training events

The aim of the training events was to standardise lesion recognition by the farmers taking part in the study. Five events were carried out around the UK in Lancashire, North Yorkshire, Cheshire and Gloucestershire and Devon. Farmers were given a practical demonstration of foot trimming and lesion recognition and completed a quiz using slides of various lesion types. The demonstration was given by Roger Blowey, FRCVS (Figure 2.2).

This thesis considers the 53 farms enrolled into the main 'visit' study.

Figure 2.2 Roger Blowey training farmers in lesion recognition

Data collection

A range of data collection methods were employed to gather data for a series of research questions. These were direct observations by researchers (cattle and farm environment), data recorded by the farmer (claw lesions) and farmer interviews. Data were collected from study farms during one of seven visits. The timing of the farm visits are summarised in Table 2.1 and the type of data collected are summarised in Table 2.2.

Table 2.1 Time and grazing season of visits to farms for locomotion scoring

Visit number	Time of visit	Housing status	Number of farms	Study period
1	Feb-May 03	Late winter housing/ early grazing	53	
2	Jun – Aug 03	Grazing	52	Year 1: Risk factor study
3	Nov – Dec 03	Early winter housing	51	
4	Jan – Mar 04	Late winter housing	51	
5	Jan – Feb 05	Late winter housing	42	Year 3: Intervention study
6	Jul – Aug 05	Grazing	42	
7	Jan – Feb 06	Late winter housing	41	

Table 2.2 Summary of data collected for the risk factor study (Feb 03-Mar 04)

Data collected	When collected	Purpose of data
Locomotion score of all cows	At all visits	To measure lameness prevalence
Cleanliness score of hind limbs and flanks of all cows	At all visits	Indicator of diet & cleanliness of environment
Hock score of all cows	At all visits	Cause of lameness & indicator of cow comfort
Assessment of bedding quality and quantity	All visits during housed period	Indicator of cow comfort
Consistency of faeces	At all visits	Indicator of gastrointestinal function
Interview with farmer	Visit 2	Identification of potential lameness risk factors associated with management
Direct observations of summer environment and walkways	Visit 2	Assessment of potential lameness risk factors in the summer environment
Direct observations of winter housing environment	Visit 3	Assessment of potential lameness risk factors in the winter environment
Observations of cubicle use by cows	Visit 4	Indicator of cow comfort
Exit questionnaire	Visit 4	Indicator of farmer attitudes to lameness

Locomotion scoring by researchers

The three point locomotion scoring method used in this study is defined in Table 2.3. The scoring system was a modification of the method described by Sprecher et al. (1997). The top 3 scores (scores 3 to 5) from the Sprecher method were merged to form a score 3 which covered all severities of clearly lame cows. It was therefore possible to locomotion score cows by observing only the back posture while walking and standing.

Table 2.3 – Locomotion score

Score 1	Score 2	Score 3
Flat back when standing	Flat back when standing	Arched back when standing
		
Flat back when walking	Arched back when walking	Arched back when walking
		

A list of cow identifications was used to ensure all cows were scored and all milking and dry cows were scored at each farm visit unless they were housed away from the farm, too sick to be scored, calving or accidentally missed. On most farms, cows were identified by the freeze brand mark usually located on their rear. Cows on 15 farms did not have freeze brands. On 14 farms the cows were identified by the farmer and on one farm the cows were identified by numbers written on tape wrapped around the tail.

To locomotion score the cows it was necessary to have a good observation point where the observer could see the cow profile as she walked past without startling the cows or disturbing cow flow. Ideally cows were scored as they exited the parlour. When there was no suitable area to observe the cattle at the exit of the parlour, cows were scored in a concrete yard (usually a feeding and/or loafing area). On 12 of the farms with unbranded cows, scoring took place in a loafing area, in between milking times, with the farmer present to identify the cows. On

the remaining two farms the cows were identified by the farmer and scored as they exited the parlour.

During the summer grazing period, cows were scored in the field unless large numbers per field made finding all cows difficult or lists of cow identifications were difficult to follow or were not available, and then cows were scored as they exited the parlour.

Recording of claw lesions causing lameness by the farmer

Farmers were asked to record claw lesions whenever a cow was treated for lameness. A recording form was designed which standardised the identification of lesions and where the location of the lesion could to be marked on a diagram (Appendix C, Page 171). Farmers were asked to use the same cow identification as used for locomotion scoring.

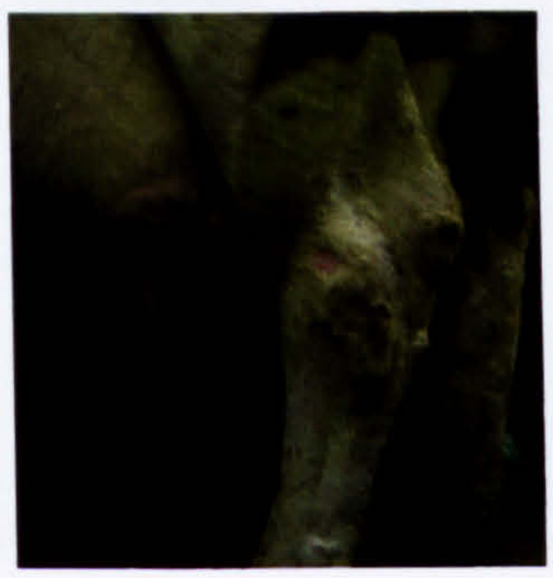
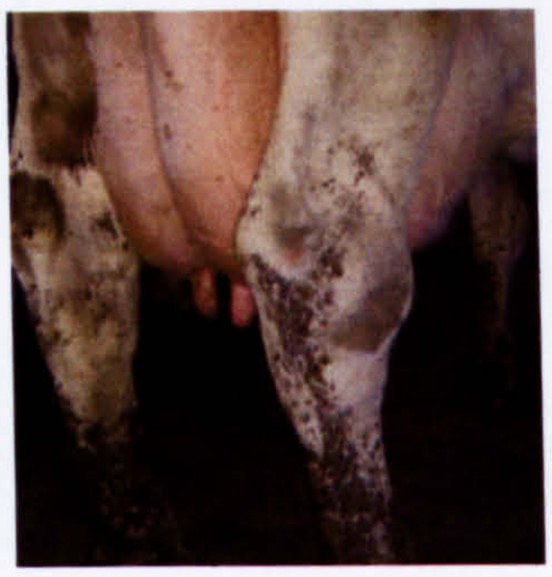
All farmers were also provided with a laminated colour copy of a lesion reference sheet which gave names, descriptions and pictures of the common presentations of all the major lesions seen across Europe (Appendix D, Page 172). In order to encourage continued participation in the study, letters containing spare lesion recording forms and prepaid envelopes were sent out to the farmers every two months.

Recording of hock lesions by researchers

All cows were scored for the presence and severity of hock lesions on both hind limbs by the researchers during the visits to the farms. Hocks were scored using a

scale of 1 to 3, where score 1 represented a hock with no damage and score 3 a severely damaged hock (Table 2.4). When the severity of the lesions on each limb differed then the highest score was recorded. The cows' hocks were examined for evidence of damage while the cows were locomotion scored. Farmers also recorded the presence of hock lesions on their cows when they considered them to be the cause of lameness.

Table 2.4 – Hock lesion scores

Score 1	Score 2	Score 3
No Lesions on hock	Hock with hair loss or mild swelling	Hock bleeding, ulcerated or with large swelling
		

Agreement between researchers for locomotion, hock and cleanliness scores

The locomotion, hock lesions and cleanliness of 20 cows was assessed by 3 researchers on the same day. The inter-observer reliability was calculated using both the percentage agreement and the Pearson's correlation coefficient.

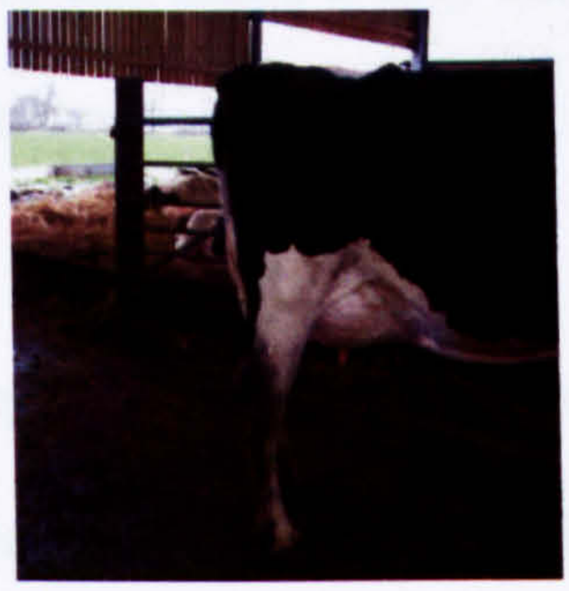
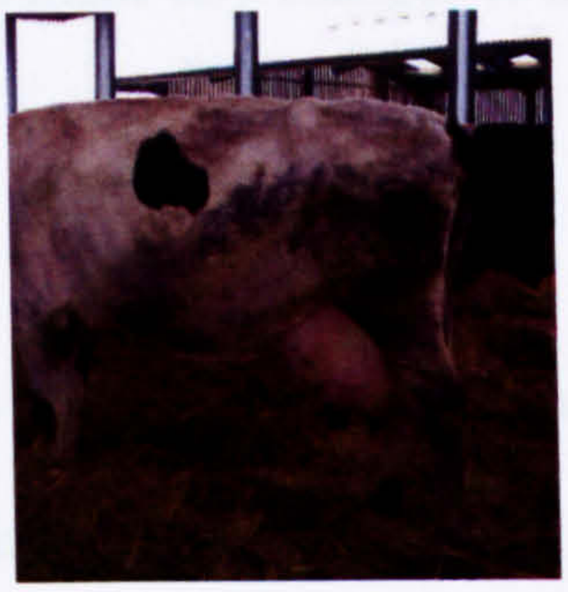
Risk factors for lameness

Cow exposures

COW CLEANLINESS

All cows were given a score for cleanliness ranging from 1 to 3 as described in Table 2.5. As with hock lesions scores, cleanliness was assessed while the cows were being locomotion scored.

Table 2.5 Cow cleanliness score

Score 1	Score 2	Score 3
Completely clean hind quarters	Dirty feet and legs	Dirty feet, legs and flank
		

Exposures

STATIC RISK FACTORS

A farmer interview and direct observations, completed at a single time point, were used to capture information which was unlikely to change between visits. A comprehensive interview was completed by all farmers at visit 2 (Appendix E, Page 174). This requested data about the management of the dairy system including housing, breeding, nutrition and herd health. A second questionnaire (exit questionnaire), was sent to farmers prior to visit 4 and was collected at that visit (Appendix F, Page 185). This was designed to gauge farmers' attitudes towards lameness in their herd.

Permanent structures on the farm such as buildings, yards, tracks and walkways were assessed once during the recording period either in winter (Appendix G, Page 187) or summer (Appendix H, Page 193) appropriate for the cow's environment. These data comprised visual assessments and measurements of the cows' environment, for example, the quality of walking surfaces and building dimensions.

VARIABLE RISK FACTORS

At each visit a number of factors which may have varied between visits were measured. Farmers were also asked if they had made any changes to housing or management practices since the previous visit.

The cleanliness and depth of the bedding was measured in each area in which cows were housed according to the scheme defined in Table 2.6.

Table 2.6 Bedding cleanliness and depth scores

	Score 1	Score 2	Score 3
Bedding cleanliness	Bedding clean and dry	Bedding lightly soiled but dry	Bedding heavily soiled and wet
			
Bedding depth	Bedding deep and even	Bedding uneven and patchy	Little or no bedding
			

The consistency of faeces was scored (Table 2.7). Where possible, 20 faecal pats were scored for each group of cows. Less than 20 faecal pats were scored where there were insufficient faecal pats present either because there were only a small number of cows in the group or the housing had been recently scraped. Pats were only considered if they were fresh (had not dried out) and their form had not been destroyed by cows walking through them.

Table 2.7 – Faecal scoring system

Score	Description
1	Dry – Faeces is stiff
2	Normal - Circular pat with depression in centre
3	Loose – Slightly liquid, and thinly spread
4	Liquid – Thin watery faeces, may be abnormal colour or contain undigested forage

Milk yield and milk quality data

Permission to access National Milk Records (NMR) herd data electronically was obtained from all but one of the farmers using the National Milk Records (NMR) milk recording service. For these herds information on current and previous lactations was obtained for all cows in the herd as an electronic download from the Interherd program (University of Reading, Pan Livestock Services) and managed in a data base (Microsoft Access 2003).

Data management and checking

A data base was created in Microsoft Access (2003) into which the data were entered and managed.

The data from five randomly selection farms were checked for data entry errors against the paper records. Data for 0.73% of cow records were entered incorrectly. Descriptive statistics were calculated for all risk factor data and unusual values checked against paper records to check for entry errors. Follow up phone calls were made to four farmers to collect data where a question in the farmer interview had been missed or an unusual response had been recorded.

Results

Farmer participation

Of the 498 farmers contacted, 53 were enrolled into the study (10.6%). The geographical location of each farm is presented in Figure 2.1. During the first year of the study three farmers withdrew from the study due to ill health or retirement. For various reasons including lack of time and plans to sell the dairy herd, seven farmers opted not to continue with the study between the final visit of the risk factor study in year one and the beginning of the intervention study in year three (Table 2.1). During the intervention study one farm was lost from the study after the herd was sold.

During the study researchers were unable to make one visit to each of three farms during the early winter housing period in 2003 (visit 3) for the following reasons.

One farm was not visited due to a family bereavement. Staff changes on the second farm lead to researchers being unable to contact the appropriate member of farm staff. The third farmer stated he was too busy for researchers to visit at that time. All other farms were visited 4 times during the risk factor study and a further 3 times during the intervention study (Table 2.1).

The first visit to all farms was planned for the end of winter 2003. However, delays in receiving replies from farmers and the extra time required for organising visits to farms at the outset of the project resulted in the first round of visits to farms taking approximately three months to complete and thus spanned the spring turnout period. Subsequent rounds of visits were completed in six-nine weeks each and avoided any periods where housing changes might be occurring.

Repeatability of scoring systems

There was moderate agreement and significant ($p<0.01$) Pearson's correlation for locomotion scores between the researchers present at the farm visits (Table 2.8). ZB scored higher JW when locomotion scoring i.e. score both more cows with score 3 (lame) and fewer cows with score 1 (non-lame) than JW. The selection of cows was not ideal for calculating the repeatability of the of the hock lesion and cow cleanliness scoring systems because the only two of the three available scores were represented. Agreement was also moderate and good for hock lesion and cleanliness scores respectively. ZB was again scored higher when scoring hock lesions and cow cleanliness than JW.

Table 2.8 Percentage agreement and Pearson's correlation coefficients for the locomotion, hock lesion and cow cleanliness scores of 20 cows recorded by two researchers

	Percentage agreement	Pearson's correlation coefficient
Locomotion score	65%	R^2=0.64 ($p<0.01$)
Hock lesion score	60%	R^2=0.40 ($p<0.1$)
Cow cleanliness score	95%	R^2=0.79 ($p>0.01$)

Farmer records of lesions causing lameness

Despite regular letters and contact at the visits some of the farmers lagged behind in returning data on lesions treated. Most forms from the first year of recording were returned promptly but three farmers had still not returned forms by September 2005 - almost 18 months later. These farmers were contacted regularly by phone until the completed forms were returned. A similar number of farmers had outstanding lesion records at the end of the intervention study (31/01/06). These were completed and returned by March 2006.

Complete records of lesions were returned by the farmers for 49 farms for study year 1 (01/02/03-31/01/04) and 41 farmers continued to return lesion records in years 2 (01/02/04-31/01/05) and 3 (01/02/05-31/01/06).

Data on a total of 9622 lesions were recorded from the farms visited in the study. Data on 3450 lesions were excluded from the analyses for one or more of the following reasons; the lesion was not recorded within the date range of the study (01/02/03-31/01/06), the farmer did not consider the cow to be lame, the

lameness status of the cow was not recorded, the primary lesion causing lameness was not recorded or the cause of lameness stated by the farmer did not match the location that the farmer marked on the diagram.

Management and farmer attitudes questionnaires

Using an interview technique to complete the management questionnaire ensured 100% compliance. All the interviews were successfully completed at visit 2. The completed exit questionnaire was either collected at the final visit of year one or returned by post shortly after by 47 of the 50 farms. Three farmers failed to return the exit questionnaire.

Training events

Farmers representing 30 out of the 53 farms attended one of the five training events (Table 2.9).

Table 2.9 Location, date and attendance at 5 training events held for study farmers

Event Location	Event Date	Number expected	Attendance
Hartpury College, Gloucestershire	01/05/03	14	7
Myerscough College, Lancashire	08/05/03	8	6
Reasheath College, Cheshire	09/05/03	9	6
Castiles Farm, North Yorkshire	21/05/03	9	6
Seale Hayne College, Devon	29/05/03	13	5

Discussions of methods

Representiveness of the study population

The study population represent a range of geographical regions. There were fewer farms representing Cheshire, an important dairying area, than the South West the other major dairying area in England. An amount of selection bias may occurred by selecting farmers who had participated in previous study of mastitis in dairy cow (Peeler et al., 2002). The farmer selected therefore had a positive attitude towards research projects. However, the prevalence of lameness and incidence of claw lesions in the study population was unlike to be affected by this selection.

Visit logistics

The extended time taken to complete the first group of visits was unavoidable because replies to the recruitment letters were still being received after the farm visits had begun. It was hoped that all farms within a region could be visited in one trip to maximise time efficiency, however due to the delay in some replies some regions were visited more than once. The initial phone calls to farmers also took longer than on subsequent occasions because it was necessary to explain the format of the visit to the farmer and to answers any questions about the project. It was also necessary to obtain herd size, milking times and directions to the farm from the farmer. It would have been preferable not to have had cows on some farms housed and cows on others at grazing during the same round of visits. However, we felt it was more important to arrange visits

promptly after the farmer had agreed to participate. This meant we met the farmer personally and emphasised the importance of the study to them. The first meeting with the farmers and the following contact at visits and by telephone ensured farmers remained interested in the study.

Data collection

Locomotion scoring

The lameness scoring system used in this study used only the presence or absence of an arched back posture while standing and while walking to differentiate between different severity scores. The scoring method allowed the majority of cows to be scored quickly and easily therefore providing a useful research tool. The simplicity of the scoring method suggests it may also be suitable for use as herd health management tool for farmers. For a small number of cows there were exceptions where the score failed to adequately describe the locomotion. The reasons for this are outlined below:

1. Some cows stood with a flat back but were not weight-bearing on one foot. These cows walked with an obvious arch in their back and were clearly lame and therefore were assigned a score 3.
2. Some cows had an arched spine or dipped loins as a result of poor conformation. In these cases it was necessary to look more carefully at the transition between walk and halt. If the cow's back appeared to relax and the arch decrease when the cow stopped walking then the cow was scored as arched walking and flat standing therefore were given a score 2.

Techniques used for locomotion scoring cows are often criticized for being too subjective. The three simple three point score used in this study was developed with aim of reducing the subjectivity of locomotion scoring. Disappointingly, the inter-observer repeatability suggests that the scoring method used was no more objective than the current published scoring systems. Inter-observer repeatability was 65% compared with 68% reported by (Winkler and Willen, 2001) and 40% reported by (Engel et al., 2003). Expressed as a Pearson's correlation coefficient inter-observer repeatability was 0.64. Flower and Weary (2006) reported inter-observer repeatability's of 0.71 for a scoring system which assessed locomotion while taking into account 6 attributed of the gait of cattle. Where the severity of arching of the spine was assessed alone, by the same authors, inter-observer repeatability was 0.69.

The moderate agreement between researchers, while disappointing, was not considered detrimental to the study results as the majority of the locomotion scoring was completed by one researcher (ZB). Where two researchers were present at the visit any locomotion scores not immediately apparent to the first researcher where discussed with the second and an agreed score recorded. The intra-observer repeatability may have varied between the beginning and end of the study as the sensitivity of the researchers improved. This potential observer drift was not measured in this study due to lack of time and equipment at the outset of the study. Future studies of this type should ensure regular video assessments of the same cows are completed and intra-observer repeatability measured.

Flower and Weary (2006) also reported that an overall score of locomotion taking into account 6 different attributes of gait was most effective for identifying cows with sole ulcer. Individual attributes of gait were also analysed separately. Cows with sole ulcer had more pronounced back arching. This provides evidence that a locomotion scoring technique based on the presence or absence of an arched posture as used in this study is an effective tool for identifying cows lame with sole ulcer. However, the exclusion of other gait attributes from the scoring system used in this study reduced its sensitivity in the middle range. Score 2 included both cows with mild back arching when walking and abnormal gait and those with more pronounced arching when walking and a slight limp. Flower and Weary (2006) suggested that when back arching alone was considered, analysis of the back arch at the lower end of the scale, i.e. mild arching, was more difficult that when back arching was pronounced. It is therefore possible that some score 1 cows in our study were in fact score 2 lameness. Analysing the data using a continuous outcome rather than a binary one will have reduced the impact of such misclassification.

The locomotion of cows is affected by the floor surface, in particular the frictional properties of the surface (Phillips and Morris, 2001;Telezhenko and Bergsten, 2005). Therefore the scoring of cows on different floor surfaces during the study may have affected locomotion scores. It was not possible to standardise the floor surface on which the cows walked while scoring in the winter housing due to the variation in concrete type and quality between farms. However turns, slopes and areas where cows were observed to slip were avoided. In the summer months cattle were scored either on grass whilst at grazing or on

concrete at the parlour exit. Telezhenko and Bergsten (2005) reported that locomotion was improved in both lame and non-lame animals when the floor surface was yielding such as at pasture. This must therefore be considered when interpreting the results of the analysis. It would therefore have been preferable not to assess the locomotion of cows on different farms on both concrete and grass. However, where the farmer was required to identify the cows, scoring had to be completed at their convenience and therefore the location was determined by the time of day i.e. whether the cows had been returned to grazing or not. Summary statistics at visit 1 are therefore grouped by visit and pasture / housed location.

Hock lesion scoring

As with locomotion scoring the hock lesion severity score was also less objective than desired. The differences between hocks with hair loss and abscesses or bleeding were easily defined. The allocation of scores based on the presence of hair loss and abscesses or bleeding was straight forward. However, there was greater ambiguity when defining the degree of swelling of the hock. As it was not possible to physically measure the amount of swelling around the hock of each cow researcher relied upon a visual assessment. Some misclassification of individual cows was inevitable but the effect of such under and over scoring of cows would be minimised at the herd level.

Cow cleanliness scoring

The cleanliness scores for individual cows provided an indirect measure of the management of the cows' environment, for example the cleanliness of bedded lying areas and cleanliness of concrete yards and passage ways. The cow

cleanliness score was also used as an indirect measure of the nutrition of individual cows. Although data on the components of the dairy cow ration were collected for all farms it was not possible to measure the feed intake of individual animals. If a ration lacks fibre or is too high in rapidly fermentable starch then the fermentation times are reduced and re-absorption of water is reduced resulting in looser faeces. This decreases the cleanliness of individual cows and result in increased amounts of slurry in the yards and passageways. Low fibre and high starch diets also result in a lower rumen pH causing acidosis. Acidosis is associated with increased incidence (Livesey, 1984; Livesey et al., 1998) and severity (Webster, 2001) of hoof lesions.

Cow cleanliness score was also used along with bedding cleanliness as a measure of the management of the housed environment, to establish whether cows were using the lying area correctly.

Inter-observer repeatability of the cow cleanliness score was good. However, it was not very sensitive. This is because it was very rare to find completely clean cows, even in the summer grazing period, because the cows are still collected into yards for milking twice per day where their legs become splashed with slurry. As a consequence, only 0.1% of cows had a score of 1 for cleanliness. The cleanliness score also failed to distinguish between those cows which had patches of dirt on the flanks and cows caked in slurry due to exceptionally dirty housing or from failing to lie in the cubicles. However, as it was not until after the summer grazing visits that the short comings of the scoring system became

clear it was decided to continue with its use to ensure the visit data were comparable.

Lesions causing lameness recording forms

Lesion recording forms were completed well by most farmers and returned on a regular basis. The variation between farmers was minimised by providing a laminated colour guide of all the lesions to aid correct identification. Less than 1% of lesions were excluded from the analysis because the diagnosis given by the farmer and the location of the lesion indicated on the foot map did not match. The main reason for excluding lesions was farmers failed to identify the primary lesion - the lesion they believed to be causing lameness. The incidence is therefore underestimated. It may have been possible to reduce the number of lesion records excluded as a result of the farmer failing to identify a primary lesion by asking the farmers to record the severity of each lesion. However this would have increased the complexity of the lesion recording sheet which some farmers already found labour intensive to complete.

Training Events

The training events were well received by the attending farmers. Attendance was variable between events. The main reason for the poor attendance at the final training event at Seale Hayne was that it coincided with a few days of good weather during silaging time. For all of the training events, the farmers who failed to attend were predominantly those with furthest to travel.

Conclusions

The locomotion scoring technique was simple to use and provided a useful research tool. However, it did not prove more objective that other scores currently described in the literature. There was good repeatability between researchers using the cow cleanliness scoring method. However very few cows were scored with the lowest score and it did not distinguish between dirty cows and cows with caked on slurry. A 100% compliance with the farmer interview ensured complete data for investigation of potential risks for lameness. The variation in lesion recording between farmers was reduced by the simple recording sheet design, colour reference list and training in lesion recognition. Training event attendance was not as high as had been hoped and might have been improved by reducing the distance required to travel by the farmers.

Chapter 3

Descriptive summary of individual cow measures

Materials and Methods

Locomotion scores, hock lesion scores and cow cleanliness data were collected at farm visits between February 2003 and February 2006. Records of lesions causing lameness were collected by the farmers enrolled in this study. The methods of data collection employed are fully described in Chapter 2.

In this chapter the lameness of the cows on the farms in the study is described in terms of locomotion observed approximately every 4 months (prevalence of lameness in the herd) and rates of lesions causing lameness (which can possibly be considered as the incidence of lameness).

Case definitions for the incidence of lesions

The length of time each lesion event lasted was not recorded so it was not possible to separate repeat treatments of the same lesion from new cases. For the purposes of calculating the rate of lesions per calendar month it was assumed that a cow could not become lame with the same lesion type on the same claw more than once during that study year (1st Feb – 31st Jan). To adjust for herd size, lesion rates per 100 cows per month were calculated for each farm and the arithmetic mean of all farm lesion rates used.

For 31 herds lactation information was provided by National Milk Records (NMR) with the permission of the farmers. The rates of lesions per month in milk for the first ten months of lactation were calculated for the cows in these herds with a lesion defined as the first occurrence of a lesion type on each claw in that lactation.

Results

The mean herd size was 109 (range 38 to 421). The mean milk yield was 7830 (range 5000 to 10200) kg per cow per year. The majority of herds were comprised of entirely Holstein and/or Holstein-Friesian (n = 42) or mainly Holstein-Friesian cattle and a small proportion of other breeds (n = 7) including pure bred Jersey, Ayrshire, Brown Swiss, and Meuse Rhine Issel (MRI) or these breeds crossed with Holstein-Friesian.

Cow specific measures made during visits to farms: locomotion, cleanliness and hock scores

The mean farm locomotion score in the first year of the study was 1.77 (s.e.m. 0.02) with a range of 1.53 to 2.05 and in the third year of the study was 1.77 (s.e.m. 0.03) with a range of 1.57 to 2.04. The mean farm cleanliness score was 2.28 (s.e.m. 0.05) and ranged from 2.01 to 2.68 in the first year of the study and 2.40 (s.e.m. 0.05) and ranged from 2.10 to 2.78 in the third year of the study. The mean farm hock lesion scores was of 1.28 (s.e.m. 0.02) and range of 1.03 to 1.76 in the first year of the study and 1.37 (s.e.m. 0.06) with a range of 1.01 to 2.11 in the third year of the study. The percentage of cows with each of the three

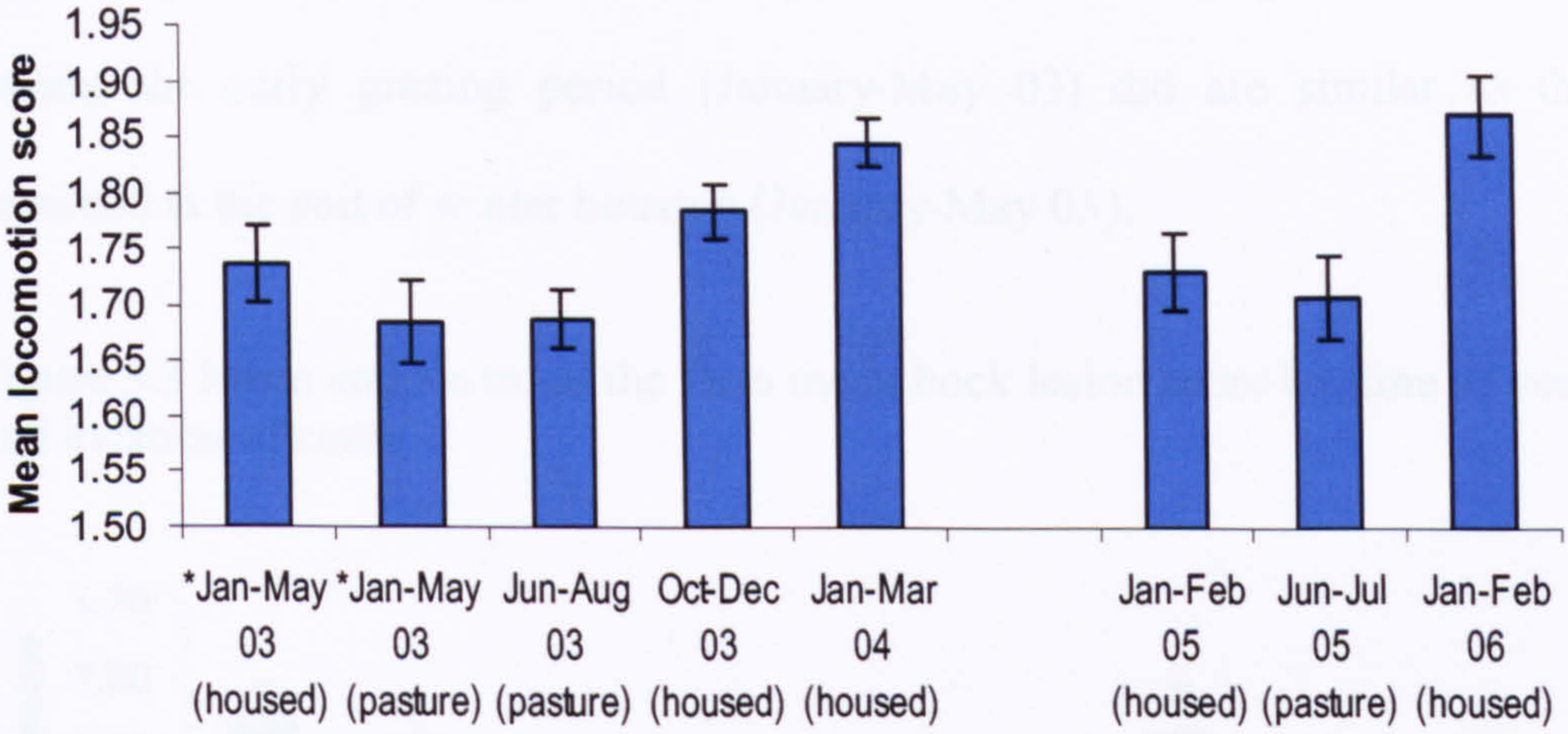
scores for locomotion, cow cleanliness and hock damages are summarised in Table 3.1.

Table 3.1 Mean of the farm percentage (range) of cows in each score category (1-3) for locomotion, cow cleanliness and hock damage for study years 1 and 3

Year of study	Score	Farm mean percent of each score of locomotion (range)	Farm mean percent of each score of cleanliness (range)	Farm mean percent of each score of hock damage (range)
1	score 1	32.7 (14.9 – 53.1)	0.3 (0 – 5.0)	73.0 (36.5 – 97.5)
	score 2	57.7 (40.6 – 72.0)	71.7 (32.5 – 96.8)	25.7 (2.2 – 51.0)
	score 3	9.6 (0.8 – 22.4)	28.3 (3.2 – 67.5)	1.3 (0 – 12.6)
3	score 1	31.3 (21.2 – 45.3)	0.8 (0 – 3.7)	64.1 (5.0 – 98.7)
	score 2	60.3 (50.9 – 69.6)	58.6 (21.9 – 89.4)	34.4 (1.3 – 78.8)
	score 3	8.4 (0.4 – 24.7)	40.6 (10.1 – 78.1)	1.5 (0 – 16.2)

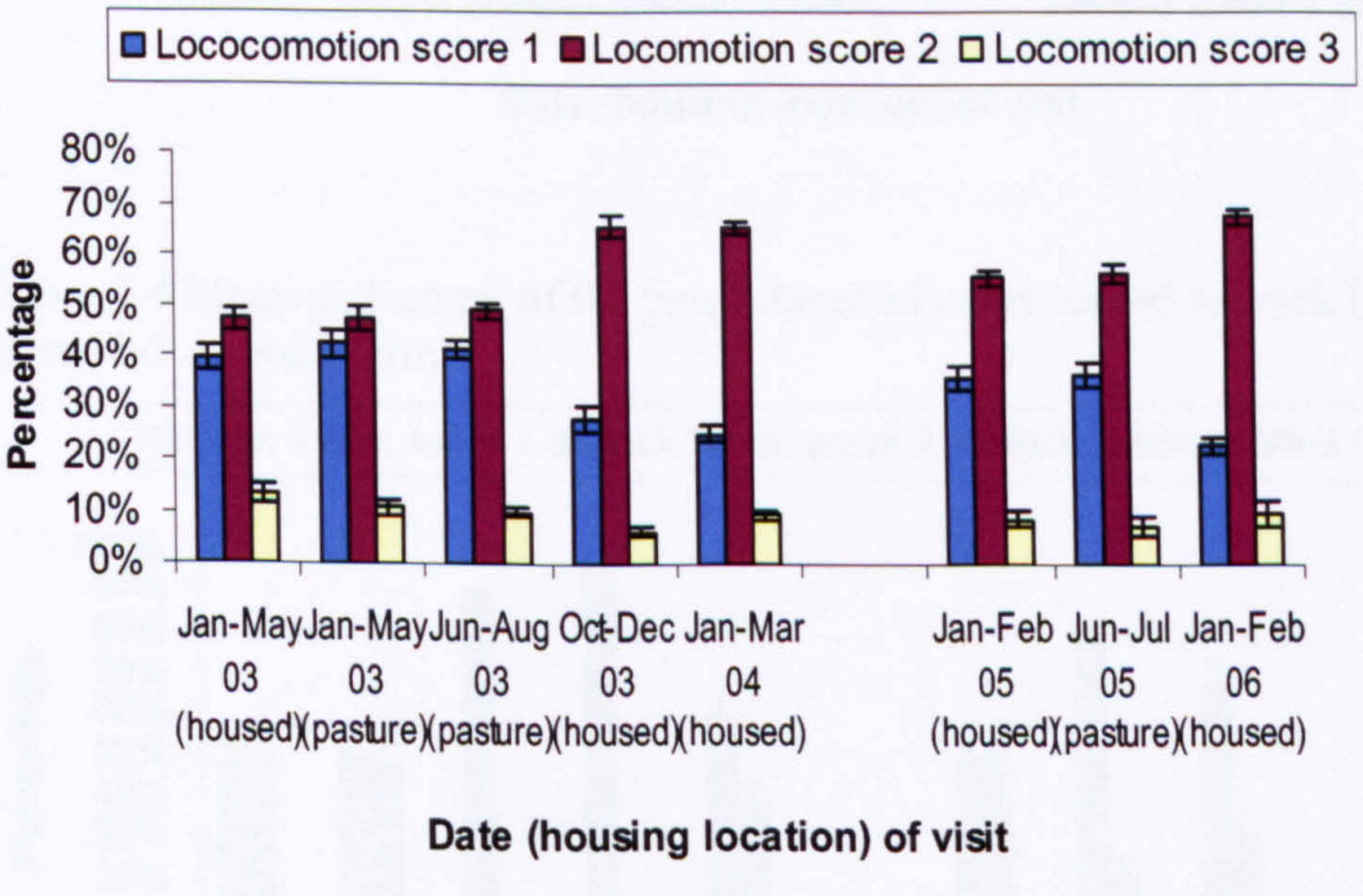
Visits to farms which occurred between January and May 2003 were divided into 2 categories; whether cattle were a) housed or b) at pasture at the time of the visit. Mean farm locomotion scores were lower (i.e. locomotion was improved) where cows were at pasture (Figure 3.1) compared with housed. Increased numbers of cows with score 2 and fewer cows with score 1 were recorded for most of the winter visits compared with visits taking place in the summer months (Figure 3.2). The exception to this being the visits which took place between January and February 05 where the percentage of score 2 was lower than other winter time visits is reflected in the lower mean locomotion score (Figure 3.1).

Figure 3.1 Mean and s.e.m. of the farm mean locomotion score by time of year and location of cattle



*All visits completed between Jan-May 03 were 'visit 1'. The farms are divided according to the location of the cows at visit 1.

Figure 3.2 Mean and s.e.m. of the percentages of cows scored as locomotion scores 1-3 on each farm

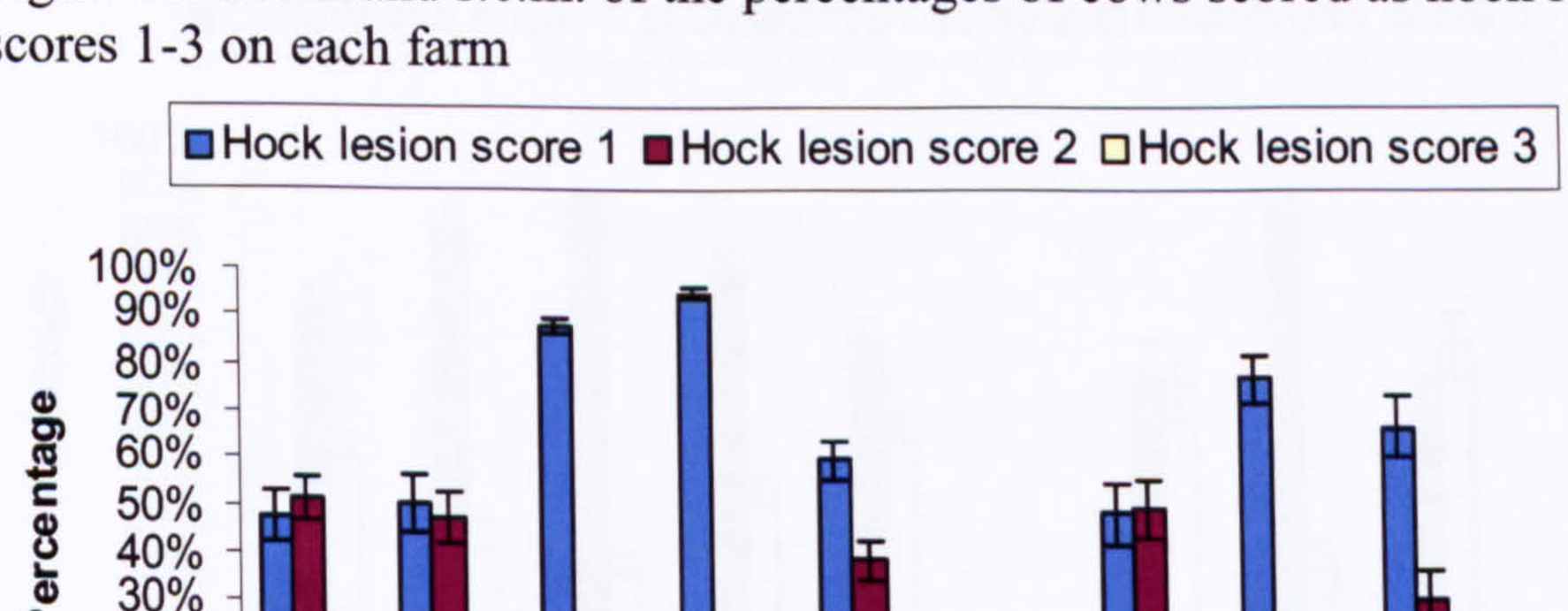


Both the prevalence and severity of hock lesions were affected by cattle location (Figure 3.3 & 3.4). The mean farm hock lesion scores recorded in the middle of the grazing periods, June-August 03 and June-July 05 were lower than if scores during the late winter housing. The mean farm hock lesion score remained low during the early winter housing in October-December 03 as the percentage of

animals with no hock damage (score 1) was high. The mean farm hock lesion score (Figure 3.3) and distribution of hock lesion scores (Figure 3.4) recorded during the early grazing period (January-May 03) did are similar to those recorded at the end of winter housing (January-May 03).

Figure 3.3 Mean and s.e.m. of the farm mean hock lesion score by time of year and location of cattle

Figure 3.4 Mean and s.e.m. of the percentages of cows scored as hock lesion scores 1-3 on each farm



The mean cow cleanliness score was lower (i.e. cows were cleaner) when cows were at pasture (Figure 3.5). Similarly, the percent of cows with score 3 cleanliness was also lowest for cows at pasture (Figure 3.6).

Figure 3.5 Mean and s.e.m. of the farm mean cleanliness score by time of year and location of cattle

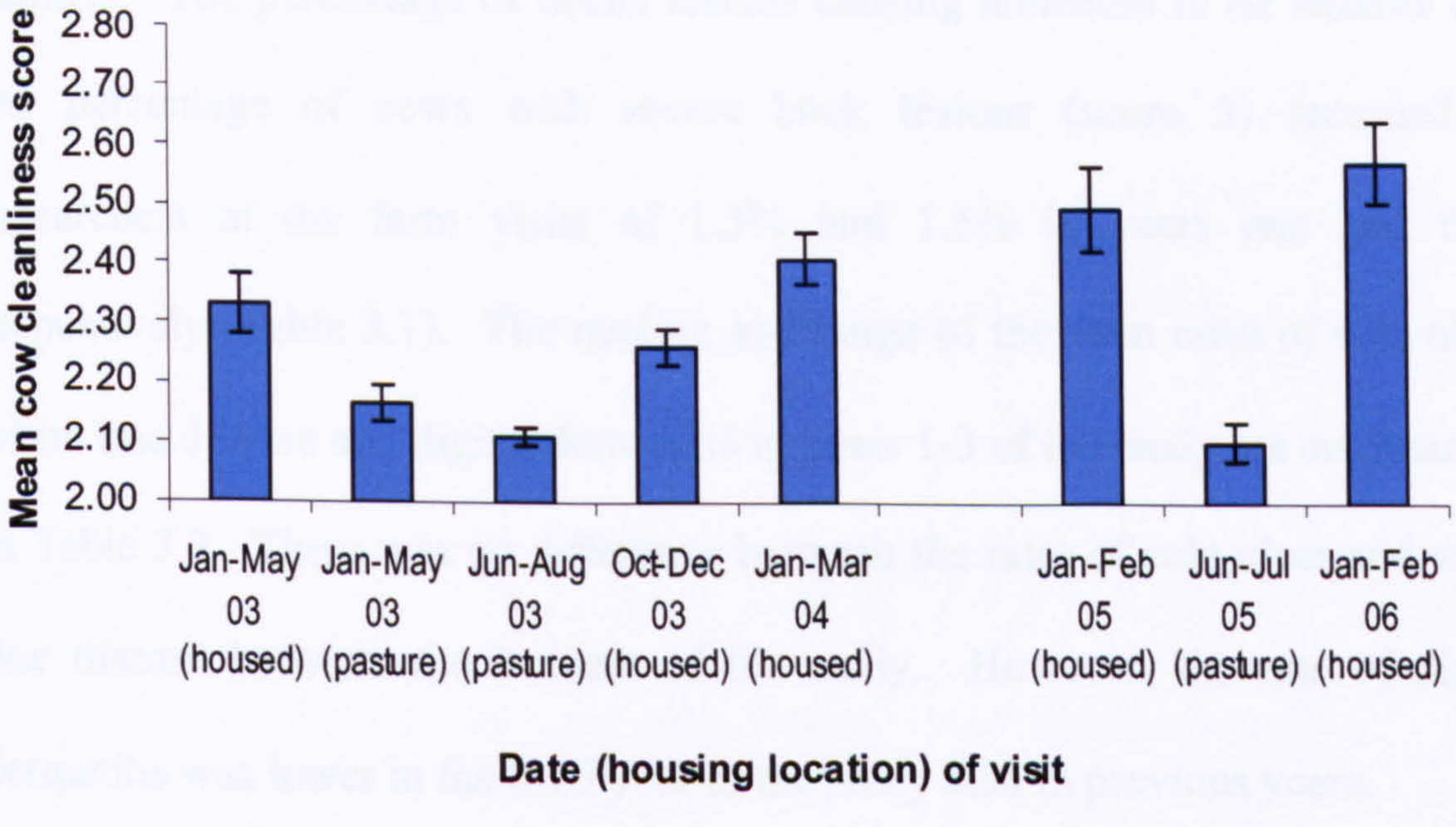
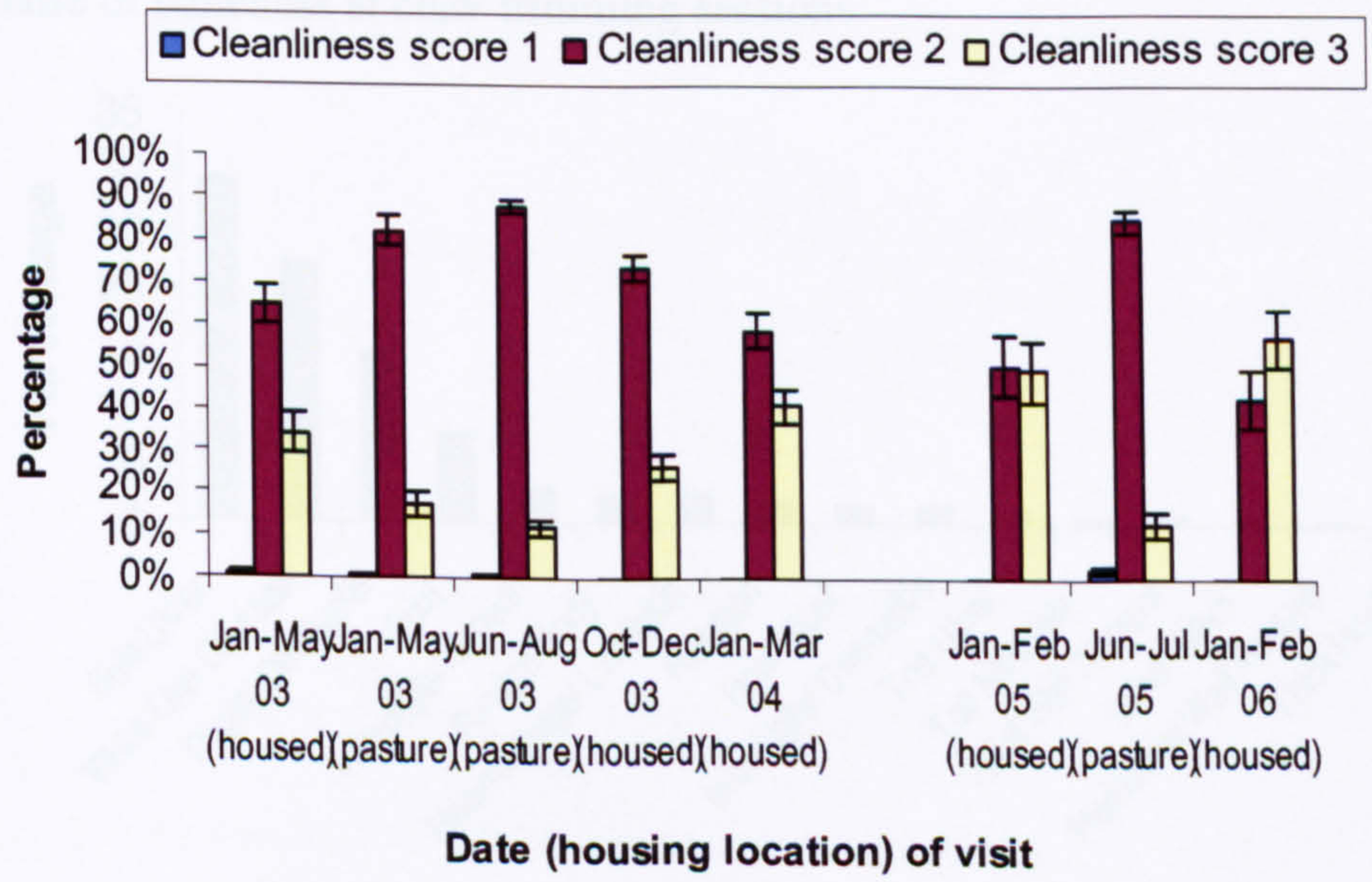


Figure 3.6 Mean and s.e.m. of the percentages of cows scored as cleanliness scores 1-3 on each farm



Lesions causing lameness

Sole ulcer (29.3%), white line disease (22.2%) and digital dermatitis (14.6%) were the three most frequent lesions recorded by farmers treating lame cows and together accounted for 66.2% of all lesions (Figure 3.7). Hock lesions accounted for only 0.12% of the all the lesions recorded as a primary cause of lameness by farmers. The percentage of hocks lesions causing lameness is far smaller than the percentage of cows with severe hock lesions (score 3) recorded by researchers at the farm visits of 1.3% and 1.5% in years one and three respectively (Table 3.1). The median and range of the farm rates of sole ulcer, white line disease and digital dermatitis in years 1-3 of the study are summarised in Table 3.2. There was no difference between the rates of sole ulcer and white line disease between the 3 years of the study. However, the rate of digital dermatitis was lower in the third year of the study than in previous years.

Figure 3.7 Percentage of 16 most frequent lesion types recorded as the primary cause of lameness at claw trimming sessions.

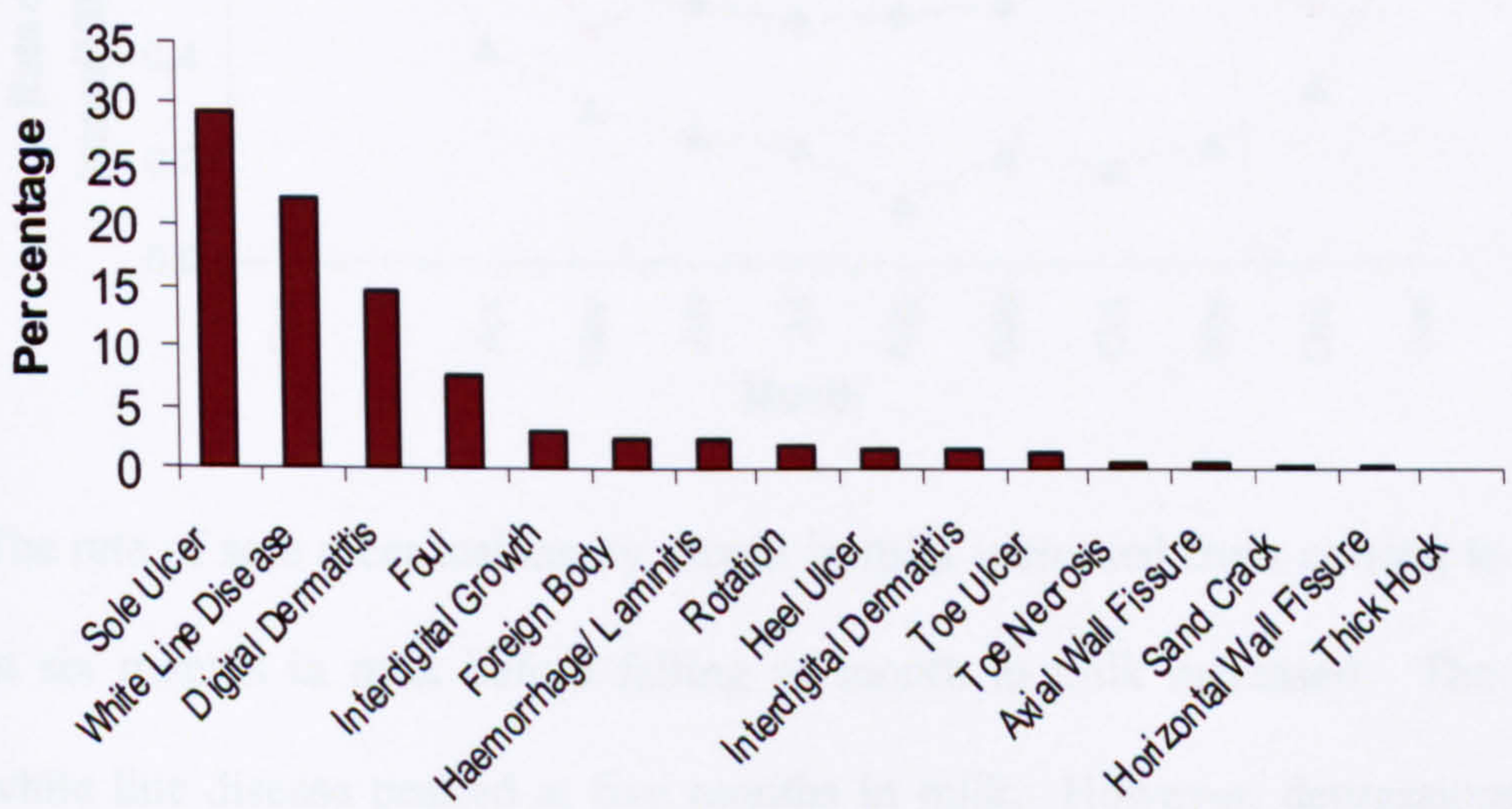
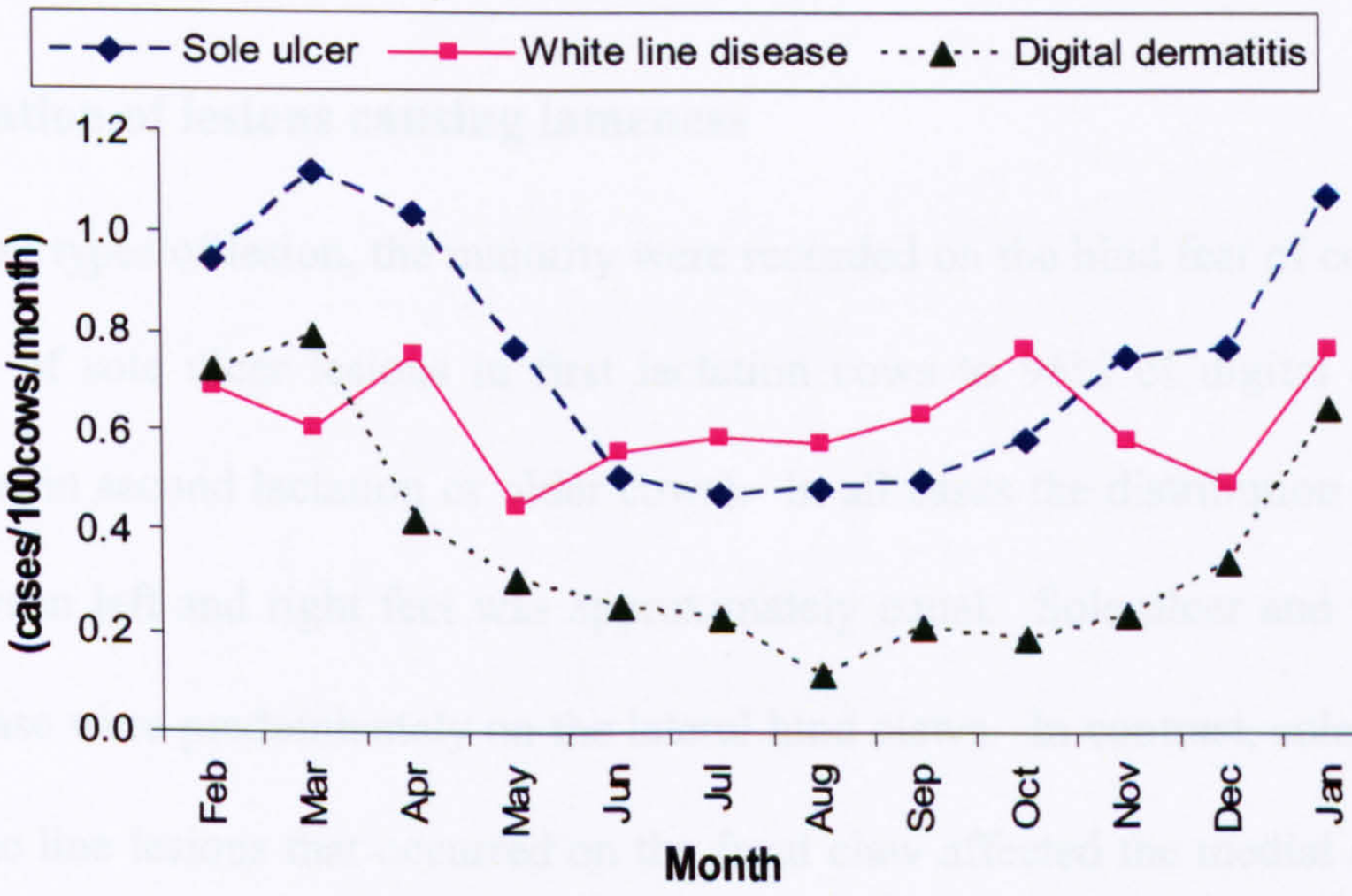


Table 3.2 Median (range) of the farm rates of sole ulcer, white line disease and digital dermatitis for three study years

Study year	Median rate of sole ulcer per 100 cows per year (range)	Median rate of white line disease per 100 cows per year (range)	Median rate of digital dermatitis per 100 cows per year (range)
1	6.2 (0 - 28.5)	5.5 (0 – 30.7)	2.8 (0 – 69.5)
2	8.4 (0 – 41.2)	5.4 (0 – 41.1)	2.1 (0 – 56.7)
3	6.0 (0 – 54.8)	5.8 (0 – 19.4)	0.6 (0 – 17.2)

Clear seasonal patterns were observed for sole ulcer and digital dermatitis rates per month (Figure 3.8). The rates of both these lesions were reduced during the summer months. Such patterns were not observed for the rate of white line disease.

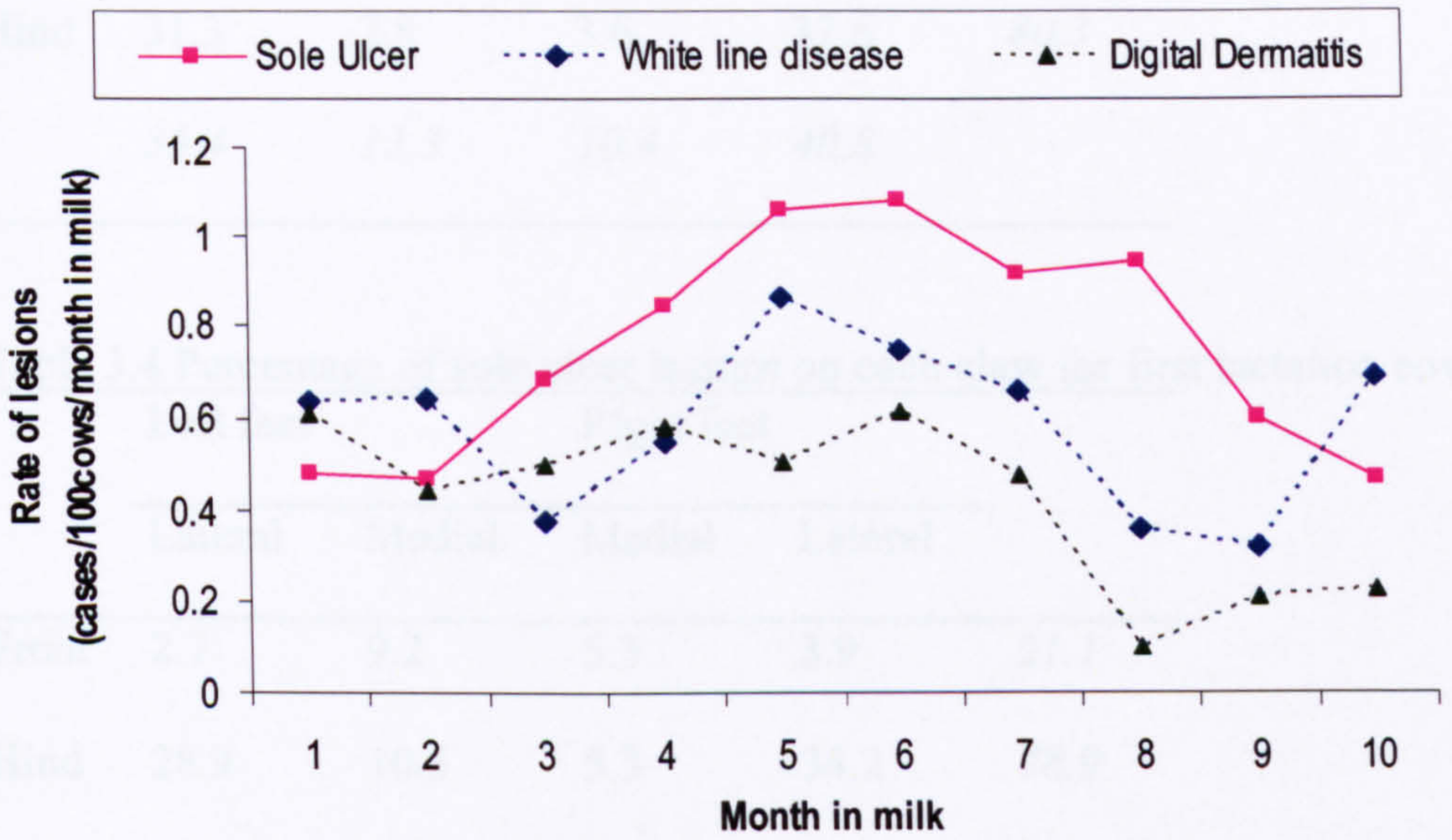
Figure 3.8 Rate of sole ulcer, white line disease and digital dermatitis lesions per study month as recorded by farmers



The rate of sole ulcer lesions by month in milk increased from calving to a peak at six months in milk before falling as month in milk increased. The rate of white line disease peaked at five months in milk. However, depressions in the rates of white line disease were recorded at three and nine months in milk (Figure

3.9). There was little variation in the rate of digital dermatitis during the first seven months of lactation after which it fell and remained at a lower rate.

Figure 3.9 Rate of sole ulcer, white line disease and digital dermatitis lesions by month in milk



Location of lesions causing lameness

For all types of lesion, the majority were recorded on the hind feet of cows (from 79% of sole ulcer lesions in first lactation cows to 96% of digital dermatitis lesion in second lactation or older cows). In all cases the distribution of lesions between left and right feet was approximately equal. Sole ulcer and white line disease were predominately on the lateral hind claws. In contrast, sole ulcer and white line lesions that occurred on the front claw affected the medial claws to a greater extent (Tables 3.3-3.11). For white line disease and digital dermatitis lesions the percentage reported on the front feet was greater in first lactation cows compared with adult cows.

Table 3.3 Percentage of sole ulcer lesions on each claw for all cows

	Left feet		Right feet		
	Lateral	Medial	Medial	Lateral	
Front	4.1	5.6	6.8	3.2	*19.7*
Hind	31.3	7.8	3.6	37.6	*80.3*
	35.4	*13.3*	*10.4*	*40.8*	

Table 3.4 Percentage of sole ulcer lesions on each claw for first lactation cows

	Left feet		Right feet		
	Lateral	Medial	Medial	Lateral	
Front	2.7	9.2	5.3	3.9	*21.1*
Hind	28.9	10.5	5.3	34.2	*78.9*
	30.6	*19.7*	*9.2*	*39.5*	

Table 3.5 Percentage of sole ulcer lesions on each claw for second lactation or older cows

	Left feet		Right feet		
	Lateral	Medial	Medial	Lateral	
Front	4.5	4.8	7.1	3.0	*19.4*
Hind	31.8	7.1	3.3	38.4	*80.6*
	36.3	*11.9*	*10.4*	*41.4*	

Table 3.6 Percentage of white line lesions on each claw for all cows

	Left feet		Right feet		
	Lateral	Medial	Medial	Lateral	
Front	3.3	5.2	5.2	3.3	*17.0*
Hind	42.6	3.0	2.6	34.8	*83.0*
	45.9	*10.3*	*6.9*	*38.1*	

Table 3.7 Percentage of white line lesions on each claw for first lactation cows

	Left feet		Right feet		
	Lateral	Medial	Medial	Lateral	
Front	3.4	6.9	6.9	3.4	*20.6*
Hind	34.6	3.4	0.0	41.4	*79.4*
	38.0	*10.3*	*6.9*	*44.8*	

Table 3.8 Percentage of white line lesions on each claw for second lactation or older cows

	Left feet		Right feet		
	Lateral	Medial	Medial	Lateral	
Front	3.3	5.0	5.0	3.3	*16.6*
Hind	43.6	2.9	2.9	34.0	*83.4*
	46.9	*7.9*	*7.9*	*37.3*	

Table 3.9 Percentage of digital dermatitis lesions on each claw for all cows

	Left	Right	
Front	4.7	1.3	*6.0*
Hind	41.9	52.1	*94.0*
	46.6	*53.4*	

Table 3.10 Percentage of digital dermatitis lesions on each claw for first lactation cows

	Left	Right	
Front	7.0	5.3	*12.3*
Hind	33.3	54.4	*87.7*
	40.3	*59.7*	

Table 3.11 Percentage of digital dermatitis lesions on each claw for second lactation or older cows

	Left	Right	
Front	4.0	0.0	*4.0*
Hind	44.6	51.4	*96.0*
	48.6	*51.4*	

In total, over 90% of lesions causing lameness were treated only once. The percentage of times a cow was treated for a lesion occurring on the same claw more than once in the same lactation is summarised in Table 3.12.

Table 3.12 The percentage of treatments by the farmer of the same lesion type on the same claw in the same lactation.

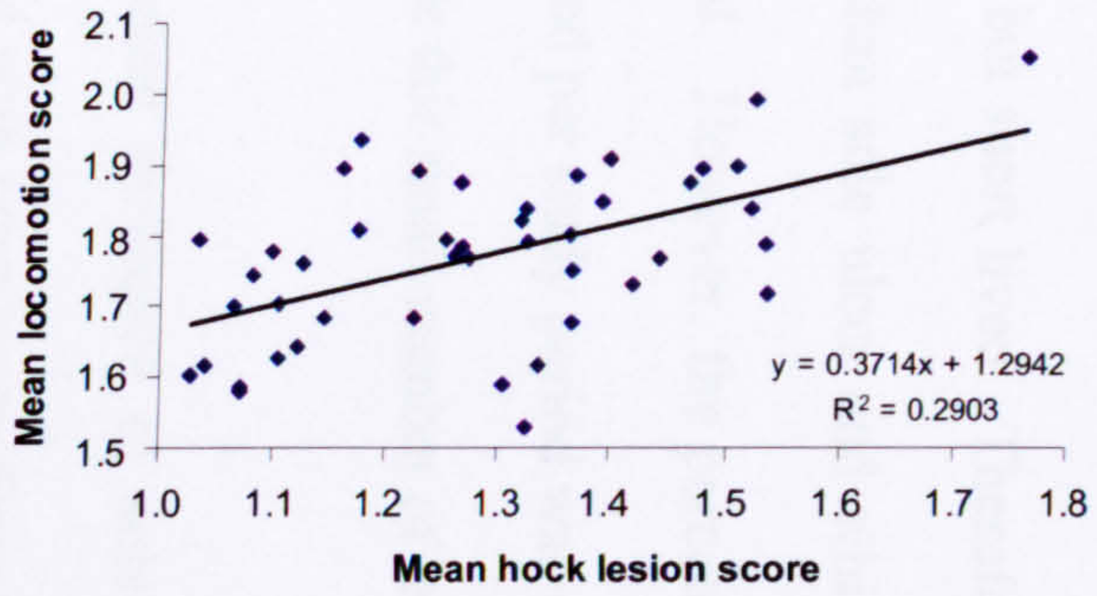
No. of lesion occurrences	Sole ulcer	White line disease	Digital dermatitis	All other lesions
1	88.1%	89.9%	92.2%	93.4%
2	10.0%	8.9%	6.1%	5.7%
>2	1.9%	1.3%	1.7%	0.9%

Associations between locomotion, hock lesions and cow cleanliness and claw lesions causing lameness

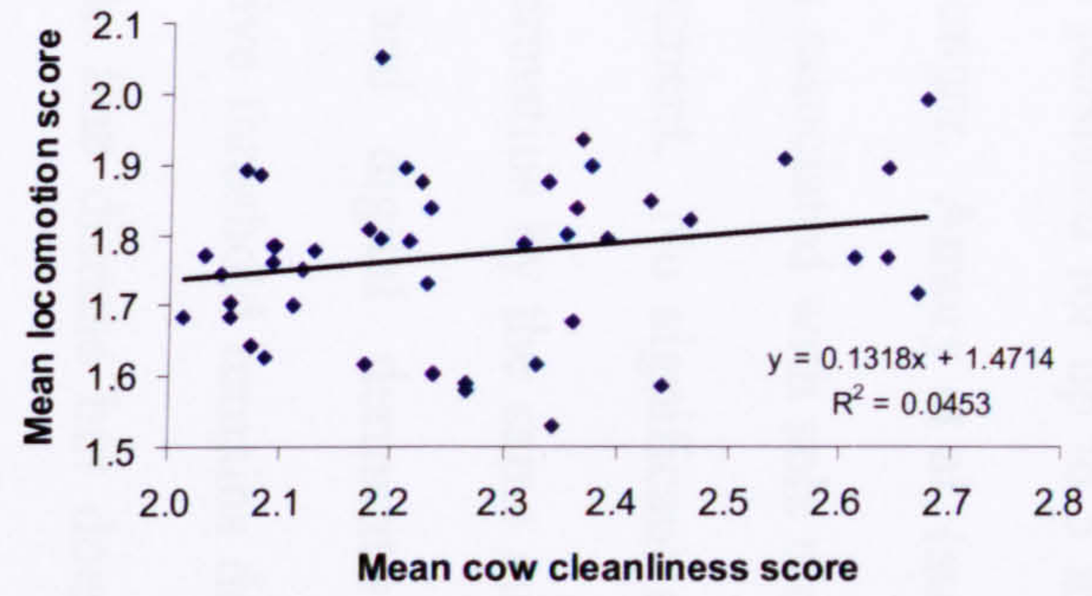
There were positive association between locomotion score and hock lesion scores ($p<0.01$) (Figure 3.10a) and hock lesion scores and cow cleanliness score ($p<0.05$) (Figure 3.10c). Locomotion score was not correlated with cow cleanliness score ($p=0.16$) (Figure 3.10b). Mean locomotion score was also positively correlated with the incidence of sole ulcer ($p<0.05$) (Figure 3.11a) and digital dermatitis lesion ($p<0.05$) (Figure 3.11c) but not white line disease ($p=0.24$) (Figure 3.11b).

Figure 3.13 Scatter diagrams of farm means for locomotion, hock lesion and cleanliness scores with regression line

a) Locomotion and hock lesion scores



b) Locomotion and cow cleanliness scores



c) Hock lesion and cow cleanliness scores

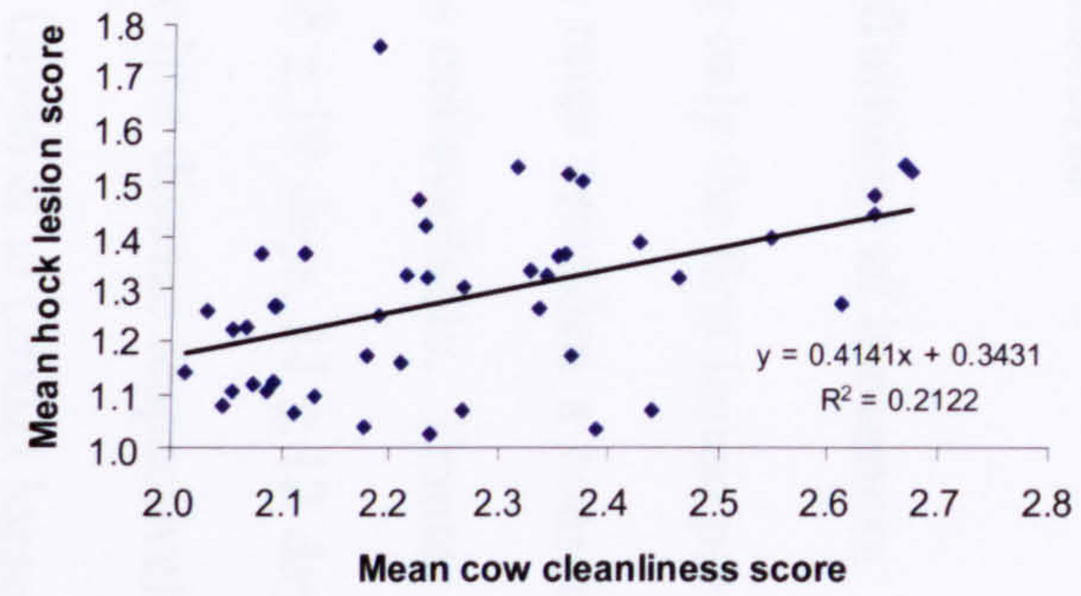
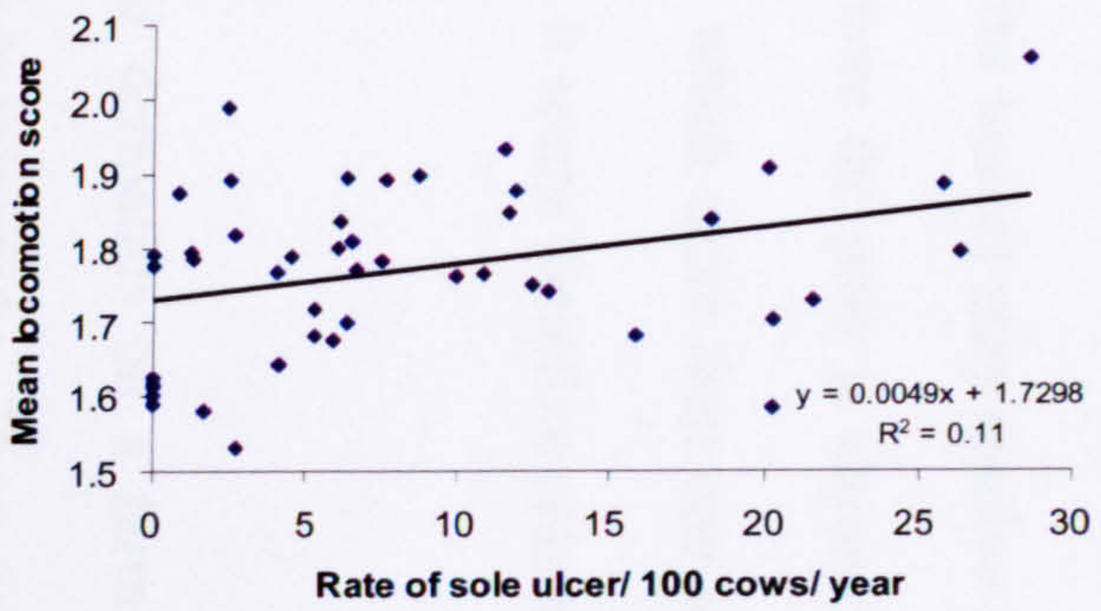
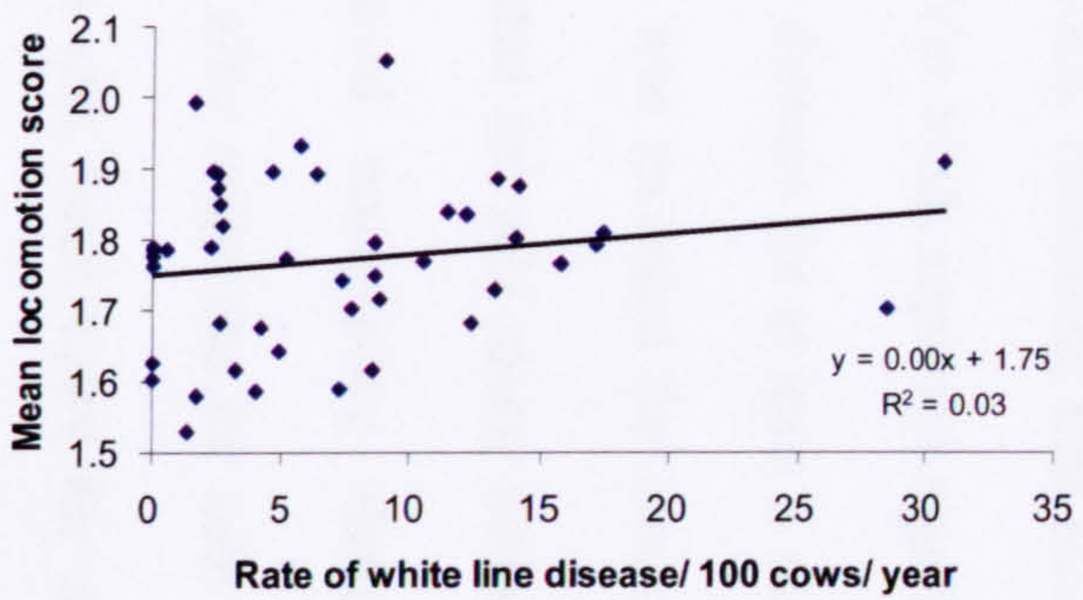


Figure 3.14 Scatter diagrams of farm means for locomotion score and lesions causing lameness

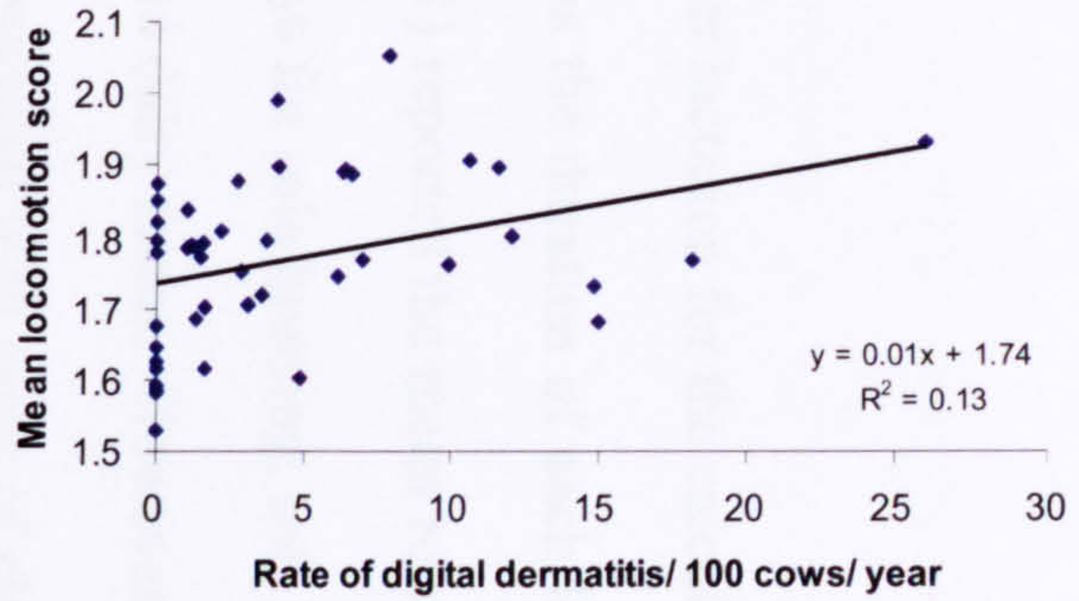
a) Locomotion score and sole ulcer



b) Locomotion score and white line disease



c) Locomotion score and digital dermatitis



Discussions

Case definitions of lameness

Including only the first lesion per study period or per lactation for the calculation of lesion rates provided a conservative estimate, as the duration of each lesion event was not available. Tranter and Morris, (1991) reported the mean recovery time as 38 ± 19 days, 32 ± 12 days and 35 ± 20 days for sole bruising, sole ulcer and white line disease respectively, on New Zealand dairy farms. However, in a study by Green et al (2002) losses in milk yield associated with cases of clinical lameness persisted for up to 5 months after diagnosis, indicating that recovery may be longer. Amory et al, (submitted in Prev. Vet Med) reported significant milk loss associated with sole ulcer and white line disease for at least 5 months after treatment. No significant reduction in milk was recorded for cows with digital dermatitis by the same authors. Cows treated for sole ulcer, white line disease and digital dermatitis have a decreased nociceptive threshold. Nociceptive threshold remains depressed 28 days after treatment for sole ulcer and white line disease but does not differ from non lame cows for digital dermatitis (Whay et al., 1998). Pain associated with digital dermatitis is likely to be acute but short lived. Therefore digital dermatitis lesions may resolve more quickly than sole ulcer and white line disease where the pain is chronic and prolonged. However, the percentage of cows for which more than one lesion was treated per study period was small (Table 3.9). It seems therefore reasonable to exclude this small number of lesions records.

An increased incidence of sole ulcer and digital dermatitis on a farm was associated with poor mean farm locomotion scores in this study. There was no

such association for the incidence of white line disease and mean farm locomotion score. This may be because the farm means do not fully reflect the response of an individual cow to lesions causing lameness. It may also be that that the way in which a cow alters her gait differs between lesion types and the locomotion method used in this study is less sensitive for white line disease than other lesions. Matching of the lesions recorded by farmers and the locomotion scores would provide further information into the effects of individual lesion cases on the locomotion of the affected animal. The length of time locomotion is affected after treatment may also be estimated. The time taken for farmers to treat cows with poor locomotion scores can be calculated providing an insight into the ability of farmers to detect lameness. However, the complexity of linking these two data sets precluded such analysis within the time allowed for this study. Therefore within this thesis these two data sets are analysis separately.

Variation with time in milk

Evidence exists for a peak in lameness occurrence 3-5 months after calving (Green et al., 2002; Tranter and Morris, 1991). It has been proposed that changes in the suspensory apparatus within the hoof lead to increased movement of the third phalanx within the horn capsule of the claw around the time of calving which results in an increased risk of physical damage to the sensitive corium within the claw (Tarlton et al., 2002). It is further proposed that such damage to the corium results in the production of poor quality horn which is visible at the weight bearing surface two to three months later (Lischer et al., 2001) as the hoof

horn grows. In this study the treatment rates of sole ulcer and white line disease peaked at six and five months in milk respectively (Figure 3.9). Although the figures reported by Green et al. (2002) and Tranter and Morris (1991) included all lesions causing lameness in both studies, sole ulcer, sole bruising and white line disease were the most frequently recorded lesions. One explanation for the apparent lag in the onset of white line disease and sole ulcers in our study may be poor recognition of lameness by farmers. In the study reported by Green et al. (2002) farmers had free treatment for lame cattle and the treatment rate was 70 cases / 100 cows per year and in the study reported by Tranter and Morris, (1991) farmers carried out further treatment and monitoring of lame cows perhaps providing a greater incentive to identify and treat lame cow sooner. It has been suggested that farmers underestimate the prevalence of lameness on their farms (Whay, 2002) and the current study would also indicate that many cows with locomotion scores greater than one were not treated promptly.

A combination of factors related to the start of lactation may explain the higher rate of digital dermatitis at the beginning of lactation compared with later in lactation. Firstly dietary changes and increased intakes in response to milk production result in increased production of slurry by the cows. In the study farms the stocking density of the milking cow housing was usually greater than that of the dry cow housing which may also result in increased slurry in the housing. The increased exposure to slurry represents and increased exposure to potential pathogens and therefore increased disease challenge. Although not proven, it is hypothesised by Blowey, (2004) that susceptibility to infectious diseases such as digital dermatitis is greatest in early lactation due to lowered

maternal immunity and, on most farms, reintroduction into a reservoir of infection, 'the milking herd'. Disinfectant footbathing of the milking cows was common on study farms with digital dermatitis. However, disinfectant footbathing of dry cows was rare. The main time at which farmers observe cows for signs of digital dermatitis is during milking in the parlour. The lack of observation and treatment of cows during the dry period coupled with increased observation of cows once in milk may offer an alternative explanation for the increased rate of digital dermatitis at the beginning of lactation. Disinfectant footbathing and other treatments during the lactation may contribute to the reduction in the rate of digital dermatitis later in lactation.

Seasonal variation

The rate of digital dermatitis was lower when cattle were at pasture. Stocking densities and therefore exposure to pathogens were lower at this time. During winter housing, slurry collects in passages and yards within the house, providing a reservoir for potential pathogens. Slatted floors, which reduce the build up of slurry, were associated with reduced risks for digital dermatitis (Somers et al., 2005). The increased slurry in the environment is reflected in the increased cleanliness scores (i.e. dirtier cows) observed at visits during the winter housing period.

A number of authors (Faye and Lescourret, 1989 and Rowlands et al., 1983) have reported an increased incidence of lesions causing lameness associated with winter housing. In this study the rate of sole ulcer was higher during the winter

when cattle were housed. Shorter lying times have been reported for cattle in winter housing compared with cows at pasture (Singh et al., 1993a). The same authors also reported an association between shorter lying times and increased sole ulcer scores in first lactation cows.

The lack of a clear seasonal pattern observed for white line disease provides evidence that the aetiology of the disease differs from that of sole ulcer.

Hock Damage

The percentage of cattle with severe hock lesions observed by the researchers (Table 3.1) was greater than that recorded by farmers (as a percentage of the total number of lesions causing lameness). One explanation for this difference may be that most hock lesions do not result in perceptible lameness. However, there was a significant positive correlation between mean locomotion score and mean hock score. It may be that farmers are failing to detect lameness in cows with hock lesions. However it is also possible that cows with hock lesions also have other lesions that cause lameness which are recorded as the primary lesion by the farmers.

While no studies have reported a difference in prevalence of hock lesions between cows at pasture and housed cows, numerous bedding materials commonly used in winter housing systems for cattle have been associated with an increased prevalence of hock lesions (Vokey et al., 2001); (Weary and Taszkum, 2000); (Wechsler et al., 2000)) and may explain the increased mean

hock lesion score (i.e. greater hock damage) observed while cattle were housed. Reduced hock lesions during the early winter housing period (Oct-Dec 03) suggest that prolonged exposures to damaging lying surfaces is required for hock lesions to develop. Also high mean hock scores in the early turnout period (Jan-May 03) indicate that a substantial amount of time is required for hock lesions to resolve (Figure 3.3).

The association between hock lesion scores and cow cleanliness may be a reflection of cleanliness of the environment. If the housing, in particular the lying surface, is soiled and damp, the skin over the tarsus (hock) may be softened and prone to damage may be greater. Areas where the bedding has been soiled and subsequently dried out may be rough and abrasive and further damage the skin over the tarsus.

Location of lesions

The majority of sole ulcer, white line disease and digital dermatitis lesions were on the hind limbs (79-96%). These figures are in close agreement with those of Murray et al., (1996) who reported 92% were situated on the hind limbs when considering all types of lesion. Murray et al., (1996) also reported that for those lesions occurring in the hind limbs, 65% were in the lateral claw, 14% in the medial claw and 20% affected the skin. Although the main lesion types are considered separately in this study, the lateral hind claw is the predominant location for sole ulcer and white line disease (Murray et al., 1996). Hind limbs propel the cow forwards while walking. During most of the phases of the step,

forces are greatest in the lateral hind claws, especially during the initial heel strike where greater than 95% of the force is exerted (van der Tol et al., 2004). This uneven distribution of forces offers an explanation for the greater proportion of traumatic lesions such as sole ulcer and white line disease occurring in the lateral hind claws.

Chesterton, (2004) reported an increase in the proportion of white line lesions on the front medial claws and a decrease in those on the lateral hind claws in first lactation cows compared with adult cows. He suggested this was due to differences in the way first lactation and adult cows reacted to potentially hazardous situations. Adult cows use their hind limbs to push sideways away from the hazard so forcing pressure though the lateral claws. First lactation cows will reverse away from the hazard, increasing the pressure through the front medial claws. A small increase in medial front claw lesions in first lactation cows compared with adult cows was observed in this study, though not to the same extent as that in the New Zealand system described by Chesterton, (2004). It is possible therefore that the differences between management of housing and grazing in these two countries may explain the disparity in the results.

Digital dermatitis lesions were also predominant on the hind limbs of cattle in this study. The infectious nature of digital dermatitis dictates that for there to be a greater number of lesions on the hind limbs than front limbs exposure to the pathogen in the slurry must have been greater for the hind limbs. It is possible that the behaviour of housed cows in standing with their front feet in a cubicle and their hind feet in the passage may increase exposure to pathogens in the

slurry. The positioning of cows around a feed barrier or trough when eating forces cows to reverse away from the feed barrier with their hind feet walking through any slurry which may have built up behind them. However, it is also possible the lower prevalence of digital dermatitis in front feet is due to farmers failing to inspect front feet. Farmers are often reluctant to lift from limbs as they are more awkward to trim. Farmers also tend to inspect cows in the milking parlour they are more likely to notice, and possibly treat, digital dermatitis lesions in the hind feet of cows due to the position of the cows in the parlour.

The ease of treatment for all lesion types must be considered. Trimming front claws is generally considered to be more difficult than trimming hind claws, especially where the equipment used to restrain cows is not designed for the trimming of claws. As such it is possible that the percentage of front claw lesions in this and other studies may be an underestimate of the true value.

Conclusions

Sole ulcer, white line disease and digital dermatitis were the most frequently reported lesions. The incidence of sole ulcer and digital dermatitis and the prevalence of lameness (poor locomotion) were lower in the summer months than winter. The prevalence of hock lesions was lower in late summer and early autumn suggesting prolonged exposures to damaging lying surfaces are required. Incidence of sole ulcer and white line disease peaked at five months after calving. Poor detection of lame cows by farmers may explain why this is later than previous estimates. Further investigation into the effect of lesions on the locomotion of affected individuals is required. These data may also provide information on the time between identification of poor locomotion by researchers and treatment by the farmer.

Chapter 4

Risk factors for poor locomotion in dairy cattle

Introduction

In recent years a number of risk factors for lameness have been reported. These include poor cubicle design (Faull et al., 1996), poor bedding quality or insufficient bedding (Wechsler et al., 2000; Tucker et al., 2003), floor surface (Faull et al., 1996; Somers et al., 2005), increased standing times (Singh et al., 1993a) and high starch, low fibre diets (Livesey, 1984; Livesey et al., 1998; Collis et al., 2004).

Many of the studies have used the presence of claw lesions rather than lameness to indicate areas of poor management. Claw lesions do not always cause lameness (Manske et al., 2002a) and there is considerably less information available on the risks associated with lameness compared with the risks associated with claw lesions. A number of locomotion scoring techniques have been successfully employed in studies to estimate the impact of lameness on dairy farms. This chapter investigates the relationship between on farm risk factors and poor locomotion using multivariable modelling.

Materials and methods

Data collection

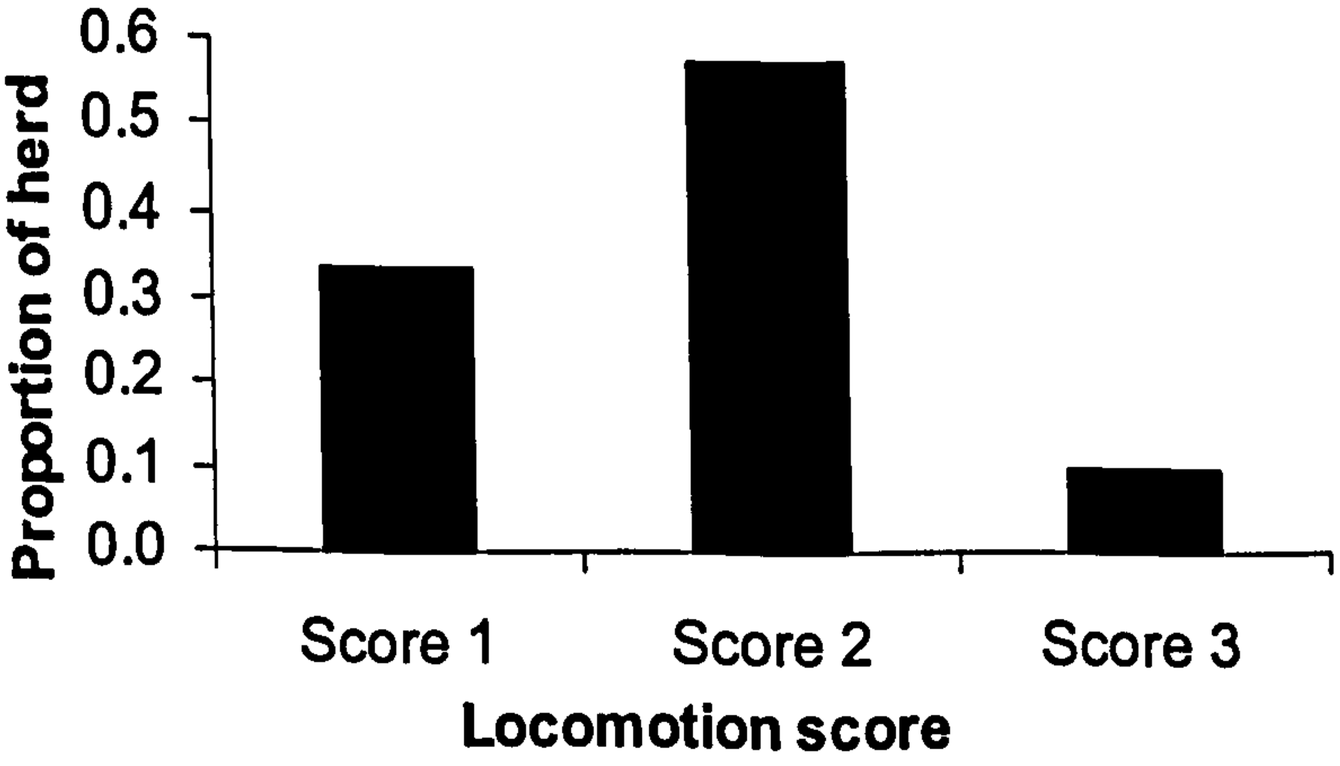
The locomotion of all cattle present on each farm at four visits, between February 2003 and March 2004, was assessed. During these visits, data on potential risk factors were collected using a farmer interview and direct observations and measurements by researchers. The details of the locomotion scoring method, farmer interviews and observations are described fully in Chapter 2.

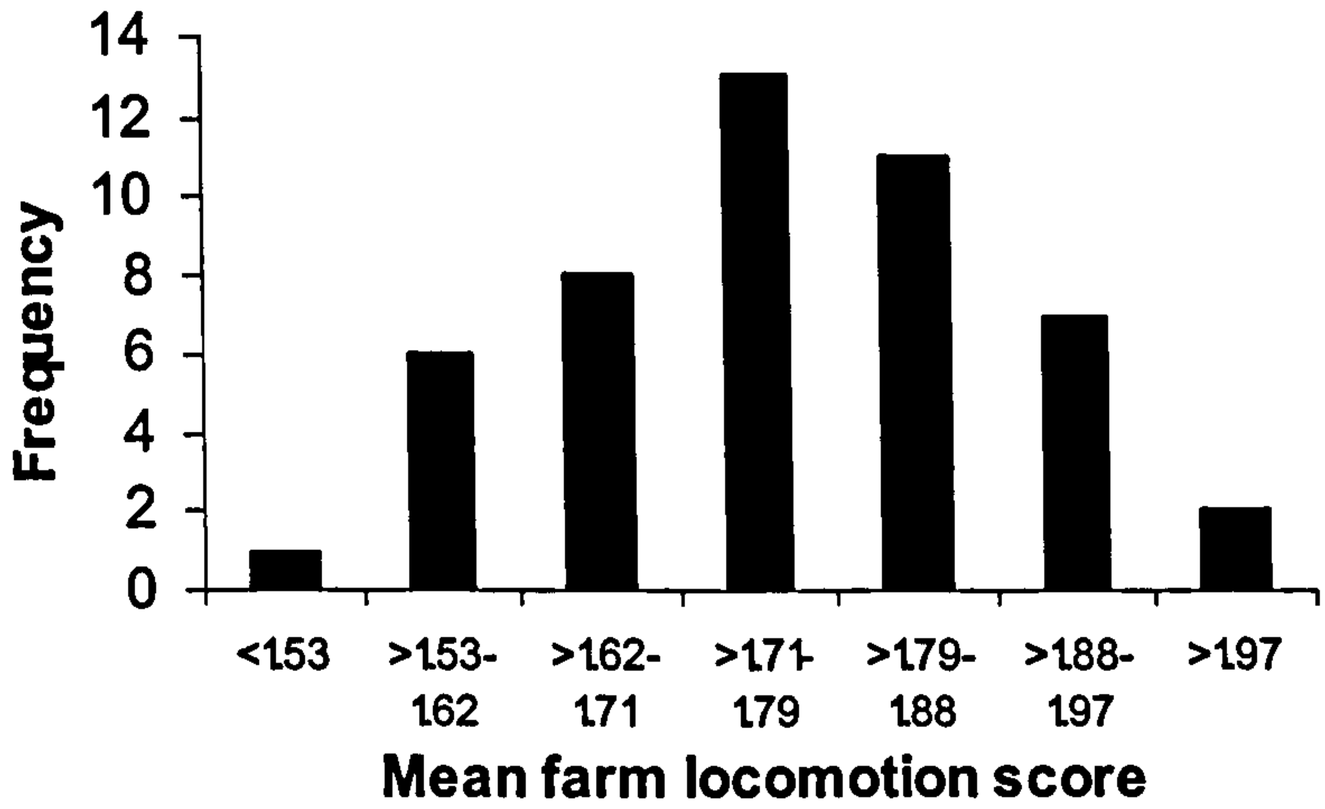
Linear modelling

Outcome variable: mean farm locomotion score

For each farm, the sum of all locomotion scores from all four visits (Figure 4.1a) was divided by the total number of locomotion score recordings taken to estimate the mean farm locomotion score, this was normally distributed (Figure 4.1b) and was used as the outcome variable.

Figure 4.1a Mean of the proportion of cows within farm with locomotion scores 1 to 3





Dependent variables

Descriptive statistics were calculated and unusual outcomes were checked. Data entry errors and missing values were amended using the paper records or by a follow up call to the farmer.

Bedding cleanliness, bedding depth and faecal score were measured for milking and dry cow groups at all visits. Mean bedding depth, bedding cleanliness and faecal consistency scores were calculated for both milking and dry cows using measurements taken at visits 3 and 4, when all cows had been in housing and fed winter rations.

Continuous variables were checked for linearity with the outcome variable and non-linear variables were categorised. Categorical variables with less than 5 observations in the area of interest were excluded from the analysis.

Screening variables

All suitable variables were tested, one at a time, in a univariable linear regression model with mean farm locomotion score as the outcome variable. All variables where $p<0.2$ were tested using backwards elimination in sub-models of the

winter housing environment, lactating cow nutrition, dry cow management, heifer management, herd health and parlour management, cubicle dimensions and damage, and summer pastures and tracks.

Multivariable general linear model

Variables with $p<0.2$ in the sub models were tested in a final general linear model developed as described above, with the five herds housed on straw yards excluded. One farm with only cows of the Ayrshire breed had an exceptionally low mean farm locomotion scores which masked the risks associated with a number of variables. It was also excluded from the final model. All non-significant variables were re-entered into the final model one by one, to investigate residual confounding and any variable significant at $p<0.05$ was left in the model. Finally, mean herd size and average annual milk yield were added to the model to check for any confounding effects. Model fit was assessed. Pearson correlation coefficients between explanatory variables were estimated. All statistical analyses were carried out using SPlus Professional Edition (Version 6.2), Insightful Corp 2003.

Results

There was no significant difference ($p=0.27$) between mean locomotion score in herds kept on straw yards (1.72, s.e.m.=0.02) compared with those housed in cubicles (1.78, s.e.m.=0.02) in this study. The crude locomotion scores by farm management and housing type are listed in Table 4.1.

Table 4.1 Number and percentage exposure, and difference in mean locomotion score for management and housing variables for 49 farms in England and Wales.

Exposures		Number (%)	Mean locomotion score ± SE	*P*
Herd type	Conventional	45 (92)	1.78 ± 0.02	
	Organic	4 (8)	1.64 ± 0.01	0.02
Herd size [1] *(Per 100 cows)*	Intercept = 1.67		*0.09 ± 0.02	<0.01
Nutrition	Milking cows not fed maize silage	32 (65)	1.73 ± 0.02	
	Milking cows fed maize silage	17 (35)	1.84 ± 0.01	<0.01
	Concentrate not fed in parlor	9 (28)	1.83 ± 0.02	
	Concentrate fed in parlor	40 (72)	1.76 ± 0.02	0.07
Trimming	No routine trimming	13 (27)	1.71 ± 0.01	
	Some cows trimmed by stockman	7 (14)	1.73 ± 0.02	0.67
	All cows trimmed by stockman	20 (41)	1.80 ± 0.02	0.01
	All cows trimmed by hoof trimmer	9 (18)	1.84 ± 0.02	0.02
Foot bathing	No footbath used	18 (37)	1.77 ± 0.02	
	Regular foot bathing	31 (63)	1.77 ± 0.02	0.91
Housing	Free stalls	44 (90)	1.78 ± 0.02	
	Straw yard	5 (10)	1.72 ± 0.02	0.28
Free stall housing only (n = 44)				
Free stall floor	Straw on bare concrete	14 (32)	1.77 ± 0.02	
	Straw on rubber mat	6 (14)	1.76 ± 0.02	0.51
	Straw on earth bed	2 (5)	1.83 ± 0.01	0.27
	Sawdust on bare concrete	3 (7)	1.77 ± 0.02	0.52
	Sawdust on rubber mat	11 (25)	1.86 ± 0.02	<0.01
	Sawdust on cow mattress	2 (5)	1.81 ± 0.01	0.32
	Paper pulp	2 (5)	1.71 ± 0.01	0.88
	Sand	3 (7)	1.69 ± 0.01	0.55
	Other (mixed bedding types)	1 (2)	1.93 (1 farm)	0.06
Scraping method	Automatic scrapers	8 (18)	1.88 ± 0.02	
	Tractor scraper	34 (77)	1.75 ± 0.02	<0.01
	Slatted floors (no scraping)	2 (5)	1.76 ± 0.02	0.15

All variables are categorical except [1] which denoted variable is continuous
* Represent the increase in mean locomotion score associated with every increase in herd size of 100 cows

Multivariable linear regression analysis

The results of the sub-models are summarised in Table 4.2. In the winter housing management sub-model the use of tractor scrapers was associated with a decrease in mean locomotion score of 0.09. In the same sub-model bedding up with sawdust on top of rubber mats was associated with an increase in mean locomotion score of 0.10. Membership of a farm assurance scheme was included in the sub-models as an indicator of farmer attitude to animal health and welfare. There was an increase in mean locomotion score on farms where the farmer indicated there was membership to a farm assurance scheme.

The five farms with straw yard housing were excluded from the multivariable model to allow inclusion of variables related to cubicle housing. Seven variables were significantly associated with raised mean locomotion score in the final general linear model (Table 4.3a). These were housing cows on straw yards compared with cubicles when dry, housing pregnant heifers with milking cows in winter compared with housing them with dry cows, passageway widths <3m compared with ≥3m, kerb height of ≤15cm compared with >15cm, routine trimming of claws of all cows by a claw trimmer or by the farmer compared with no routine trimming, feeding maize silage to milking cows, and the use of automatic scrapers compared with tractor scrapers in the cubicle house. The model explains the variation associated with both mean herd size and average annual milk yield (Table 4.3b). The fit of the model was good as indicated by the close distribution of the residuals about the model prediction (Figure 4.2).

Table 4.2 Summary of 7 sub-models of mean locomotion score for 50 farms (except[§] 45 farms with cubicle housed milking cows)

Risk Factor	n	Coeff.	SE	P-value	Lower CI	Upper CI
Winter housing management						
(Intercept)		1.81	0.05	<0.01	1.72	1.91
Automatic scrapers	*8*					
Tractor scrapers	35	-0.09	0.05	0.08	-0.19	0.01
Slatted floor (no scraping)	2	-0.16	0.09	0.10	-0.34	0.02
Straw yards (tractor scraped)	5	-0.10	0.07	0.19	-0.24	0.05
No sawdust on mats	*37*					
Mats bedded with sawdust	13	0.10	0.04	<0.05	0.02	0.19
Lactating cow nutrition						
(Intercept)		1.79	0.05	<0.01	1.70	1.89
No maize silage fed	*32*					
Maize silage fed	18	0.06	0.04	0.13	-0.02	0.14
No concentrate fed in parlour	*41*					
Concentrate fed in parlour	9	-0.06	0.05	0.19	-0.16	0.03
Dry cow management						
(Intercept)		1.68	0.03	<0.01	1.62	1.74
No routing trimming	*14*					
Farmer trims some cows	7	0.05	0.05	0.38	-0.06	0.16
Claw trimmer trims all cows	9	0.16	0.05	<0.01	0.06	0.26
Farmer trims all cows	20	0.12	0.04	<0.05	0.04	0.20
Heifer management						
(Intercept)		1.76	0.03	<0.01	1.70	1.83
Pregnant heifers housed with dry cows	*33*					
Pregnant heifer housed with milking cows	15	-0.08	0.04	0.05	-0.16	0.00
Pregnant heifers only	2	-0.12	0.09	0.18	-0.30	0.06
No concentrate fed to heifers	*16*					
Heifer fed up to 2kg concentrate	27	0.03	0.04	0.40	-0.04	0.11
Heifers fed >2kg concentrate	7	0.08	0.06	0.17	-0.03	0.19
Herd health and parlour management						
(Intercept)		1.71	0.04	0.00	0.04	0.04
Not member of farm assurance scheme	*12*					
Member of a farm assurance scheme	38	0.07	0.04	0.11	-0.18	0.27

Table 4.2continued Summary of 7 sub-models of mean locomotion score for 50 farms (except[§] 45 farms with cubicle housed milking cows)

Risk Factor	n	Coeff.	SE	P-value	Lower CI	Upper CI
Cubicle dimensions and damage[§]						
(Intercept)		1.65	0.05	<0.01	1.56	1.74
No neck rail	*7*					
Neck rail 0-45cm from cubicle front	13	0.09	0.06	0.13	-0.02	0.20
Neck rail >45cm from cubicle front	25	0.16	0.05	<0.01	0.06	0.26
Summer pastures and tracks						
(Intercept)		1.74	0.02	<0.01	1.69	1.78
No electric fences	24					
Electric fences used	25	0.06	0.03	0.05	0.00	0.13

Table 4.3a Overall multivariable linear regression model of mean farm locomotion score for 44 cubicle housed dairy herds

Risk Factor	n	Coeff.	SE	P-value	Lower CI	Upper CI
(Intercept)		1.65	0.04	<0.01	1.57	1.74
Cows in cubicles when dry and in milk	*33*					
Cow in straw yards when dry	9	0.06	0.03	0.04	0.01	0.12
Unknown	2	-0.01	0.08	0.90	-0.17	0.15
Max passage width 3m or more	*24*					
Max passage width less than 3m	20	0.06	0.02	0.02	0.01	0.12
Automatic Scrapers	8					
Slatted floor (no scraping)	2	-0.02	0.06	0.72	-0.14	0.09
Tractor scrapers	34	-0.10	0.03	<0.01	-0.16	-0.04
Pregnant heifers housed with dry cows	*31*					
Pregnant heifers housed with milkers	12	0.09	0.03	<0.01	0.03	0.15
Pregnant heifers only	1	-0.14	0.12	0.25	-0.37	0.09
No routine trimming	*11*					
Farmer trims some cows	7	0.03	0.04	0.51	-0.05	0.11
Claw trimmer trims all cows	9	0.18	0.04	<0.01	0.11	0.25
Farmer trims all cows	17	0.13	0.03	<0.01	0.06	0.19
Maize silage not fed	*29*					
Maize silage fed	15	0.10	0.03	<0.01	0.04	0.15
Kerb Height over 15cm	*31*					
Kerb height 15cm or less	13	0.07	0.03	0.03	0.01	0.12

Table 4.3b Overall multivariable linear regression model of mean farm locomotion score for 44 cubicle housed dairy herds with the inclusion of mean herd size and milk yield to investigate confounding effects

Risk Factor	n	Coeff.	SE	P-value	Lower CI	Upper CI
(Intercept)		1.49	0.10	0.00	1.30	1.67
Mean herd size (per 100 cows)		0.02	0.01	0.18	-0.01	0.04
Milk yield (per 1000 litres)		0.03	0.02	0.12	-0.01	0.08
Cows in cubicles when dry and in milk	*33*					
Cow in straw yards when dry	9	0.07	0.03	0.03	0.01	0.12
Unknown	2	-0.03	0.08	0.69	-0.19	0.13
Max passage width 3m or more	*24*					
Max passage width less than 3m	20	0.06	0.02	0.01	0.02	0.10
Automatic Scrapers	8					
Slatted floor (no scraping)	2	-0.04	0.06	0.57	-0.16	0.09
Tractor scrapers	34	-0.07	0.03	0.04	-0.14	-0.01
Pregnant heifers housed with dry cows	*31*					
Pregnant heifers housed with milkers	12	0.10	0.03	0.00	0.04	0.16
Pregnant heifers only	1	-0.11	0.12	0.36	-0.34	0.12
No routine trimming	*11*					
Farmer trims some cows	7	0.00	0.05	0.99	-0.10	0.09
Claw trimmer trims all cows	9	0.15	0.04	0.00	0.07	0.22
Farmer trims all cows	17	0.11	0.04	0.01	0.03	0.18
Maize silage not fed	*29*					
Maize silage fed	15	0.07	0.03	0.03	0.01	0.12
Kerb Height over 15cm	*31*					
Kerb height 15cm or less	13	0.06	0.03	0.04	0.00	0.11

The use of sawdust on top of mats or mattresses was positively correlated with automatic scrapers ($r=0.34$, $p<0.05$) and negatively correlated ($r=-0.48$, $p<0.01$) with tractor scraping (Table 4.4). While both the use of automatic scrapers and sawdust on mats were associated with raised mean locomotion in the model, the high degree of correlation between the two variables prevented them from remaining in the final model together. The method of scraping was also

correlated with the presence of a brisket board (tractor scraper r=-0.41, p<0.01; automatic scrapers r=0.45, p<0.01), the distance of the neck rail from the front of the cubicle (tractor scraper r=-0.43, p<0.01; automatic scrapers r=0.35, p<0.05) and the number of cows per regular milker (tractor scraper r=-0.40, p<0.01; automatic scrapers r=0.39, p<0.01). The feeding of maize silage was negatively correlated with the feeding of concentrate in the parlour (r=-0.28, p<0.05) and with not feeding a transition ration (r=-0.37, p<0.01). However, it was positively correlated with number of cows per regular milker on the farm (r=0.50, p<0.01) and sawdust on mats (r=0.27, p<0.05). Routine claw trimming of all cows by the farmer was positively correlated with sawdust on mats whereas routine claw trimming of some cows by the farmer was negatively correlated with sawdust on mats (Table 4.4). The farmer claw trimming some or all cows routinely was positively correlated with milk yield. Routine trimming of cows' claws by a professional claw trimmer was not correlated with milk yield but was positively correlated with herd size. Using automatic scrapers and feeding maize silage were also positively correlated with herd size.

Figure 4.2 Plot of residuals versus fit

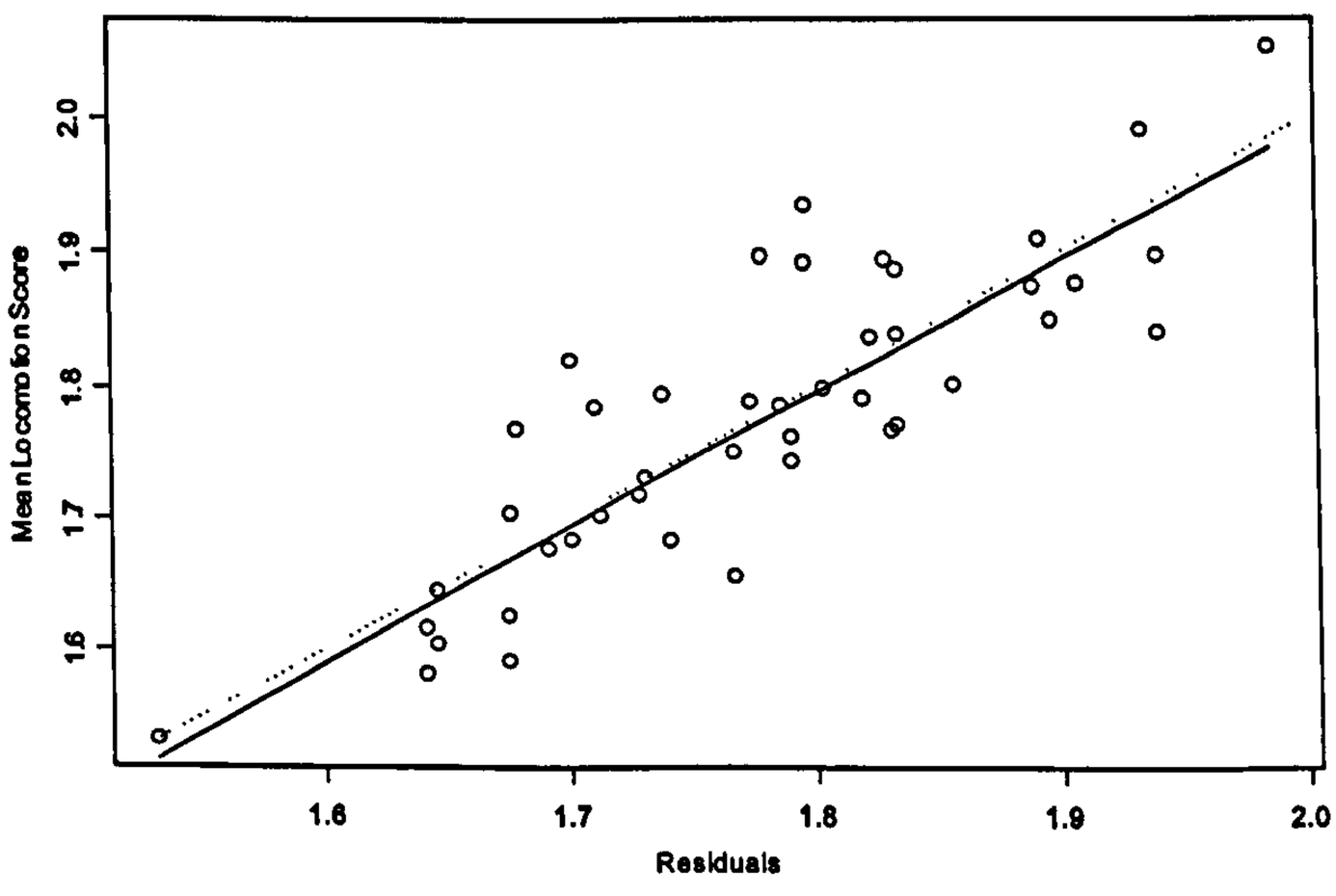


Table 4.4 Summary of variables included in multivariable analysis which correlated with variables in final model

Model variables	Correlated variables positive (R> 0.27, P< 0.05)	Correlated variables negative (R< -0.27, P< 0.05)
Maize Silage	Number of cows per milker Sawdust on mats Herd size Yield	Concentrate feed in parlour No transition ration
Tractor scraping	Concentrate fed in parlour	Milking herd in groups Distance of neck rail from front of cubicle Presence of brisket board Fed a transition ration Calve in calving pen Number of cows per milker Sawdust on mats Herd size
Automatic scrapers	Feed space per cow Distance of neck rail from front of cubicle Presence of brisket board Fed a transition ration Calve in calving pen Number of cows per milker Sawdust on mats Herd size	Concentrate fed in parlour
Passage width	Yield	
Kerb height		Distance of neck rail from front of cubicle
No routine trimming	Ration fed at flat rate No transition ration	Yield
Routine trimming all cows by hoof trimmer	Herd size	
Routine trimming all cows by farmer	Sawdust on mats Yield	No transition ration
Routine trimming some cows by farmer	Feed space per cow Yield	Sawdust on mats
Heifers with milkers before calving	Feed space per cow	

Discussion

Locomotion scoring is a valuable tool in assessing overall lameness and our main aim on dairy farms is to have cattle with normal locomotion. Whilst locomotion scoring does not provide specific information on the diseases causing lameness it allows rapid and effective scoring of large numbers of cattle. Analysis of the risks for poor locomotion (in this analysis by raised mean locomotion score) may assist in providing hypotheses for improved locomotion whatever the aetiology of specific lesions. Inevitably in large observational studies there will be misclassification of scores, which may reduce the precision of the model estimates, but we aimed to minimise this by scoring herds on four occasions with the three score definitions of locomotion. By using mean locomotion score information on the time of year is lost. Also the associations between different locomotion scores of the same animal are not considered. However, the distribution of crude and mean locomotion scores (Figures 4.1a and 4.1b) and the model fit (Figure 4.2) indicate that the use of a continuous outcome model was statistically robust.

The farmer interview and direct observations were comprehensive and designed to collect data on all aspects of the dairy cow environment and management especially where a previous association had been reported. The final model therefore takes into account the complex relationships between the large numbers of 'on farm' factors described by the data collected. It is possible that one or more of the variables in the model are not directly related to mean locomotion, but that they are correlates for another risk factor not measured. Factors correlated with those in the main model may also provide valuable information about how factors causing lameness relate to each other. Knowledge of these

relationships can help the understanding of common behaviours that are changed with exposure to one or more of the variables, thus providing a base for intervention studies. As with all studies of this type, the results produced are useful for hypothesis generation. The direct associations between risk factors and locomotion score from the final model (Table 4.3) and the correlated risks (Table 4.4) are discussed below

One variable associated with poorer locomotion in the analysis was the use of automatic scrapers compared with tractor scraping. Whilst automatic scrapers can improve hygiene in the cubicle house by increasing scraping frequency, the movement of scrapers through the cubicle house forces cows to make unnecessary rushed steps in order to move out of its path. Stefanowska et al., (2001) reported that 94% of stumble incidents observed in two different housing systems with automatic scrapers occurred as a result of contact with the scrapers. Automatic scrapers may cause further disruption during feeding times as cows, in particular those with low social rankings, may be displaced from their position at the feed barrier. The increase in mean locomotion score associated with automatic scrapers may therefore be explained by the increased disruption to the cows whilst the scrapers move in the house (tractor scraping is generally carried out at milking time while the cows are out of the cubicle house).

However, automatic scrapers were highly correlated with cubicle design and with sawdust on mats. Such lying surfaces have previously been associated with lower lying times (Tucker et al., 2003) and decreased lying times have been associated with a greater prevalence of claw lesions and tarsal damage (Wecshler et al.,

2000) Cattle prefer deep bedding such as 7.5cm sawdust or deep sand (Tucker et al., 2003; Tucker et al., 2004). It is not possible from the current study to ascertain whether the automatic scrapers or the associated cubicle bedding type were the true association with poor locomotion. Further investigation of the method of scraping and cow lying behaviour in these systems is required to determine the relative importance of these.

Automatic scrapers were also associated with the presence of a brisket board and the distance of the neck rail from the front of the cubicle. The presence of brisket boards and the position of the neck rail can help prevent animals lying or standing too far forwards in the cubicle and so encourage dunging into the passageway in the path of the automatic scrapers. However, the position can be inappropriate and reduce cubicle comfort and increase standing time and therefore reduce lying times. The brisket boards may be positioned to hold down cow mats (on which the predominant bedding type is sawdust) and so not be in the best position for the cow.

Kerb heights of 15cm or less were also associated with increased mean locomotion scores. In contrast to this, Faull et al. (1996), reported that kerb heights >16cm were associated with increased lameness. In the current study low kerb heights were correlated with the positioning of neck rails greater distances from the front (head end) of the cubicle. Kerb height may therefore be a marker for other aspects of cubicle design.

The final variable associated with housing design was that herds housed in cubicles where the passage way widths were ≥3m compared with <3m had a decreased mean locomotion score. The wider passages allow a good flow of cattle around the house and so assist cow flow and the integration of new herd members; they also provide a larger floor area and so reduce the accumulation of slurry which might reduce the risk of digital dermatitis.

Housing cows on straw yards in the dry period and cubicle housing when in milk was associated with an increased mean locomotion score compared with cattle that were housed in cubicles all the time. This may occur because the different floor surfaces alter claw horn growth (Vermunt and Greenough, 1996). Soft floor surfaces and reduced exposure to concrete both slow horn growth and wear and alters claw conformation. Vermunt and Greenough (1996) reported an increased toe length in heifers housed in an outdoor dry lot with a straw bedded lying area due to a reduced rate of wear compared with those housed in a cubicle house with slatted floors. Increased toe length increases weight bearing at the sole and heel. The rate of wear is increased when cows return to the hard abrasive concrete walking surfaces within the cubicle housing from the straw yard accommodation. It is possible that the increased rate of horn growth required to equal the increase in horn wear does not occur immediately and may result in thinning of the sole at the site of sole ulcer, and possibly lesion development. The move into cubicle housing and start of lactation management will decrease lying times (Singh et al., 1993a) causing further wear of the distal horn.

Housing pregnant heifers with milking cows during the winter compared with being housed with dry cows was associated in this study with a small increase in mean locomotion score. A possible explanation for this is that pregnant heifers are likely to remain at the bottom of the social hierarchy. Therefore evasive turning and backing away manoeuvres by pregnant heifers may continue throughout the housing period. These turning and avoiding actions may predispose them to white line disease (Chesterton, 2004) and longer standing times competing for food and space may predispose them to sole ulcer. Any stability in the social hierarchy brought about by introducing the pregnant heifers prior to calving will be disrupted when they are removed to the calving pen and then returned to the herd after calving (Kondo and Hurnick, 1990).

The routine claw trimming of all cows, either by a professional claw trimmer or by the farmer, was associated with an increased mean herd locomotion score compared with those herds where no routine trimming took place. It is likely that the decision to routinely trim all cows was initially a response to an existing lameness problem. However, all herds where all cows were routinely claw trimmed had been doing so for over two years, suggesting that routine trimming of all cows once per year might not be an effective method of controlling the prevalence of lameness. This may be because cows were left lame until the next visit of the professional trimmer or because of poor hygiene of claw trimming equipment (Wells et al., 1999). Since the routine trimming of some cows by the farmer was not a risk for increased locomotion score (Table 4.3), trimming only lame cows or cows with overgrown claws promptly may be a more effective trimming strategy to reduce prevalence of lameness. The routine foot trimming

of sheep more than a year was associated with an increase in ovine footrot (Wassink et al., 2003).

The feeding of maize silage was associated with an increase in the mean locomotion score in the current study. Feeding maize silage has been associated with rumen acidosis and disruption of horn production due to inflammation within the claw (Mulling et al., 1999), and herds feeding maize silage will tend to be higher yielding, further increasing the risk of lameness. A study by Faye and Lescourret (1989) demonstrated that the presence of laminitis was associated with longer periods of maize silage feeding. Feeding maize silage was negatively correlated with feeding concentrate in the parlour and not feeding a transition ration. Farms feeding maize silage tend to do so as part of a total mixed ration (TMR) thus reducing the need for feeding concentrates in the parlour. The formulation and mixing of a separate transition diet is more likely where a TMR is used.

Previous studies have suggested that herd size and yield are related to lameness (Alban, 1995). These variables are not in themselves useful (no farmer will reduce herd size or yield) but they may be correlates for different farm management. Large herd size was associated with feeding maize silage, automatic scraping in the cubicle house, sawdust and mat bedding and using a professional claw trimmer. High yields were associated with using a professional hoof trimmer. These factors rather than yield or herd size may be changed to test whether they are causally related to poor locomotion.

All factors discussed above may be usefully investigated elsewhere and, where evidence is mounting, in intervention studies to test the impact of altering management policies to assist in lameness reduction.

Conclusions

Poor locomotion was associated with passageways <3m, automatic scrapers, low kerb heights, sawdust on mats, feeding maize silage, housing dry cows in straw yards, mixing pregnant heifers with milkers and routinely trimming all cows' claws. This provides valuable information on which to base intervention studies.

Chapter 5

Risk factors for increased rates of sole ulcer, white line disease and digital dermatitis

Introduction

Sole ulcer, white line disease and digital dermatitis are three of the most frequently reported causes of lameness in the UK (Clarkson et al., 1996; Green et al., 2002). These lesions are painful and in the case of sole ulcer and white line disease cows suffer chronic pain for more than 28 days after treatment (Whay et al., 1998). In addition to impaired welfare, lameness also results in economic loss to the farmer (Esslemont and Kossaibati, 2002). An individual lame cow may fail to produce around 400kg of milk in a single lactation (Green et al., 2002).

Although evidence for risks associated with lameness continue to mount there is a paucity of information regarding the risks for specific lesions causing lameness. An increased incidence of sole ulcer was associated with increased standing times (Singh et al., 1993a) and feeding maize silage (Faye and Lescourret,1989). An increase in the incidence of digital dermatitis was associated with restricted or zero grazing while there was an associated decrease when cow were housed on slatted floors with scrapers compared with solid floor (Somers et al., 2005). Having an external claw trimmer and failing to wash claw trimming equipment between cows were also associated with increased incidence of digital dermatitis (Wells et al., 1999). Further investigations of the risk factors of individual lesions causing lameness are required.

Materials and methods

Data collection

Monthly milk data

Permission was requested and granted from 29 farms taking part in the study to download electronic data on individual cows from National Milk Records (NMR). These data included breed, calving dates, parity number, monthly milk yield and milk quality data for current and previous lactations.

Lesion data

Claw lesions were recorded by the farmers on standard recording forms which were returned by post at regular intervals.

Risk factor data

Data on potential risk factors were collected via a farmer interview and direct observations and measurements made on the farm by the researchers. The details of the interview and direct observations are described in Chapter 2.

Data management and analysis

Data handling

Records of claw lesions, management groups (i.e. in milk, high yield, low yield or dry) and monthly milk recordings for individual cows were stored in a number of relational databases. The individual cow records within these databases were matched on cow identification number or name and NMR line number. A unique identification number was then generated for every cow.

A data table was generated with farm identification, cow identification, parity, month from calving (MC) and monthly milk yield. Treatments for sole ulcer, white line disease and digital dermatitis lesions were linked to each MC. A lesion occurrence was defined as the first lesion of that type per claw in a given parity. For each MC for each cow a milking status was recorded i.e. in milk or dry. On two farms milking status was recorded as high yield, low yield and dry. This was because high and low yielding cows on one farm were housed on very different bedding typed i.e. deep sand or sparse sawdust on mats. On the second farm high yielding cows were never at pasture 24 hours a day. For these farms cows were allocated to high or low yield groups based on the approximate stage of lactation at which the cows were split on the farm as stated by the farmer. For each MC for each cow a housing status was recorded using the housing and turnout dates for the relevant management group. Cows were categorised as housed (housed 24 hours a day), intermediate (housed at night but at pasture by day) or pasture (at pasture 24 hours a day). Accurate drying off dates were not available, so for the purposes of these analyses it was assumed that a cow was dry 2 weeks after the date of the last milk recording.

A data table containing the housing type, bedding type and floor surfaces for loafing and walking for each milking status (dry or milk) and housing status (housed, intermediate or pasture) on each farm was created. These two data tables were merged using the milking status and housing status of each cow for each MC. The final data table also included farm level variables collected in the farmer interview and direct observations.

Multi-level modelling

The model was constructed using 37401 monthly milk records from 3154 cows on 28 farms. The presence or absence of sole ulcer, white line disease or digital dermatitis in a given MC was used as the binary outcome variable in 3 multi-level models, the comparison group was cattle with no foot lesion. Each was a binomial logistic regressions model with, MC nested within cows and cows nested within farms.

For each lesion (outcome variable) all variables were screened in univariable models. Variables with $p<0.2$ were taken forward for multivariable analysis. Variables remained in the final model after a process of backwards elimination when $p<0.05$. To control for parity and MC these variables were included in all multivariable models. When a variable had significant association with one lesion type it was added to all the models so that there were comparable models for sole ulcer, white line disease and digital dermatitis. All non significant variables were re-entered into the final models one by one, to investigate residual confounding and any variable significant at $p<0.05$ left in the model. The Hosmer-Lemeshow goodness of fit test was used to assess model fit (Dohoo et al., 2003, p.360-361). All statistical analyses were carried out using MLwiN version 2.01.

The model took the form:

$$Y_{ijk} = \beta 0 + + + \beta X_k + \beta X_{jk}\, \beta X_{ijk}\, uj + vj_k + e_{ijk}$$

Where β0 is the intercept, β = coefficients for the vector of X variables varying at ilevels k, jk and ijk and v_k = residual error between farms, u_{jk} = residual error between cows and e_{ijk} = residual error between months.

Results

Summary data

Of the 50 farms with complete lesion and risk factor data, NMR records were available for 29 farms (3229 cows, 38401 records). Holstein and Holstein Friesian cows represented 98.8% of the breeds of cow on the farms. The number of cows from other breeds was too small for the effect of breed to be analysed. Therefore all 57 cows (777 records) from one herd of Ayrshire's were excluded. A further 18 cows (223 records) which were of breeds other than Holstein Friesian were also excluded from the data set. The number and percentage of cows with sole ulcer, white line disease and digital dermatitis lesions associated with potential risk factors tested in these analyses are summarised in Table 5.1.

Table 5.1 Number and percentage of sole ulcer, white line disease and digital dermatitis lesions treated for different cow and farm characteristics

		Number (and percent) cases treated		
		Sole ulcer	White line disease	Digital dermatitis
Herd Size				
	≤79	22 (0.39)	23 (0.41)	3 (0.05)
	80-159	58 (0.36)	47 (0.29)	77 (0.48)
	≥160	81 (0.63)	60 (0.46)	75 (0.58)
Parity Number				
	1	32 (0.33)	15 (0.15)	47 (0.48)
	2	36 (0.42)	23 (0.27)	38 (0.44)
	3	20 (0.32)	22 (0.35)	18 (0.29)
	4	24 (0.54)	30 (0.67)	18 (0.40)
	5	20 (0.69)	18 (0.62)	14 (0.48)
	6	12 (0.65)	11 (0.60)	14 (0.76)
	≥7	17 (0.76)	11 (0.49)	6 (0.27)
Month from calving				
	1	10 (0.33)	7 (0.23)	15 (0.49)
	2	16 (0.50)	11 (0.34)	13 (0.40)
	3	10 (0.31)	18 (0.56)	9 (0.28)
	4	20 (0.63)	16 (0.51)	14 (0.44)
	5	19 (0.61)	13 (0.42)	17 (0.54)
	6	17 (0.57)	12 (0.40)	14 (0.47)
	≥7	69 (0.40)	53 (0.31)	73 (0.42)
Milking status total				
	Milking	155 (0.52)	125 (0.42)	148 (0.49)
	Dry	6 (0.10)	5 (0.08)	7 (0.12)
Housing status				
	Housed	99 (0.49)	71 (0.35)	110 (0.55)
	Intermediate	18 (0.51)	15 (0.43)	8 (0.23)
	Pasture	44 (0.35)	44 (0.35)	37 (0.29)
Track surface				
	No track (direct to field)	13 (0.37)	8 (0.23)	3 (0.08)
	Concrete tracks/ roadways	28 (0.54)	30 (0.58)	28 (0.54)
	Rough stone/ dirt tracks	21 (0.34)	26 (0.42)	11 (0.18)
Floor surface				
	Grooved concrete	32 (0.70)	30 (0.66)	81 (1.78)
	Slatted concrete	3 (0.20)	5 (0.33)	1 (0.07)
	Non-grooved solid concrete	64 (0.50)	36 (0.28)	24 (0.19)
Bedding type				
	Deep bedding	4 (0.09)	20 (0.44)	4 (0.09)
	Sparse bedding	113 (0.63)	66 (0.37)	114 (0.64)

Multi-level models

One farm with an extremely high reported incidence of digital dermatitis (80 cows, 969 records) was removed from all models as it distorted the model of digital dermatitis. The fit of the 3 models are summarised in Figures 5.1-3. There was good agreement between the expected and observed values for the sole ulcer and white line disease models. The digital dermatitis model over estimated the number of digital dermatitis cases in the highest category. This digital dermatitis data does not fit the model well therefore care should be taken in interpreting the results.

Figure 5.1 Model fit for multi-level model of risk factors for sole ulcer

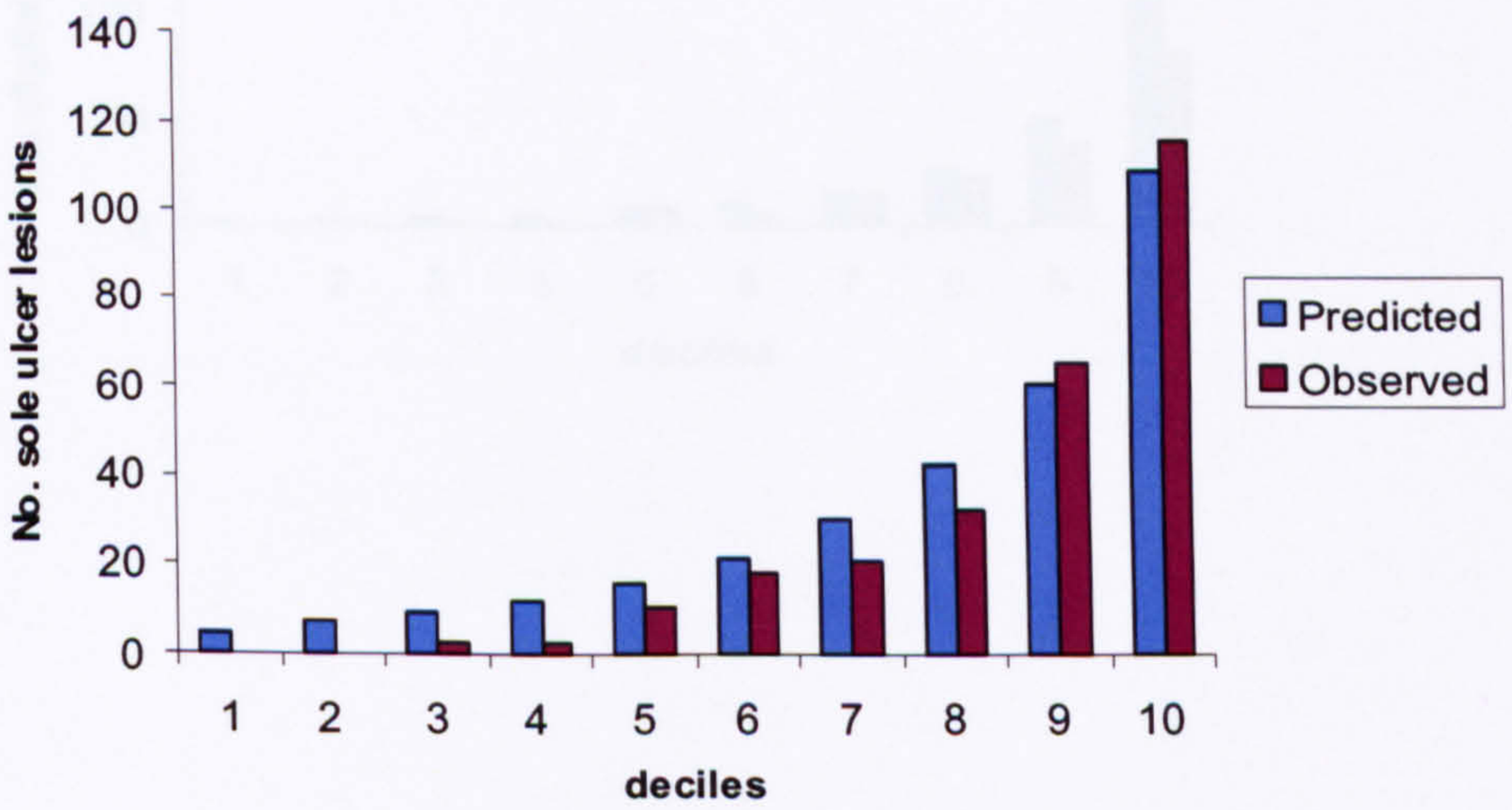


Figure 5.2 Model fit for multi-level model of risk factors for white line disease

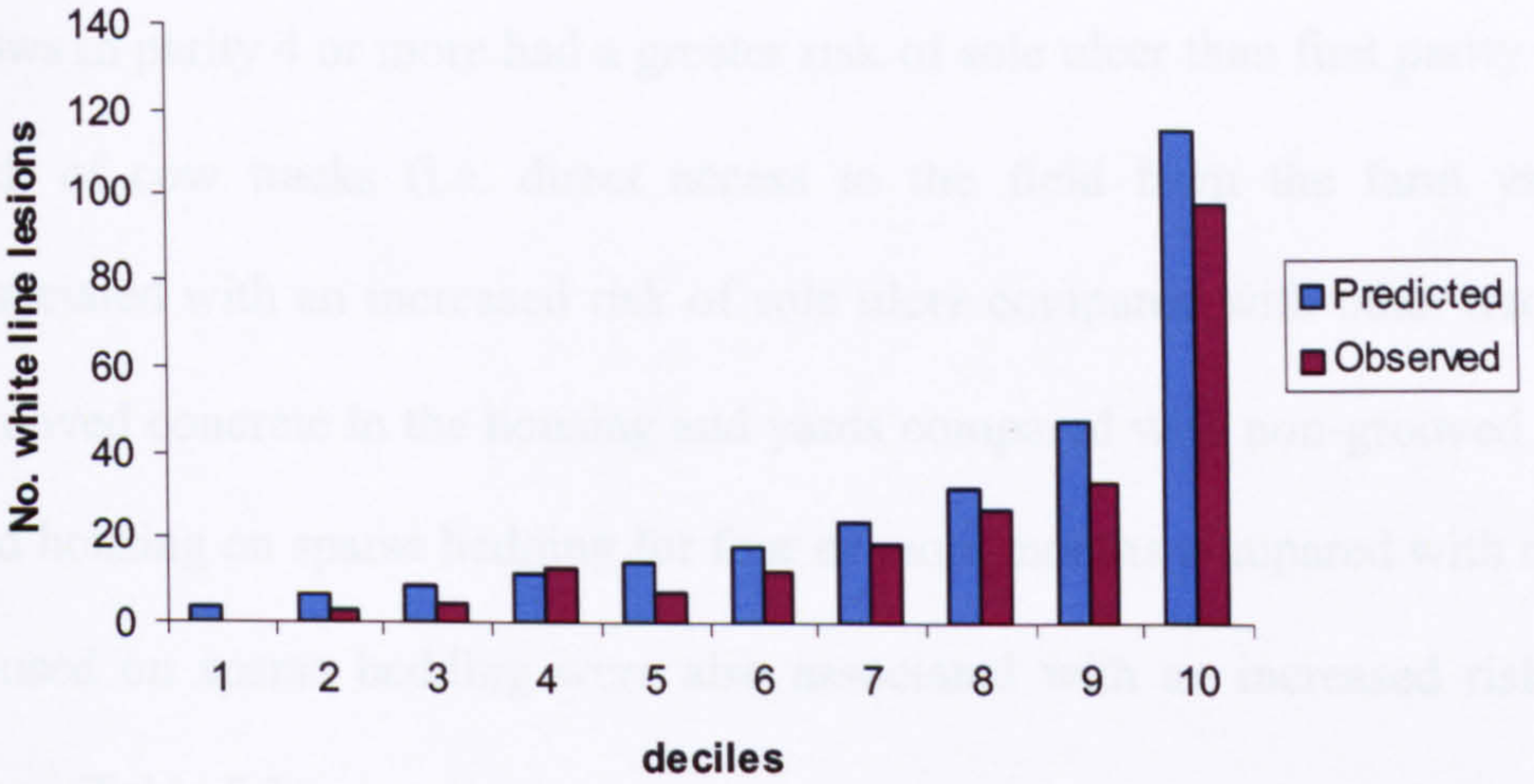
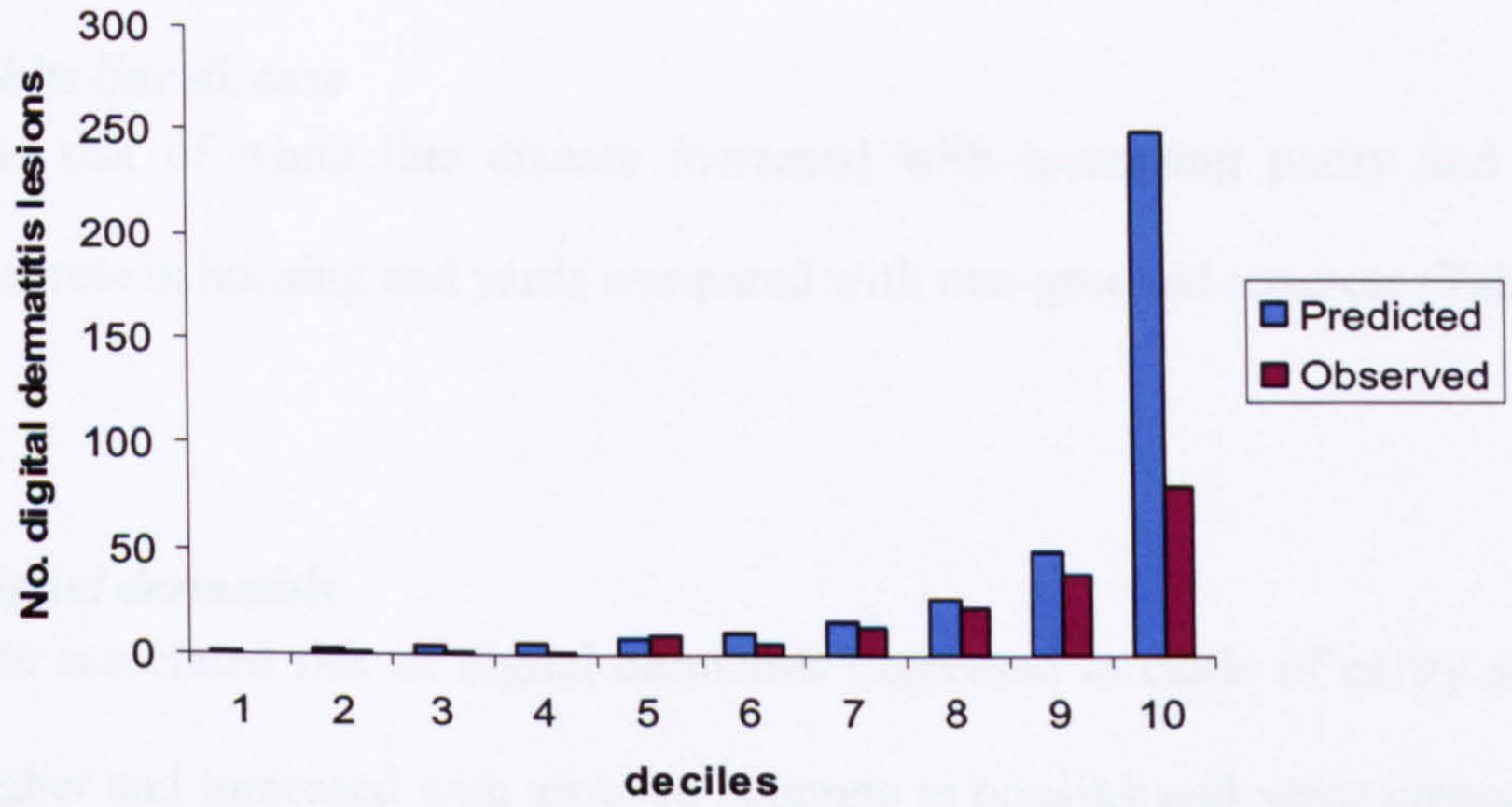


Figure 5.3 Model fit for multi-level model of risk factors for digital dermatitis



Sole ulcers

Cows in parity 4 or more had a greater risk of sole ulcer than first parity cows. A lack of cow tracks (i.e. direct access to the field from the farm yard) was associated with an increased risk of sole ulcer compared with other track types. Grooved concrete in the housing and yards compared with non-grooved concrete and housing on sparse bedding for four or more months compared with not being housed on sparse bedding were also associated with an increased risk of sole ulcer (Table 5.2).

White line disease

The risk of white line disease increased with increasing parity and grooved concrete in housing and yards compared with non-grooved concrete (Table 5.2).

Digital dermatitis

The associated risk of digital dermatitis decreased in cattle of parity seven and higher and increased with grooved concrete in housing and yards compared with non-grooved concrete (Table 5.2).

Table 5.2 Mixed effects models of risk factors for sole ulcer, white line disease and digital dermatitis lesion

Risk Factor (reference)	No. cattle	No. farms	Sole ulcer Odds Ratio (95% CI)	P value	White line disease Odds Ratio (95% CI)	P value	Digital dermatitis Odds Ratio (95% CI)	P value
Mean herd size			1.53 (1.02-2.29)	<0.05	1.17 (0.79-1.73)		2.06 (1.06-4.01)	<0.05
Parity Number								
1*	10319	27						
2	9082	27	1.32 (0.82-2.13)		1.64 (0.86-3.13)		0.86 (0.53-1.40)	
3	6722	27	1.11 (0.63-1.93)		2.31 (1.21-4.39)	<0.05	0.63 (0.33-1.19)	
4	4790	27	1.78 (1.05-3.02)	<0.05	4.22 (2.29-7.80)	<0.01	0.68 (0.36-1.29)	
5	3265	27	2.27 (1.29-4.00)	<0.01	3.83 (1.93-7.60)	<0.01	0.56 (0.25-1.26)	
6	2097	27	2.03 (1.02-4.05)	<0.05	3.24 (1.43-7.33)	<0.01	0.91 (0.42-1.93)	
≥7	2506	27	2.59 (1.41-4.77)	<0.01	3.39 (1.56-7.39)	<0.01	0.12 (0.02-0.77)	<0.05
Not at pasture*	24398	27						
Pasture	13456	27	1.19 (0.59-2.40)		0.89 (0.43-1.83)		0.84 (0.33-2.18)	
Outdoor walking surfaces								
Tracks*	35198	19						
No tracks (field only)	3583	8	2.32 (1.03-5.22)	<0.05	1.88 (0.84-4.22)		1.70 (0.52-5.60)	
No concrete tracks*	32937	18						
Concrete tracks/ roadways	5844	9	1.52 (0.76-3.06)		1.95 (0.93-3.92)		1.52 (0.61-3.78)	

*Reference category

Table 5.2 continued

Risk Factor (reference)	No. cattle	No. farms	Sole ulcer Odds Ratio (95% CI)	P value	White line disease Odds Ratio (95% CI)	P value	Digital dermatitis Odds Ratio (95% CI)	P value
Indoor Walking surfaces								
Non-grooved concrete*	32760	17						
Grooved concrete 32760	4905	10	2.20 (1.15-4.21)	<0.05	2.06 (1.06-4.00)	<0.05	10.33 (4.53-23.53)	<0.01
Non-slatted concrete*	36153	25						
Slatted concrete	1512	2	1.07 (0.31-3.74)		2.36 (0.80-6.97)		1.66 (0.26-10.76)	
Time on sparse bedding								
Not on sparse bedding	18125	27						
Up to 3 months	8928	21	1.09 (0.59-1.99)		0.77 (0.42-1.43)		1.06 (0.49-1.07)	
4 months or over	10701	21	2.15 (1.20-3.87)	<0.05	0.88 (0.47-1.66)		0.47 (0.21-1.07)	
Month from calving (1)								
1*	3341	27						
2	3500	27	1.53 (0.70-3.32)		1.50 (0.59-3.79)		0.73 (0.35-1.49)	
3	3469	27	0.89 (0.38-2.13)		2.36 (1.00-5.59)	<0.05	0.37 (0.15-0.91)	<0.05
4	3430	27	1.37 (0.62-3.03)		2.06 (0.84-5.02)		0.78 (0.36-1.73)	
5	3377	27	1.37 (0.62-3.04)		1.79 (0.72-4.49)		1.07 (0.52-2.23)	
6	3229	27	1.19 (0.54-2.62)		1.70 (0.67-4.33)		0.42 (0.16-1.11)	
≥7	18435	27	0.88 (0.44-1.77)		1.30 (0.67-2.52)		0.59 (0.32-1.10)	
Intercept			*-7.20*		*-7.23*		*-6.81*	
Residual error between farms			0.48		0.41		1.39	
Residual error between cows			0.00		0.00		0.00	

*Reference category

Discussion

The modelling method employed allows the effects of both individual cow and herd level risks to be compared for three frequently reported claw lesions; sole ulcer, white line disease and digital dermatitis. The risk factors associated with each of these lesions are discussed. The implications of these finding on our understanding of the aetiology of the lesions and potential interventions are discussed.

Bedding quantity

The use of sparse bedding was associated with an increased risk of sole ulcer. Low bedding usage has previously been associated with poorer scores of locomotion (chapter 4) and increased sole ulcer (Leonard et al., 1994). A likely reason for this is the lack of comfort to the cow afforded by such bedding. Preference tests have demonstrated that cows choose deeply bedded cubicles over minimal bedding on top of mattresses (Tucker et al., 2003). Cows lie down for longer on more comfortable bedding surfaces (Singh et al., 1993b). Increased sole lesion scores and locomotion scores were associated with increased time spent standing (Singh et al., 1993a). The results of this study also suggest that the length of time that cows are exposed to sparse bedding is important. The effect of sparse bedding on the risk of sole ulcer was only detected in cows housed on sparse bedding for four months or more. In a study by Webster (2002) the number and severity of sole ulcer lesions was greater in 1st parity cows housed in cubicles for four months than those on cubicles for one month when measured at 12 weeks post calving.

Floor surfaces in houses and yards

The risk of sole ulcer and white line disease was more than doubled when cows were exposed to grooved concrete in the housing or yards. Hinterhofer et al. (2006) reported that the mechanical stresses within the claw were increased where the abaxial wall of the claw was unsupported on at slatted floor surface. It is possible that the grooves in the concrete provide less mechanical support to the claw and lead to abnormal loading. However, the same authors reported that the stresses are not increased where the claw (direction of travel) is perpendicular to the slat. On the study farms with grooving a typical diamond or square design with narrow grooves was used. The risk of the abaxial wall being unsupported in this situation is less than on 28mm wide. Grooving of concrete is often used as a method of reducing the slipperiness of worn concrete. An alternative explanation for the increased risk for sole ulcer is that despite grooving, concrete remains slippery. Alterations in the gait are observed when cows are walking over floor surfaces with low frictional properties (Phillips and Morris, 2001; Telezhenko and Bergsten, 2006). Slippery floor surfaces are associated with an increase in lameness (Faull et al., 1997; Dembele et al., 2006). It was hypothesised by Faull et al. (1997) that altered weight bearing on the claw resulting from abnormal gait of cows on slippery floors increases pressure on the sole and white line. In addition to having an altered gait when walking on slippery floor surfaces some cows physically stumble or slip. As a cow regains her balance, following a stumble or slip, one or more of her claws will strike the floor with increased force resulting in a direct trauma to the sole and white line.

A small quantity of slurry remains in the grooves in the concrete after it has been scraped. It is possible therefore that the grooves in the concrete act as a reservoir for the bacteria causing digital dermatitis offering an explanation for the large increased risk for digital dermatitis on this floor type. Wells et al. (1999) also reported the risk of digital dermatitis on for cows walking on grooved concrete was over 2.7 that of cows walking on textured concrete. It is perhaps more likely that there is an indirect association between digital dermatitis and grooved flooring and factors not measured are associated with digital dermatitis. One such factor is the quantity of slurry present on the floors of passageways and yards. Floor types which reduce slurry have been associated with decreased digital dermatitis (Somers et al., 2005). In this study grooved concrete areas were scraped at the same frequency as all other floor types which were scraped using a tractor. Potential differences in the quantity of slurry were not related to the scraping frequency. Other factors may affect the quantity of slurry in yards and passageways for example high stocking rates. The dry matter intake of the cows and the ration would also affect the quantity and consistency of the faeces produced by cows. The quantity of slurry present on yards and passageways could not be assessed due to the different times of day visits were made to different farms when the floor may have just been cleaned or not have been cleaned for several hours. The presence of slurry on the yards and passageways may also exacerbate the risk for sole ulcer and white line disease by increasing the slipperiness of the concrete further and softening the claw due to increased moisture content (Borderas et al., 2004).

Track surfaces

Having no cow track, i.e. cows walking straight from the farmyard into fields, was associated with an increased risk for sole ulcer. The areas of highest cow flow are those closest to the farm. If these areas do not have a man made track surface then they may become damaged by cows (and vehicles) especially in wet weather. Such areas become wet and stones are visible at the surface which can be carried onto the concrete yards causing traumatic injuries to the sole. Wet conditions on the track would also cause increased softening of the sole horn further increasing the risk of sole ulcer (Borderas et al., 2004).

Parity

There was an increased risk of sole ulcer from parity four upwards. Alban (1995) also reported increased claw lesion in cows of parity four and above. The risk for white line disease increased with parity as also reported (Potzsch et al., 2003; Hirst et al., 2002). In the current study the lameness history of the cows was not known. However, the increase in lameness at higher parities may be partially explained by lesion occurrences in a previous lactation leading to an increased risk in the current lactation. The effects of calving on the complex processes involved in the formation of claw horn are also yet to be fully elucidated and may further explain the associations with parity. Previous studies have reported that first lactation cows have an increased risk of digital dermatitis and this risk diminishes with increasing parity (Somers et al., 2005; Rodriguez-Lainz et al., 1999). However, in this study, no association was detected between digital dermatitis and parity of the cow until parity seven plus.

Herd Size

No direct biological argument can be made for a direct association between sole ulcer and herd size irrespective of previous such associations (Rowlands et al., 1985). It is therefore likely that herd size is a proxy for one or more risk factors for sole ulcer that were not measured. On possible indirect effect of increased herd size on sole ulcer is the potential number of social interactions, in particular aggressive and bullying behaviour, that may lead to increased standing times in submissive cows and that these could be higher in larger herds. A biologically plausible explanation for the association between digital dermatitis and herd size is that increasing group sizes within larger herds provide a larger susceptible population within which an infection disease can spread. Somers et al. (2005) reported increased risk for digital dermatitis with increased herd size.

There were marked differences between sole ulcer and white line disease in terms of their associated risks. This provides further support for the theory that the aetiology of these diseases differ (Le Fevre et al., 2001). Lying comfort and outdoor surfaces should be considered when planning and making interventions for the reduction of sole ulcer and white line disease respectively.

Variation between herds and between cows

Multi-level modelling allowed the variation between farms and between cows to be assessed. There was no variation between individual cows for any of the three

lesion models. This suggests the use of a rate of lesions for the farm would have been appropriate. However, the use of a cow level within the model allowed the inclusion of data on the parity of the cows and month since calving. Data were also structured to allow for the differences in housing location and therefore exposures across time. More variation could be accounted for at the farm level for digital dermatitis than could be for sole ulcer and white line disease. This is likely due to the infectious nature of digital dermatitis. Whole herds in the data set remain uninfected by digital dermatitis where as almost all farms have some level of sole ulcer or white line disease.

Conclusions

Cows in parity four upwards were at greater risk of sole ulcer. Grooved concrete floors, no cow tracks, larger herd sizes and housing on sparse bedding for four or more months were also associated with an increased risk for sole ulcer. Risk factors for increased white line disease were increased parity, and grooved concrete floors. Increased herd sizes and exposure to grooved concrete floors were associated with increased digital dermatitis. These results contribute to our increasing understanding of the factors which may lead on to the development of specific claw lesions. This provides useful information which will help in the formulation of farm and lesion specific lameness control strategies. There are no conflicting risks between lesions; this is useful information since farmers do not have to choose between conflicting managements to minimise lameness.

Chapter 6

Interventions for lameness reduction on commercial dairy farms

Introduction

The overall aim of this project was to reduce lameness in dairy cattle. Our understanding of the risk factors for lameness and claw lesions causing lameness has increased in recent years. The results from the multivariable models discussed in Chapters 4 and 5 add to this knowledge further. Despite this, there have been few studies which test the impact of intervening on known risk factors for lameness. Hughes et al. (1997) reported reduced incidence of lameness in two herds which replaced existing cubicles with loose straw yards. In two further herds modifications were made to cubicle dimensions: although observations of lying and rising restrictions were reduced, the incidence of lameness was not. Manske et al. (2002b) carried out a control trial to test the effectiveness of two different topical treatments for digital dermatitis. Hedges et al. (2001) tested the effect of supplementation with biotin on the incidence of claw lesions. In a large intervention study of mastitis control on dairy herds the amount cows affected with clinical mastitis was reduced by 22% (Green et al., 2007).

Intervention studies are currently recognised as the best available method of assessing animal health interventions as they provide high quality evidence on which to base animal health control strategies (Lavori and Kelsey, 2002). Important considerations in the design of an intervention study include the study population used (i.e. do they represent the target population?) and the method of

allocating subjects to the treatment or control groups. Masking of participants (single blinded) or participants and researchers (double blinded) may be used to reduce bias. The study population should be large enough to allow for loss of participants from the study. However, these losses should be minimised through regular communication, follow up and even incentives (Dohoo et al., 2003, p185-205).

A study was designed to assess the impact of interventions on known risk factors for lameness with the aim of improving locomotion scores and reducing the incidence of claw lesions. This chapter reports the preliminary findings of this intervention study. The results and implications of the findings for future work are discussed.

Materials and methods

Allocation of farms to control or intervention groups

At the final visit of the first year risk analysis study all farmers indicated they would continue to record lesions until the end of the study (February 2006). One herd was not considered for the intervention study as it was the only herd with Ayrshire cows and could not be matched by breed with any other herd. Therefore, 49 farms were sorted according to straw yard or cubicle house, herd size, farm mean locomotion score, and the rate per 100 cows per year of sole ulcer, white line disease and digital dermatitis in the herd. Farms were paired with a farm of the same type and of a similar size and mean locomotion score. Farms were matched on locomotion score because locomotion score represented

a complete record of the lameness status of all cows and was recorded by the author and one of three colleagues. Then, where possible, farms were matched on lesion rates for each of the three lesion types. One straw yard farm remained unpaired (Table 6.1).

One farm from each pair was randomly allocated to the intervention group and the other to the control group by generation of a 0 1 Bernoulli distribution with p=0.5. This random allocation was blind and was carried out by a member of the group with no knowledge of the farms or herd locomotion. The allocation was then checked to ensure that the mean herd size, locomotion scores and lesion rates were similar for the two groups and that the main dairying areas represented by the study were evenly split across the two groups. The unpaired straw yard farm was randomly allocated to the intervention group. All farmers were contacted to confirm their continued participation in the intervention study. Seven farmers withdrew from the study at this point. Of these, four had been allocated to the control group and three to the intervention group. These farmers stated lack of time (5) and ceasing milk production (2) as the reasons for withdrawal from the study. The mean herd size, locomotion score and lesion rates were rechecked (Table 6.2).

Table 6.1 Allocation of farms to control or intervention groups as part of a randomised lameness intervention study

		Intervention						Control					
Pair	Housing type	Herd size	Loco score	Rate SU	Rate WLD	Rate DD	% loco score 3	Herd size	Loco score	Rate SU	Rate WLD	Rate DD	% loco score 3
1	Straw	49.5	1.586	22.63	6.46	0.00	3.54	70.3	1.617	0.00	10.25	0.00	3.20
2	Straw	105.8	1.777	0.76	0.76	0.00	12.29	81.0	1.796	1.98	8.89	0.99	12.04
3	Cubicle	254.3	1.909	15.42	25.80	9.75	17.50	420.5	2.055	28.73	10.08	9.89	21.88
4	Cubicle	201	1.785	6.77	0.80	0.80	12.70	245	1.842	6.87	4.58	3.92	15.53
5	Cubicle	41	1.591	0.00	5.85	0.00	2.44	38	1.656	0.00	0.00	0.00	6.579
6	Cubicle	184	1.877	10.42	12.16	2.61	11.53	162	1.744	10.88	5.44	31.65	7.88
7	Cubicle	171	1.769	3.27	12.16	8.42	7.46	135	1.772	5.34	3.56	1.19	7.79
8	Cubicle	121	1.731	19.83	12.56	18.51	7.64	114	1.683	14.10	10.57	17.62	6.17
9	Cubicle	120	1.875	5.32	11.98	3.99	11.43	127	1.702	5.06	24.66	1.90	4.35
10	Cubicle	57	1.718	5.64	8.46	2.82	4.85	50	1.802	4.82	11.26	9.65	10.05
11	Cubicle	122	1.645	6.56	4.59	0.00	2.664	119	1.677	2.02	0.67	0.00	2.32
12	Cubicle	60	1.582	1.34	4.02	5.36	0.84	62	1.616	3.90	2.60	1.30	5.285
13	Cubicle	76	1.684	3.16	2.11	3.16	8.22	76	1.626	0.00	0.00	0.00	3.28

Loco = Locomotion

Shaded rows = farm which dropped out after initial allocation

Table 6.1 continued

		Intervention						Control					
Pair	Housing type	Herd size	Loco score	Rate SU	Rate WLD	Rate DD	% loco score 3	Herd size	Loco score	Rate SU	Rate WLD	Rate DD	% loco score 3
14	Cubicle	88	1.840	19.15	11.85	103.93	11.40	69	1.935	16.17	5.78	21.95	16.61
15	Cubicle	105	1.751	9.19	6.89	3.06	7.89	99	1.837	5.69	8.93	1.62	13.45
16	Cubicle	78	1.894	5.11	5.11	6.13	15.97	79	1.892	2.03	3.04	8.10	17.72
17	Cubicle	75	1.821	2.13	3.19	0.00	6.64	77	1.850	9.38	2.08	0.00	6.515
18	Cubicle	65	1.795	24.81	16.12	0.00	12.79	64	1.704	16.19	6.23	2.49	7.782
19	Cubicle	89	1.789	4.49	3.60	0.90	11.24	91	1.799	0.00	1.75	7.89	10.41
20	Cubicle	124	1.992	1.29	0.00	3.22	13.88	120	1.887	0.67	2.00	0.00	14.97
21	Cubicle	149	1.898	10.24	4.31	4.31	14.31	173	1.896	5.10	2.32	10.20	16.81
22	Cubicle	60	1.763	7.97	0.00	7.97	8.30	83	1.767	8.70	14.50	16.44	8.76
23	Cubicle	96	1.531	0.00	0.00	0.00	6.27	82	1.604	0.00	0.00	5.85	2.44
24	Cubicle	101.3	1.786	0.79	0.00	0.79	13.82	66.5	1.792	1.20	0.00	1.20	10.902
25*	Straw	46.0	1.810	6.96	13.91	0.00	15.22						
Mean		105.5	1.768	7.73	6.91	7.43	9.63	112.5	1.773	6.20	5.80	6.41	9.70

Loco = Locomotion

*No pair

Shaded rows = farm which dropped out after initial allocation

Table 6.2 Intervention and control group means for final farm allocation

	Herd size	Loco score	Rate SU	Rate WLD	Rate DD	% loco score 3
Intervention	107.0	1.781	8.39	7.46	8.16	10.16
Control	112.4	1.766	6.80	6.08	6.56	9.29

Loco = Locomotion

Study design and data recording considerations

Analysing farm specific recommendations

The main consideration in the design of this part of the study was the variation both in farm environment and management and in the lameness scores and rates on each of the farms. This prevented the use of a single set of recommendations for all farms since not all recommendations would apply to all farms; this might be because they were specific to a housing or management type which did not exist on that farm (e.g. an intervention on cubicle type on a farm with only straw yards) or because they were aimed at a specific type of lameness that did not exist on that farm (e.g. footbath recommendations on a farm with no digital dermatitis). The use of farm specific recommendations would also have created variables with too few data in the categories where a recommendation was only made to a small number of farms. The farm specific recommendations were therefore made using five target areas based on current working hypotheses of the causes of sole ulcer, white line disease and digital dermatitis (Table 6.3). Recording forms were designed with specific recommendations under the five target areas (Figure 6.1). For each recommendation made to the farmer comment of 'should do' or 'must do' was added by RB based whether there was a low or high incidence of the lesion which the recommendation was targeting. Not all recommendations were made to all farmers.

Figure 6.1 Interventions recording form

Cubicle House Interventions **Cow Group(s) Present:**

Current Group size:	Lying space:
Non-lying space:	No. Cubicles:
Feed Space:	Average Faecal Score:

HYGIENE					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Increasing cleanliness of passage and yard floors					
Ensuring low stocking densities. i.e. $3m^2$/cow loafing space in cubicle house					
Adequate scraping: *at least 6/day + during milking for automatic scrapers* ***or*** *at least 2/day for tractor scraped*					
Avoid dietary upset leading to runny faeces **Check:** Chop length, Amt Conc/Meal, Conc:Forage Ratio					

COW COMFORT AND STANDING TIMES					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Increase cubicle comfort to increase lying times					
By ensuring adequate bedding: *Current amount:* *Cubicle Base/Bedding:* *Recommended Amount:*					
By providing comfortable lying space with even base and free from foreign objects					
By providing cubicles with appropriate dimensions **Check:** Position of neck rails, Height side rails at rear					
By providing adequate lying space: *10% more cubicles than cows in cubicle house*					
By providing adequate passage space to allow movements in and out of cubicles: *>6'(1.8m) but ideally for slurry >10'(3m)*					
Reducing standing time on concrete					
Avoiding blind ended passage ways					

FLOOR QUALITY AND COW FLOW					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Provide a non-slip walking surface which does not cause excessive wear					
Recommend replacing concrete if badly worn *(slippery /rough)*					
Recommend grooving the concrete					

Loose House Interventions **Cow Group(s) Present:**

Current Group size:

Lying space: Non-lying space:

Feed Space: Average Faecal Score:

HYGIENE					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Increasing cleanliness of passage and yard floors					
Ensuring low stocking densities. *(8m²/cow (inc 6m²/cow bedded) in loose house)*					
Adequate scraping for stocking level ***(please record below)*** Current scraping: Recommended scraping:					
Avoid dietary upset leading to runny faeces **Check:** Chop length, Amt Conc/Meal, Conc:Forage Ratio					

COW COMFORT AND STANDING TIMES					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Increase cubicle comfort to increase lying times					
By ensuring adequate bedding *(please give amount)*					
By ensuring lying area is free of foreign objects					
By providing adequate lying space i.e. >6m²/cow bedded in loose yard					

FLOOR QUALITY AND ANIMAL FLOW					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Provide a non-slip walking surface which does not cause excessive wear					
Recommend replacing concrete if badly worn *(slippery /rough)*					
Recommend grooving the concrete					

Parlour and Collecting Yard Interventions

Parlour size/ type:

Standing time - Before milking: After milking:

HYGIENE					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Increasing cleanliness of passage and yard floors					
Collecting yard is clean before milking					

COW COMFORT AND STANDING TIMES					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Reducing standing time on concrete					
Reduce standing times at milking (max 4hrs/day) • Small groups going to milking at any one time • Reduce milking times • Leave cow lying till after milking has started • Allow to return to housing straight after milking					

FLOOR QUALITY AND ANIMAL FLOW					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Provide a non-slip walking surface which does not cause excessive wear					
Recommend replacing concrete if badly worn *(slippery /rough)*					
Recommend grooving the concrete					
Allowing the cows to place their feet more carefully					
Cows should be allowed to walk at their own speed with their heads down as they move					
If used; Backing gates should have a bell or other audible warning					
Sharp turns should be avoided on the farm or, if necessary, provide rubber floor					

Loafing/Feeding Yard Interventions **Cow Group(s) Present:**

Yard Area:

Feed Space:

FLOOR QUALITY AND ANIMAL FLOW					
Recommendation	NA	Not Req'd	Do Now	Shoul d Do	Must Do
Provide a non-slip walking surface which does not cause excessive wear					
Recommend replacing concrete if badly worn *(slippery /rough)*					
Recommend grooving the concrete					

HYGIENE					
Recommendation	NA	Not Req'd	Do Now	Shoul d Do	Must Do
Increasing cleanliness of yard					
Adequate scraping for stocking level *(please record below)* Current scraping: Recommended scraping:					
Avoid dietary upset leading to runny faeces **Check:** Chop length, Amt Conc/Meal, Conc:Forage Ratio					

COW COMFORT AND STANDING TIMES					
Recommendation	NA	Not Req'd	Do Now	Shoul d Do	Must Do
Reducing standing time on concrete					
Reduce time standing to feed by ensuring: *at least0.8m/cow feed space*					

Footbath and Lameness Control Interventions

Footbath routine:
Solution changed:

FOOTBATHS AND LAMENESS CONTROL					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Reducing infectiousness of cows with digital dermatitis					
By using a footbath in the following ways:					
Low DD: <5% cows with raw open lesions Disinfectant: 4% formalin, 3-4days consecutively for winter housing period Antibiotics: None					
High DD >5% cows with raw open lesions Disinfectant: 4% Formalin, at least 5 days a week 365 days per year					
Improving the footbath procedure for cow and stockman					
• *Ensure that the maximum number of cow passages = 250 before solution is exchanged* • *Avoid stress and defecation in the footbath by using it regularly (i.e. at least 3x/week) and using a firm comfortable base.* • *Recommend a prewash of circulation cleaner* • *Site footbath at least one parlour row of cows away from parlour on normal return route from the parlour*					
Reducing the spread of pathogenic organisms and improving healing					
Isolating severely lame cows ('limping' cows)					
Use dressings on digital dermatitis cases					
Apply blocks to cows with hoof lesions					

Heifer/Dry cow transition and integration interventions

Heifer cubicle training:
Heifer cow transition diet:
Dry cow transition diet:

HEIFER INTEGRATION TO THE MILKING HERD					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Reducing trauma in freshly-calved heifers due to concrete					
Increase lying times/ cubicle usage in fresh calved heifers • Rearing heifers in cubicles • House heifers in cubicle house for 3-4weeks during the summer before they calve (while milking herd out at grass)					
Reducing bullying of heifers/ dry cows on entry to milking herd					
Housing should avoid blind ended passages					
A separate heifer group could be maintained					
Heifers could be mixed with dry cows for social exposure					
Heifers should be introduced as a group to the main milking group					
Heifers should be mixed at night					
Heifers should be mixed during feeding					
Reducing digestive upsets due to dietary change					
A low level (eg 10 kg) of the post calving ration, or even better a specific DCAB ration should be given for 3 weeks before calving					
Add Biotin into ration at 20mg/cow/day					
Minimising digital dermatitis post partum					
When entering heifer/dry cow transition group footbathing should begin twice a week (see footbathing)					

DRY COW INTEGRATION TO THE MILKING HERD					
Recommendation	NA	Not Req'd	Do Now	Should Do	Must Do
Reducing digestive upsets due to dietary change					
A low level (eg 10 kg) of the post calving ration, or even better a specific DCAB ration should be given for 3 weeks before calving					
Add Biotin into ration at 20mg/cow/day					

Tracks and Gateways Interventions

FLOOR QUALITY AND ANIMAL FLOW					
Recommendation	NA	Not Req'd	Do Now	Shoul d Do	Must Do
Reducing cows slipping on slippery floor surfaces					
Recommend replacing concrete if badly worn *(slippery /rough)*					
Recommend grooving the concrete					
Recommendation	NA	Not Req'd	Do Now	Shoul d Do	Must Do
Reducing foot wear due to surfaces of tracks and gateways					
Recommend using rubber flooring					
Possible wet areas that cows will avoid					
Removal of bricks and stones or cover with rammed chalk/alternative					
Keeping hedges well trimmed back					
Brushing stones off tracks/yard surface					
Making a stone trap at end of track					
Rerouting track *i.e. to reduce steepness*					
Recommendation					
Allowing the cows to place their feet more carefully					
Cows should be allowed to walk at their own speed with their heads down as they move					

A set of 'standard values' for recommendations (e.g. bedding depth, space allowance) were agreed upon. These were based on current best practice and veterinary knowledge. These allowed both a clear guideline for where a recommendation should be made and a tool for monitoring changes made.

Table 6.3 Summary of five target areas for intervention and hypotheses and aims for reducing lameness

Target Area	Hypothesis	Aim
Cow comfort & standing times	Excessive standing increases risk of sole ulcer	Reduce involuntary standing times and encourage increased lying times
Floor quality & cow flow	Turning and slipping movements increase the risk of white line disease	Prevent sharp turns, avoidance behaviours and poor quality floors
Hygiene	Poor hygiene increases risk of infectious diseases	Reduce contact with potential pathogens in slurry
Footbathing & lameness control	Footbathing and individual treatment reduces risk of infectious lameness and prevalence of non infectious causes	Reduce spread of infectious disease and improve recovery by treatment
Integration & socialisation	Poor integration and socialisation and integration of newly calved animals into the herd increases the risk of sole ulcer and white line disease	Reduce bullying that would lead to increased standing times and avoidance behaviours

The presentation of recommendations to study farmers

In addition to the content of the recommendations, a second consideration was who should make the recommendations and how these should be explained to the farmer. Roger Blowey (RB) is a veterinarian with considerable knowledge of the dairy industry and lameness in dairy cattle. He hosted the five lameness and lesion recognition training events for study farmers during the first year of the study (Chapter 2). Feed back from these farmers following the training events was very positive with most farmers commenting on his ability to communicate

with the farmers in a useful and informative way. Therefore RB and either Joanne Wright (JW) or ZB attended all intervention visits with RB presenting the recommendations after a farm inspection.

It was extremely important that both intervention and control farms continued to the end of the intervention study. The intervention farms were visited at the start of the intervention study and as an incentive to stay in the study the control farms were offered a similar farm visit at the end of the study.

Data collection

The timings and data collected at the farm visits during the 'intervention study' are summarised in Tables 6.4 and 6.5. For visits 5-7, as with previous visits, one or more researchers visited the farm. RB was accompanied by a researcher on the pre-intervention and post-intervention visits.

Table 6.4 Time and grazing season of farm visits.

Visit number	Time of visit	Housing status	Number of farms	Study period
Pre-intervention	Nov – Dec 04	Winter housing	22 *	
5	Jan – Feb 05	Late winter housing	42	Year 3:
6	Jul – Aug 05	Grazing	42	Intervention
7	Jan – Feb 06	Late winter housing	41	study
Post-intervention	May – Sep 06	Grazing	17 **	

* Intervention farms only. ** Control farms only

Table 6.5 Farm visits and data collected between November 2004 and February 2006

Data collected	When collected	Purpose of data
Locomotion score all cows	Visits 5 - 7	To measure lameness prevalence
Cleanliness score of hind quarters all cows	Visits 5 - 7	Indicator of diet & cleanliness of environment
Hock score all cows	Visits 5 - 7	Cause of lameness & indicator of cow comfort
Assessment of bedding quality and quantity	All visits during housed period	Indicator of cow comfort
Consistency of faeces	Visits 5 - 7	Indicator of diet
Detailed farm risk factor assessment	Pre-intervention visit	To identify areas for intervention
Details of interventions implemented	Visit 6 & 7	To monitor uptake and effect of interventions
Summer & winter risk factor summaries	Visit 6 & 7	Comparison of risk factors present on intervention and control farms
Recording of lesions at trimming*	Feb 03 – Feb 06	Identification of causes of lameness

*Lesions recorded by farmer continuously between visits

Pre-intervention visit

The 22 farms allocated to the intervention group were contacted by telephone to arrange a farm visit by RB and one of two researchers. A letter was sent to the farm veterinarian with a brief description of the project (Appendix I, page 195). All visits were carried out according to the following procedures.

Intervention visit procedure

◊ A pre-visit summary sheet (Appendix J, page 196) was produced and sent to RB the week before the intervention visit.

◊ RB was guided around the farm by the farmer/herdsman following the flow of the cows through the buildings. Buildings were visited in the same order on all visits.

◊ RB complete personal notes while the researcher followed the intervention sheets advising RB of any necessary measurements or points to be discussed.

◊ RB went through suggested recommendations to the farmer after the farm tour indicating whether he felt the recommendation was a 'should do' or a 'must do'.

◊ The farmer was asked to state whether he would be willing to implement each of the recommendations, with a 'yes', 'no' or 'maybe' response. This response was noted by JW or ZB.

◊ After leaving the farmer, RB and the researcher completed an overall impressions sheet (Appendix K, page 197) which recorded the general impression of the visit success including the attitude of the farmer.

◊ RB produced a report of the visit detailing the points discussed with the farmer (Appendix L, page 198).

◊ A recommendation summary sheet was completed by the researcher present at the visit (Appendix M, page 200).

◊ The report of the visit and summary sheets were posted to the farmer.

Monitoring interventions

A updated copy of the intervention summary sheet was taken to the intervention farms at each subsequent visit (visits 5-7) and the farmers were asked to provided details of any changes made.

Recording risk factors

Risk factors at pasture and during winter housing were recorded on standard forms (Appendix N, page 201) for all farms at visits 6 and 7 respectively. The risk factors were recorded using yes/no responses to questions relating to the presence or absence of features of the cows' environment or management practices considered to be a risk. In cases where measurements were taken the 'standard values'were used to define the threshold for a 'yes' response by the recorders.

Individual cow, housing and management data

All cows were scored for locomotion, hock lesions and cleanliness at each of visits 5, 6 and 7. Faecal consistency, bedding depth and bedding cleanliness were also scored for each cow house/group. Details of all scoring techniques are described in chapter 2. At each visit farmers were also asked to provide details of any housing or management changes occurring since the date of the previous visit. Farmers were also reminded to continue to record claw lesions observed during treatment.

Exit Questionnaire

At visit 7 all farms were asked a short exit questionnaire which was designed to capture farmer opinion on the study. Farmers were also asked to provide a summary of the animals culled in the previous 12 months and the reason for culling.

Post-intervention visit

After the end of the study, farmers in the control group were contacted to arrange a visit by RB and a researcher. A letter was again sent to the farm veterinarian and the visit was completed using the 'intervention visit procedure' described above.

Analysis of intervention data

Farm mean locomotion scores

Analysis of locomotion scores was completed using data from 22 treatment farms and 19 control farms. Mean locomotion scores were calculated for the farm visits that took place in late winter housing (year 1, January to March 2004; year 2, January and February 2005 and year 3, January and February 2006).

Individual cow locomotion score

As described in Chapter 5, each of the various cow identifications used throughout the study (freeze brand, UK ear tag, management tag and line number) were matched and each cow was assigned a new unique identifier. Locomotion scores taken at each visit were grouped for each cow. The percentage of each possible change in locomotion score between visits 5 and 6, 6 and 7, 5 and 7 was calculated for each farm.

Rates of lesions

One farm failed to return any records of lesions so was excluded from the analysis of lesions rates. The number of control farms in the analysis was consequently 18.

Lesion rates were calculated for the first (February 03 to January 04), second (February 04 to January 05) and third (February 05 to January 06) years of the study. Intervention recommendations were given to farmers at the end of the second year of the study, therefore the third year of the study may represent the changes of lesion rates in response to interventions in the treatment group. A lesion occurrence was defined as the first of that type of lesion per claw recorded by the farmer during treatment for lameness. As with locomotion score the differences in the rates of specific lesions between the years of the study were calculated for each farm (*Equation a*).

Equation a $D = R_n - R_{n-1}$

Where

D = *Difference in rate of lesions*

R = *Rate of lesions*

$_n$ = *Year of study*

Results

Participation

Only one farm failed to complete the intervention recording period as the herd was sold in December 2005. Although this was close to the end of the study period the herdsman had fallen behind with lesion recording and was no longer available to complete the records so the farm was removed from the analysis. All lesion forms were returned by 30th March 2006 following reminders at the final visit and subsequent telephone calls if required.

Uptake of interventions

Table 6.6 Uptake of recommendations within 5 target areas

Target area	Total no. given	Total implemented		Farmer response where recommendation was implemented			Farmer response where no recommendation was implemented		
		no.	%	Yes	Maybe	No	Yes	Maybe	No
Cow comfort & standing times	70*	12§	17.1	7	3	1	18	21	18
Floor quality & cow flow	78	13	16.7	11	1	1	20	30	15
Footbathing & lameness control	40	12	30.0	12	0	0	16	10	2
Hygiene	35*	8	22.9	5	2	1	8	3	15
Integration & socialisation	24	11	45.8	10	1	0	3	8	2
Other	23*	11§	47.8	7	3	0	8	4	0
Total	**270**	**67**	**24.8**	**52**	**10**	**3**	**73**	**76**	**52**

*Four farmer responses not recorded (2 Cow comfort, 1 Hygiene, 1 Other)
§Two recommendation without farmer response implemented (1 Cow comfort, 1 Other)

The percentage of recommendations implemented across farms ranged from 25% to 62%. The greatest numbers of recommendations were made under the cow comfort and standing time (CC&ST) or floor quality and cow flow (FQ&CF) target areas (Table 6.6). However, the percentages of recommendations implemented by farmers in these two target areas were lowest. The types of recommendations given to the farmers within the target areas are summarised in Table 6.7. Examples of three recommendations implemented by farmers are photographed in Figure 6.2. The recommendations implemented within the CC&ST and FQ&CF target areas were often small repairs or additions (e.g. repair concrete, add rubber floor at parlour) or management changes (e.g. increase cubicle bedding, milk in groups to reduce standing at milking).

Forty one point six percent of the recommendations that farmers said they would implement were fully implemented while 10 (11.3%) of the 86 recommendations that initiated a 'maybe' response from the farmers were adopted. Where a farmer responded 'no' to a recommendation 3/51 (5.5%) were implemented. Of the 'no' responses received 56.9% were given to recommendations which involved structural changes to buildings or walkways. A further 11.8% were achievable without structural changes but had high cost implications, namely increasing the number of cubicles per cow and installing cubicle mats/mattresses. Responses for four recommendations were not obtained as they were not posed to the farmer during the visit but were added to the summary of recommendations sheet sent to the farmer by post following the visit. Of these, two of the recommendations were implemented by the farmer.

Figure 6.2 Improvements to track surface on hilly terrain from hardcore/ mud track used by tractor and cows to separate cow track with pine peelings over reclaimed railway sleepers

a) Before

b) After

Figure 6.2 Rubber at parlour exit

Figure 6.3 Access to concrete for heifers and dry cows

Table 6.7 Summary of recommendations made to farmers

Recommendations	Total Given	Total implemented	
		No	%
Cow comfort and standing times			
10% more cubicles than cows	8	0	0.0
Add mats or mattresses	4	0	0.0
Change cubicle dimensions	3	0	0.0
Increase bedding quantity	16	5	31.3
Increase feed space	7	1	14.3
Add brisket board	3	1	33.3
Increase lunging	10	0	0.0
Move brisket board to 1.77m	5	0	0.0
Reduce standing time during milking	6	5	83.3
Replace cubicles	4	0	0.0
Other	4	0	0.0
Floor quality and cow flow			
Improve track	10	1	10.0
Increase loafing space	3	1	33.3
Increase turning space in parlour	5	0	0.0
Improve cow flow in house /feed area	11	2	18.2
Improve flow through parlour	3	1	33.3
Load collecting yard from back	3	0	0.0
Repair areas of rough/damaged concrete	15	3	20.0
Rubber floor feed area	3	0	0.0
Rubber floor parlour/ parlour exit	9	3	33.3
Groove/Re-groove slippery concrete	5	2	40.0
Widen cubicle passages	4	0	0.0
Improve concrete and/or drainage to remove pooling	2	0	0.0
Other	5	0	0.0
Hygiene			
Improve ventilation	8	1	12.5
Increase scraping	9	3	33.3
Reduce pooling/ puddles of slurry	5	3	60.0
Widen cubicle passage	9	0	0.0
Other	4	1	25.0

Table 6.7 continued

Recommendations	Total Given	Total implemented	
		No	%
Footbathing and lameness control			
Apply block to cows with hoof lesions	3	2	66.7
Buy new footbath with no ridges	2	1	50.0
Treat and dress digital dermatitis lesions for 3 days	10	3	30.0
Increase footbathing frequency	18	4	22.2
Move footbath	3	1	33.3
Remove severely lame cows to straw yard	2	0	0.0
Other	2	1	50.0
Integration & socialisation			
Cubicle training for heifers	7	1	14.3
Expose heifers to concrete	4	3	75.0
Specific dietary changes	8	6	75.0
Other	5	1	20.0
Other			
Add 20mg/cow of biotin to dairy ration	17	6	35.3
Keep closed herd and don't buy in stock	6	5	83.3

Comparison of control and intervention groups

Incidence of claw lesions

The rates of sole ulcer for the intervention group were lower than the control group for each quarter (3 months) after the pre-intervention visits (November 04 – January 06) in which the recommendations were made to the farmer (Figure 6.5). On farms where reductions in the rate of sole ulcer were achieved the decrease was greater for farms in the intervention group and greater than in the previous year. Where the rate of sole ulcer was increasing on farms the increases were smaller for farms in the intervention group (Figure 6.8a,b).

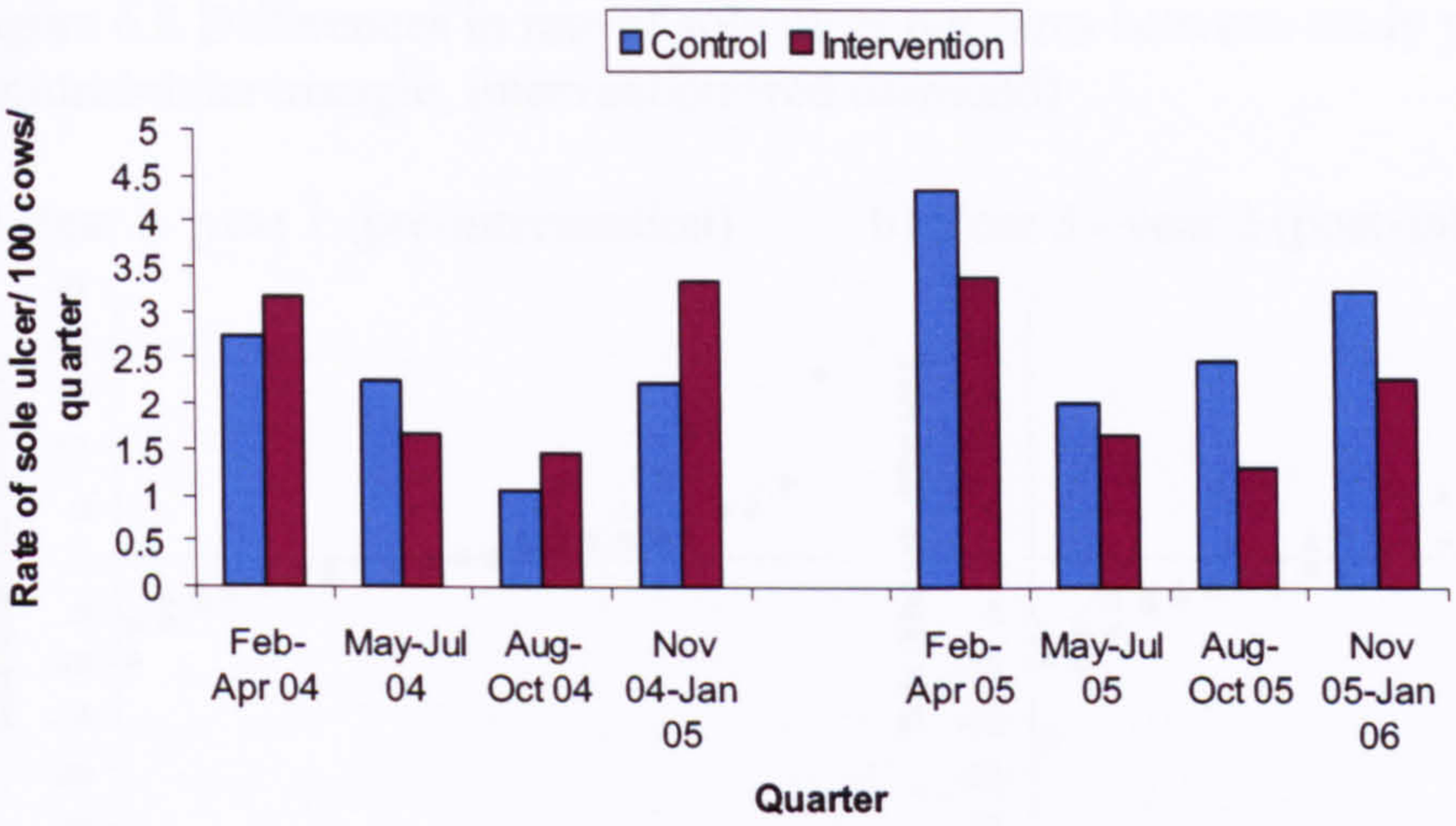
The rate of white line disease fluctuated over time for both intervention and control groups (Figure 6.6). On farms where the rate of white line disease decreased it did so by a greater amount on intervention farms than control farms. On most farms where there rate of white line disease increases it did so by a smaller amount on intervention farms than on the control farms. However, substancial increases in the rate of white line disease were recorded for two farms in the intervention group (Figure 6.9a,b).

The annual incidence of digital dermatitis decreased during the 3 years of the study for both the intervention and control groups (Table 6.8). The rate of digital dermatitis per quarter was smaller for the intervention group than for the control group after recommendation had been given to the farmers (Figure 6.7). However, the reported rate of digital dermatitis for the intervention group was particularly small. No differences were measured between individual farms in the control and intervention groups (Figure 6.10a,b).

Table 6.8 Mean locomotion scores and rates of claw lesions for control and intervention farms in three study years

	Control			Treatment		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
Locomotion score	1.76 (0.03)		1.77 (0.03)	1.78 (0.02)		1.78 (0.02)
Sole ulcer incidence rate	9.42 (2.05)	9.80 (2.50)	12.50 (3.75)	8.52 (1.64)	9.53 (1.80)	8.85 (1.49)
White line disease rate	8.11 (1.60)	6.58 (1.42)	7.36 (1.38)	7.41 (1.58)	8.50 (2.08)	8.47 (2.02)
Digital dermatitis rate	5.96 (1.73)	3.84 (0.85)	3.43 (1.32)	3.14 (3.13)	1.66 (2.54)	1.83 (0.97)

Figure 6.5 Rate of sole ulcer per quarter in control and intervention groups



Intervention recommendations made in Nov 04-Jan 05

Figure 6.6 Rate of white line disease per quarter in control and intervention groups

Figure 6.7 Rate of digital dermatitis per quarter in control and intervention groups

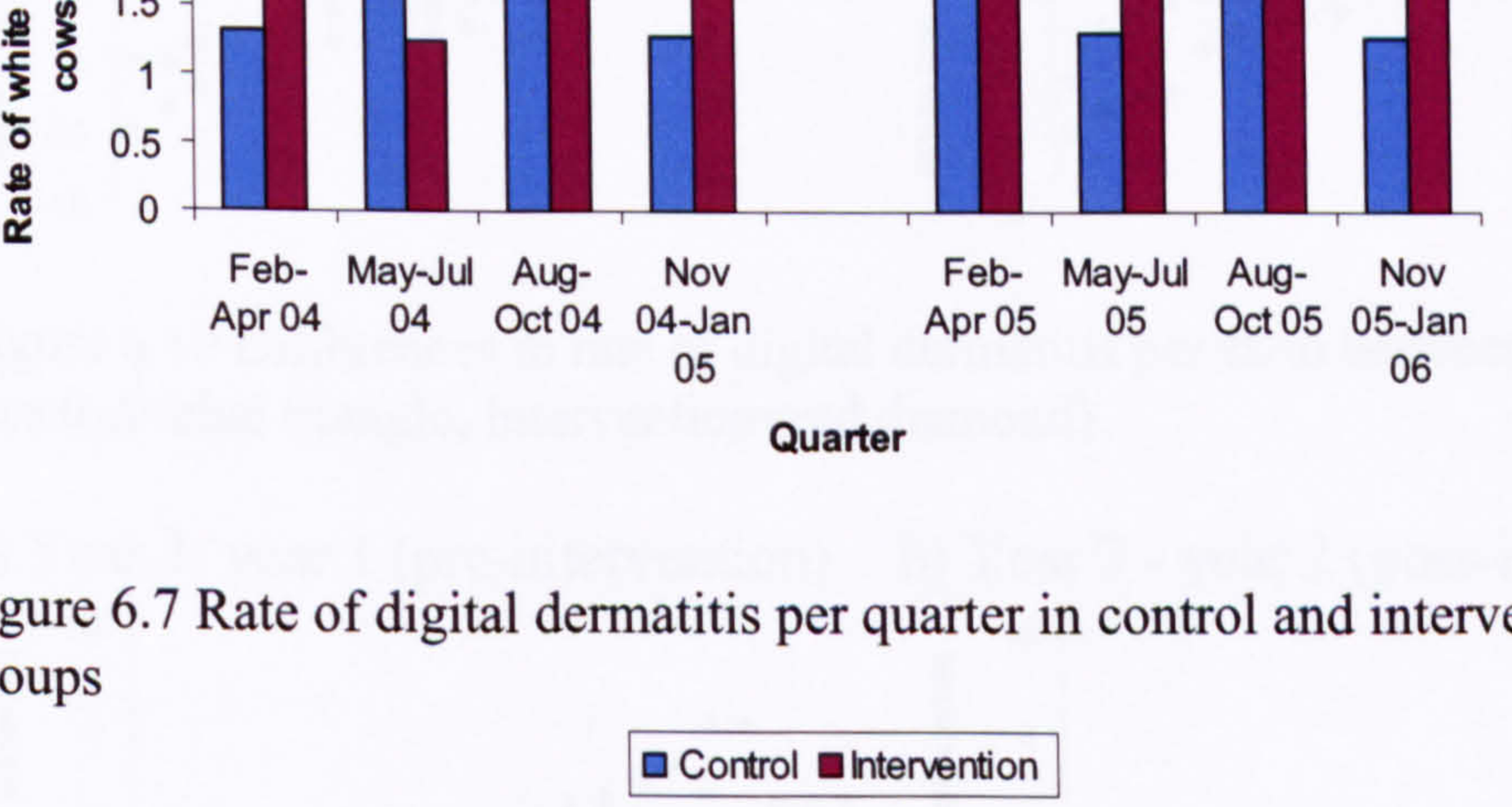
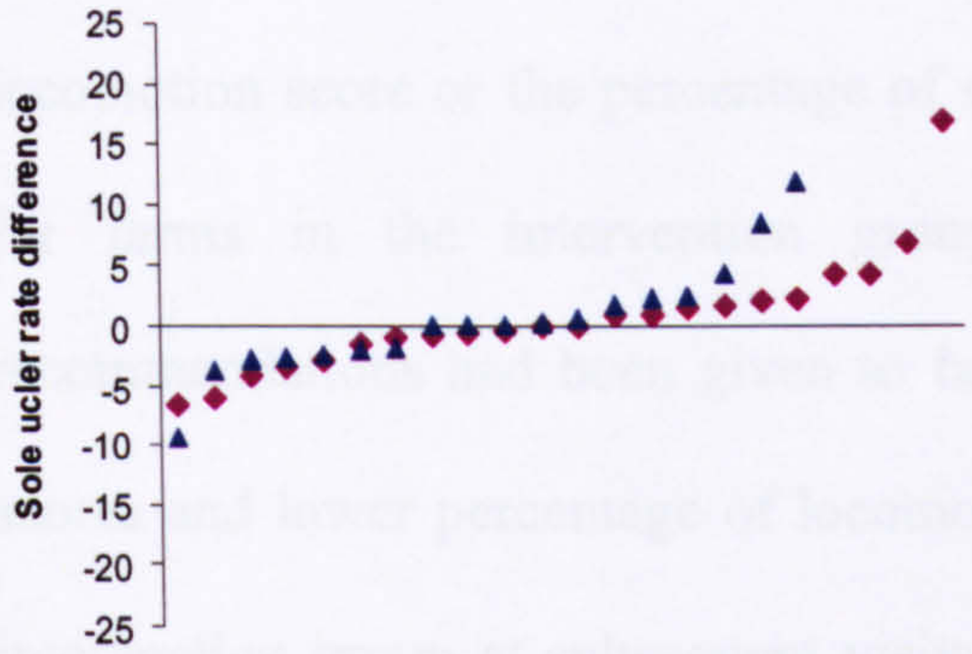


Figure 6.8 Differences in rate of sole ulcer per farm between study years (control=blue triangle, intervention=red diamond)

a) Year 2- year 1 (pre-intervention)



b) Year 3 - year 2 (post-intervention)

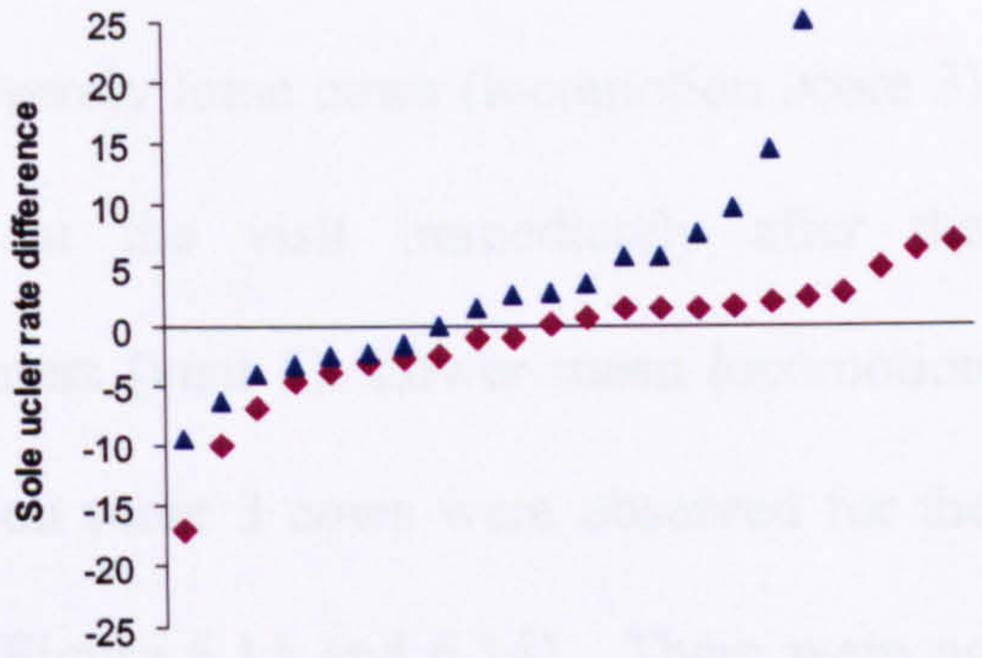
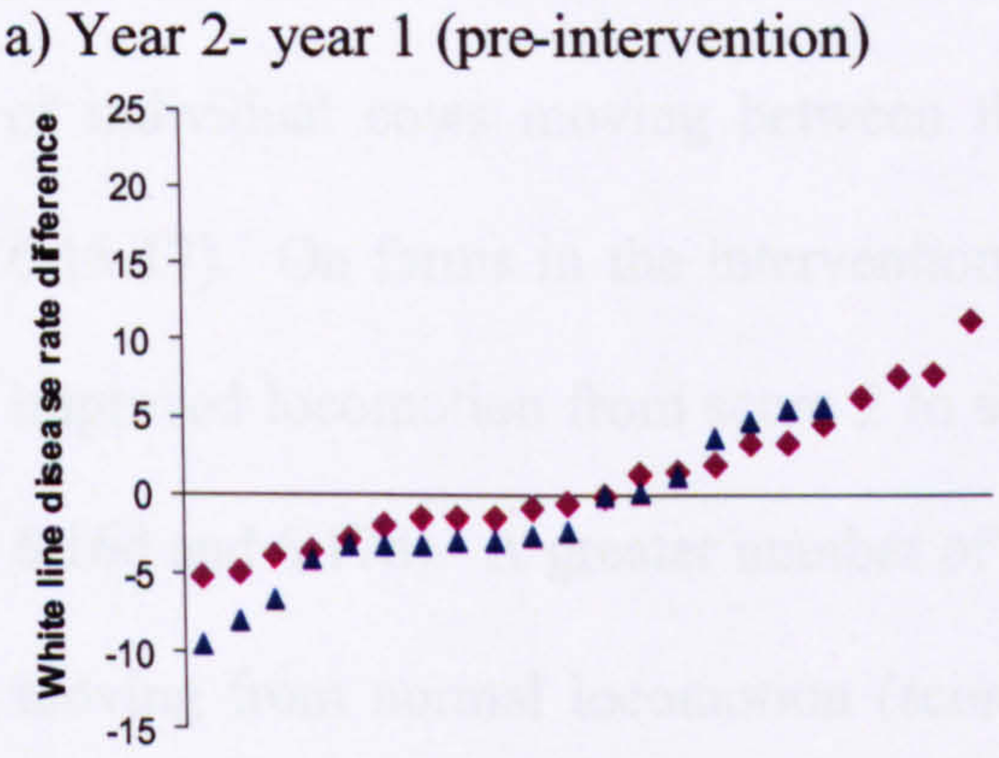


Figure 6.9 Differences in rate of white line disease per farm between study years (control=blue triangle, intervention=red diamond)

a) Year 2- year 1 (pre-intervention)



b) Year 3 - year 2 (post-intervention)

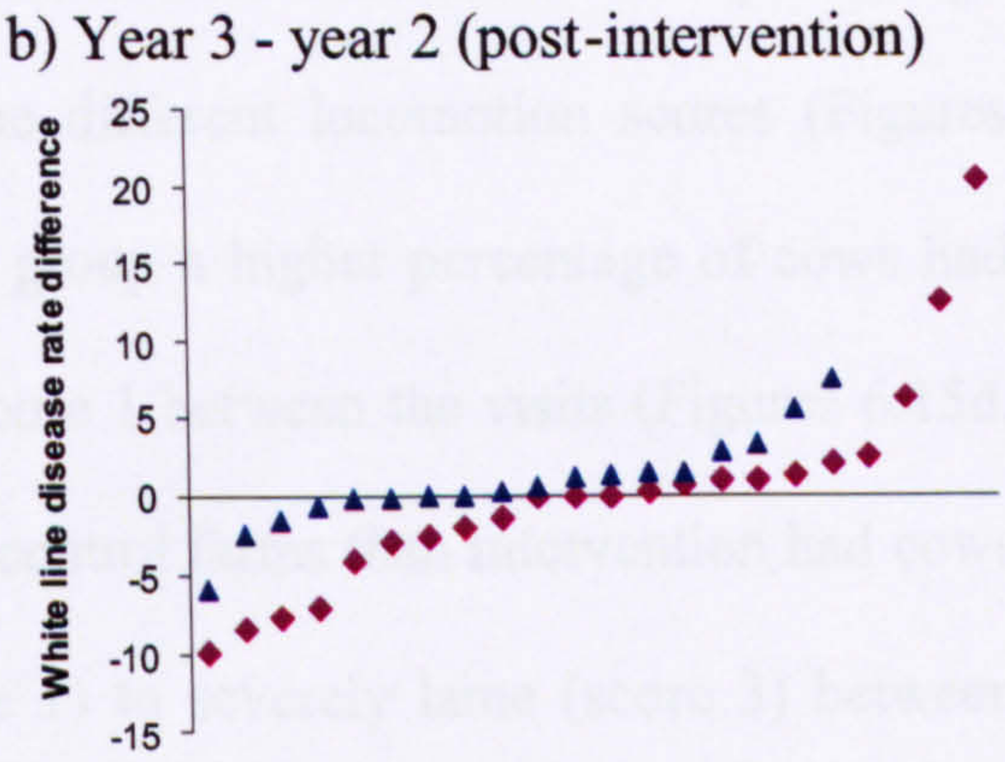
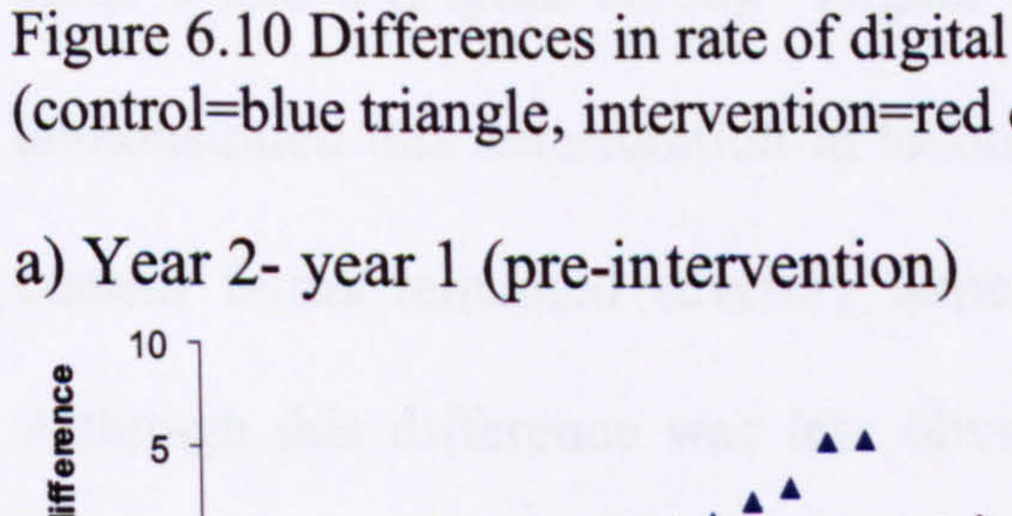
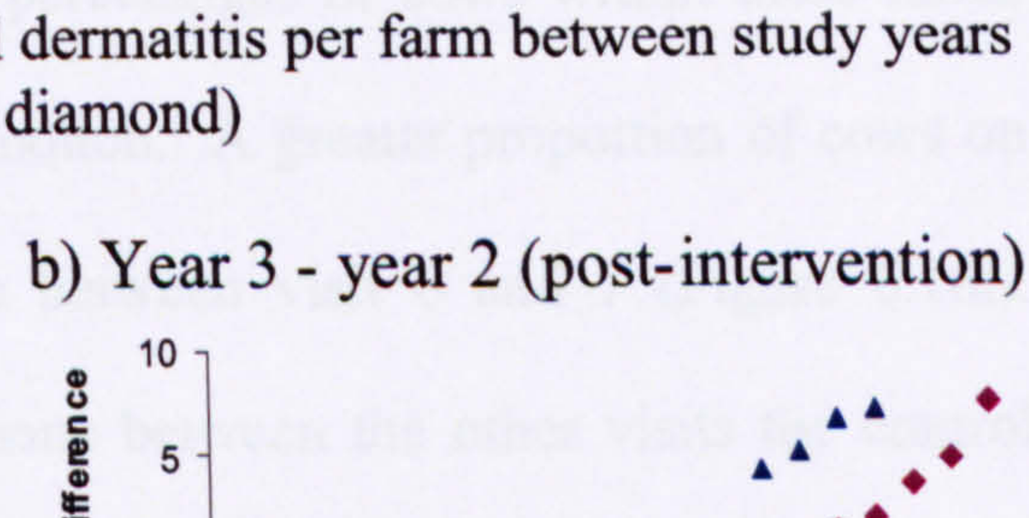


Figure 6.10 Differences in rate of digital dermatitis per farm between study years (control=blue triangle, intervention=red diamond)

a) Year 2- year 1 (pre-intervention)



b) Year 3 - year 2 (post-intervention)



Locomotion score

The mean locomotion score did not differ between the first and third years of the study for intervention or control farms (Table 6.8). There was no reduction in locomotion score or the percentage of severely lame cows (locomotion score 3) for farms in the intervention group at the visit immediately after the recommendations had been given to farmers (visit 5). Lower mean locomotion scores and lower percentage of locomotion score 3 cows were observed for the intervention group at subsequent visits (Figure 6.11 and 6.14). There were no differences in the percentage of cows with locomotion score 1 or 2 between intervention and control farms. There were notable differences in the percentage of individual cows moving between the different locomotion scores (Figures 6.15-17). On farms in the intervention group a higher percentage of cows had improved locomotion from score 2 to score 1 between the visits (Figures 6.15d, 6.16d and 6.17d). A greater number of control farms than intervention had cows moving from normal locomotion (score 1) to severely lame (score 3) between visits 5 and 6 (Figure 6.15c). Higher percentages of cows within these farms demonstrated this deterioration in locomotion. A greater proportion of cows on control farms remained severely lame between visit 6 and 7 (Figure 6.16i). Although this difference was less obvious between the other visits the control farms with the highest number of cows remaining score 3 had much greater percentages than the highest intervention farms (Figure 6.15i and 6.17i). On most farms the largest proportion of cows remained as a score 2 between any pairs of visits.

Figure 6.11 Mean score of locomotion for control and intervention groups

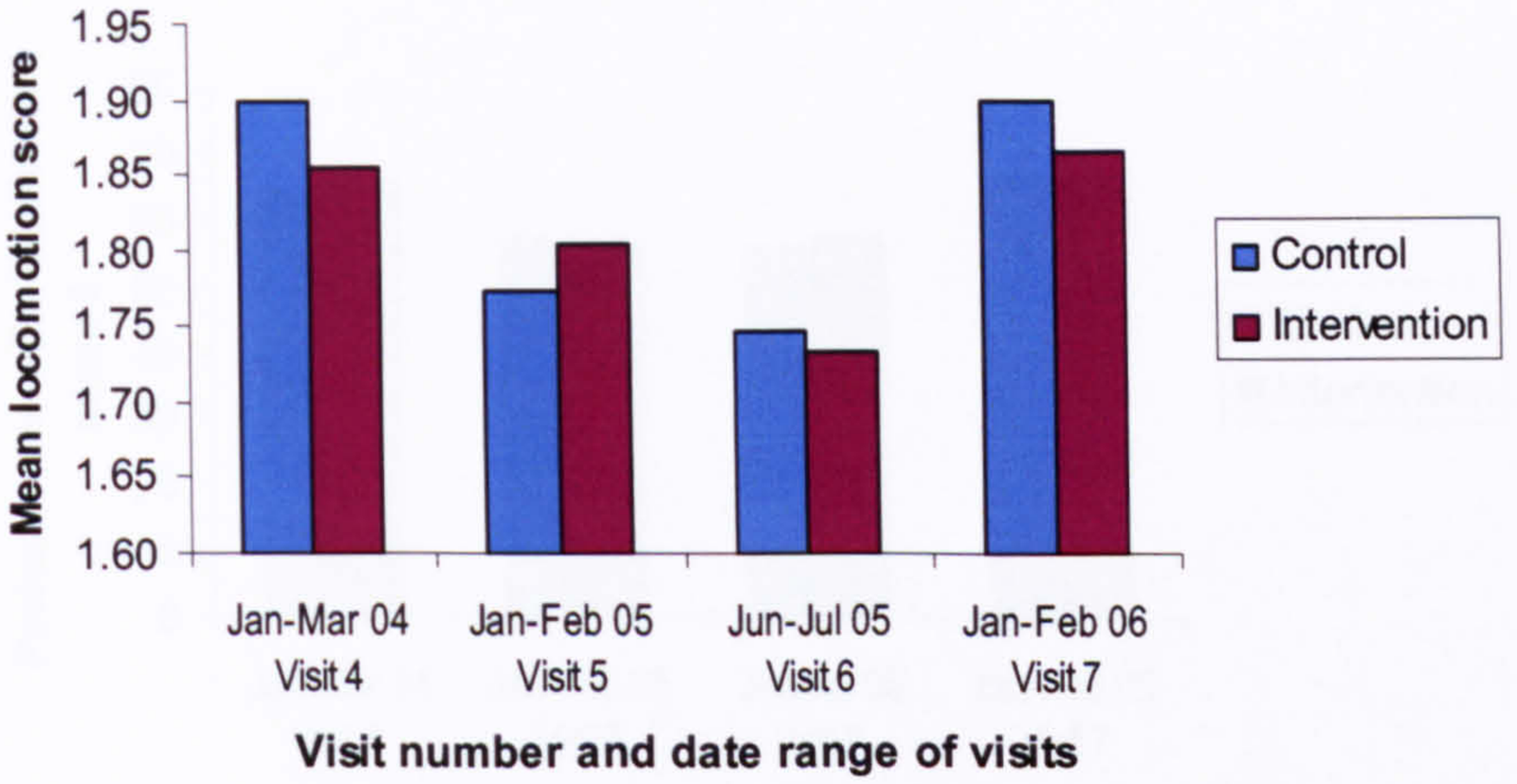


Figure 6.12 Percent of cows with locomotion score 1 in control and intervention groups

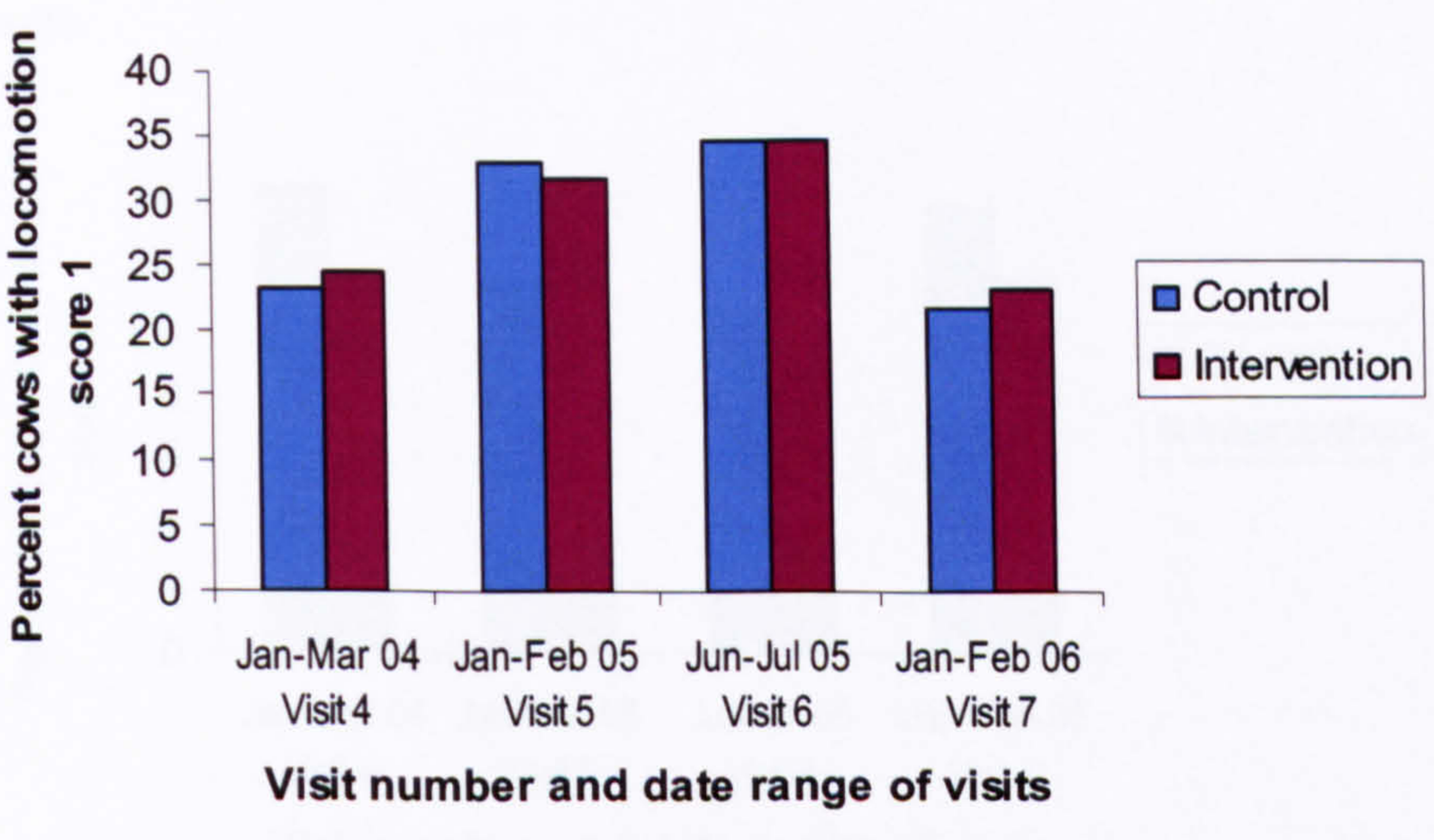


Figure 6.13 Percent of cows with locomotion score 2 in control and intervention groups

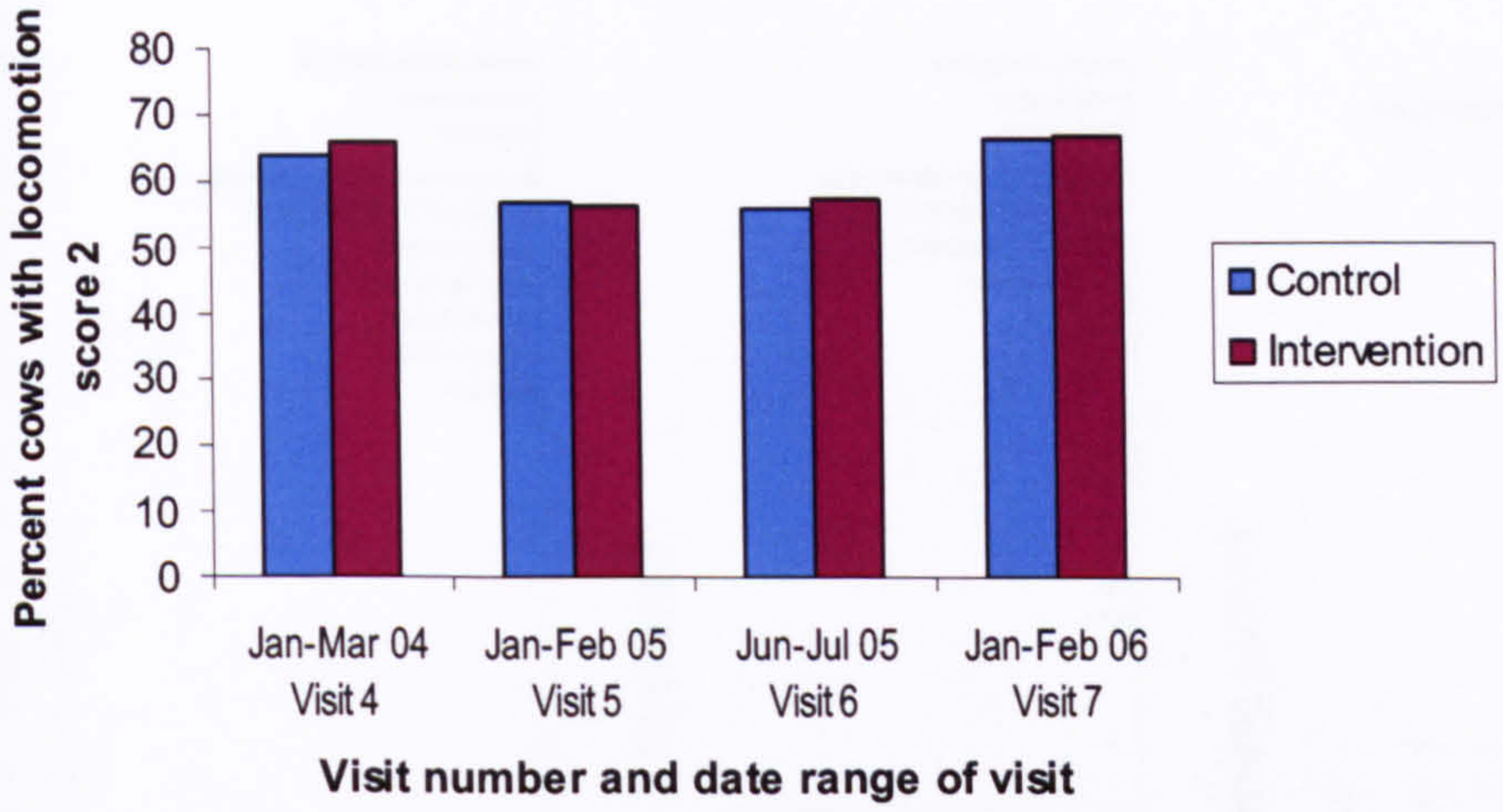


Figure 6.14 Percent of cows with locomotion score 3 in control and intervention groups

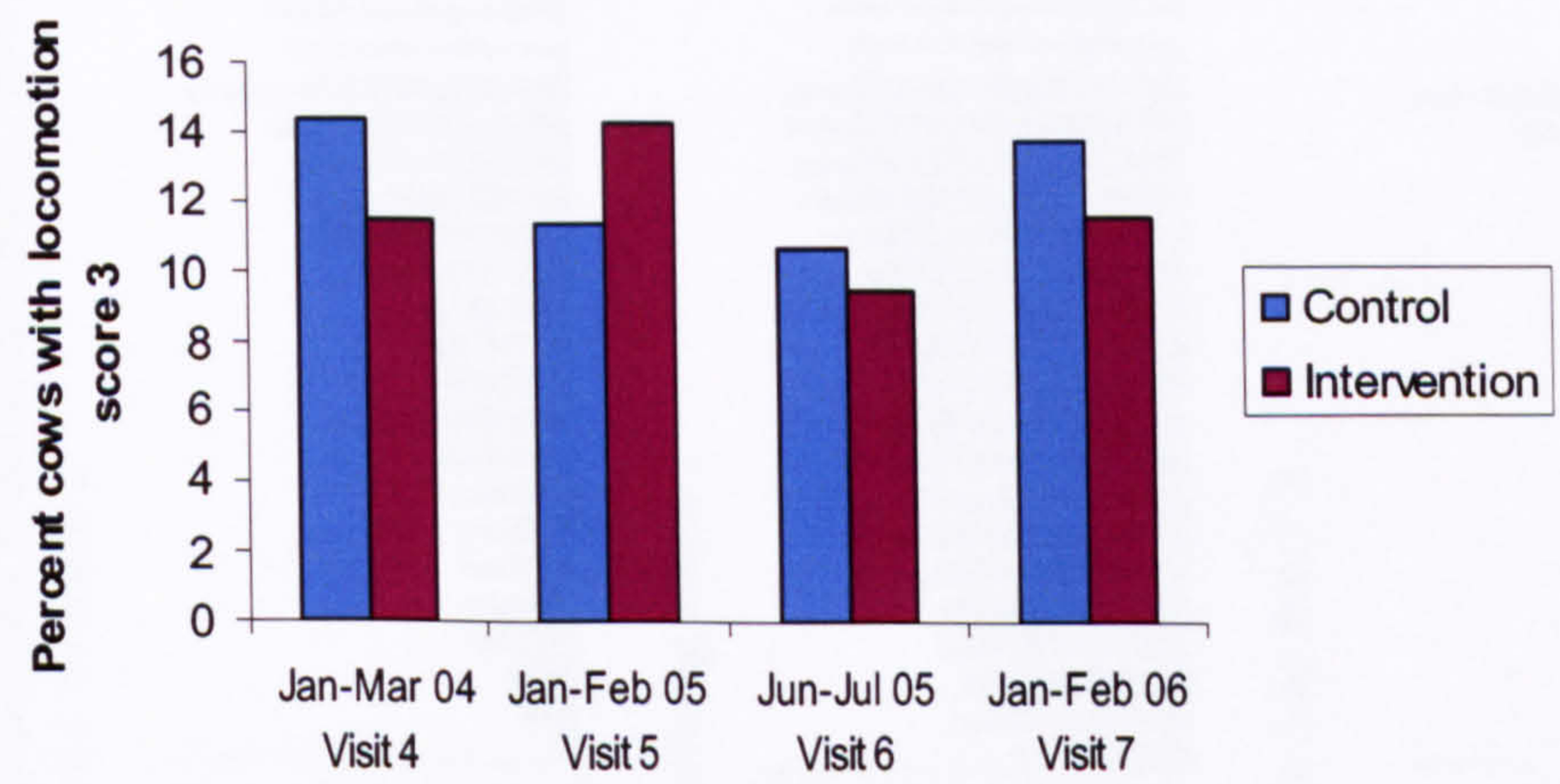
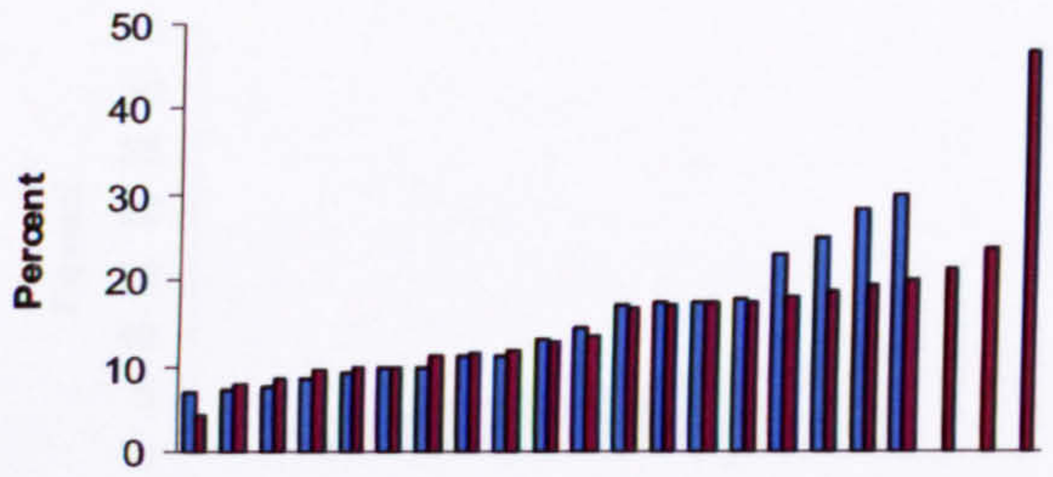
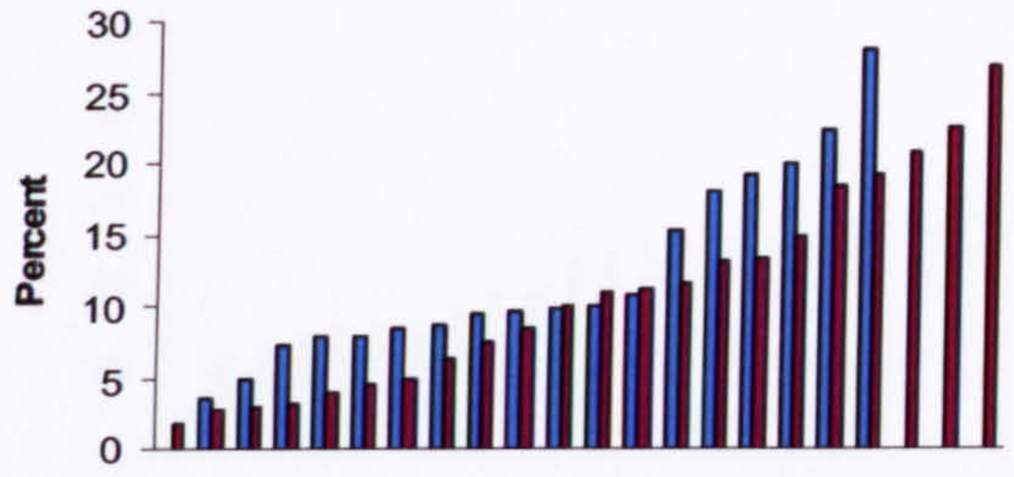


Figure 6.15 Percentage of cows per farm with each locomotion score combination between visits 5 and 6 (control=blue, intervention=red)

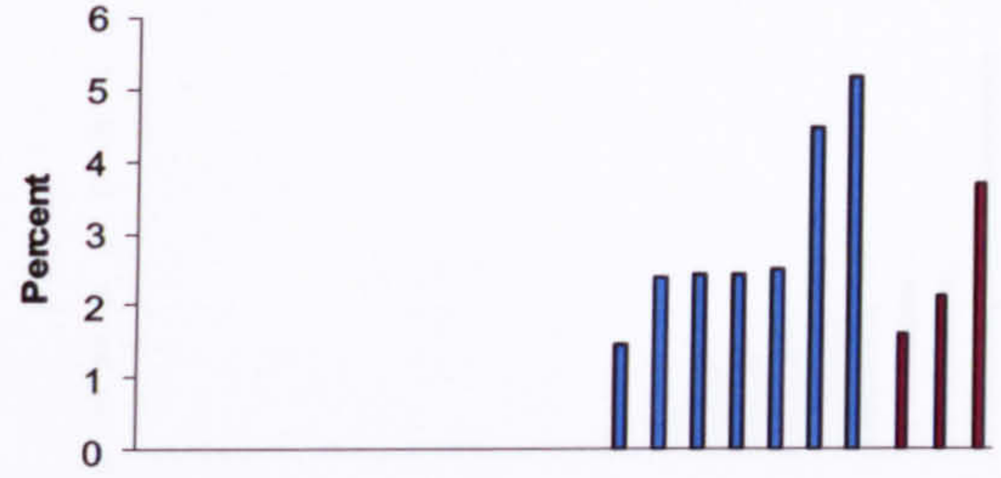
a) Remaining score 1



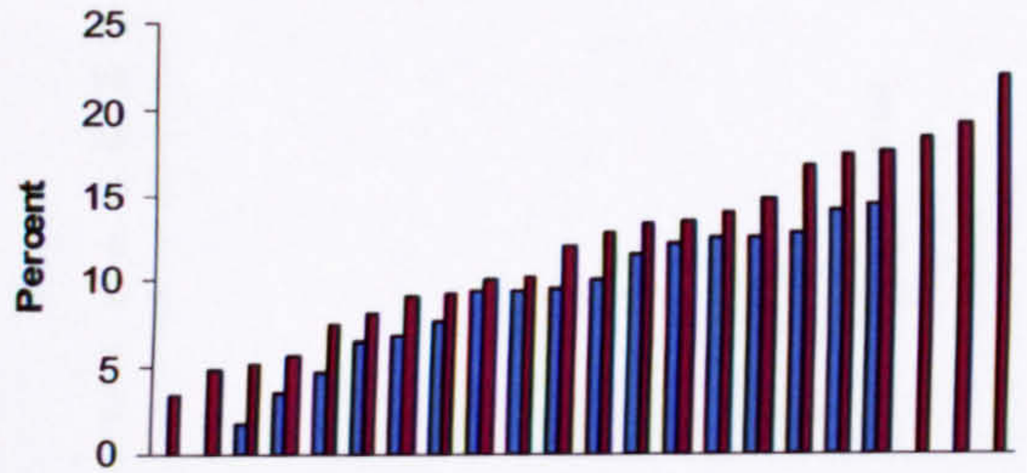
b) Score 1 to score 2



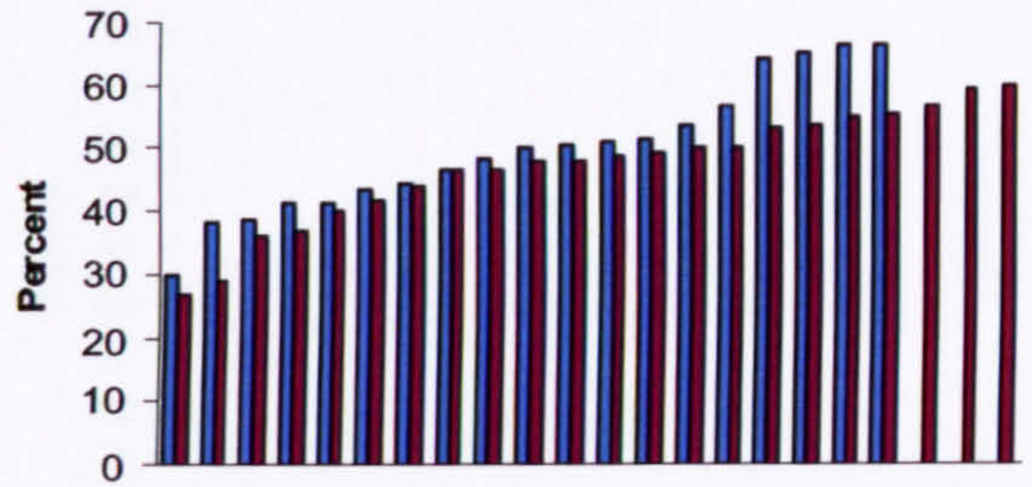
c) Score 1 to score 3



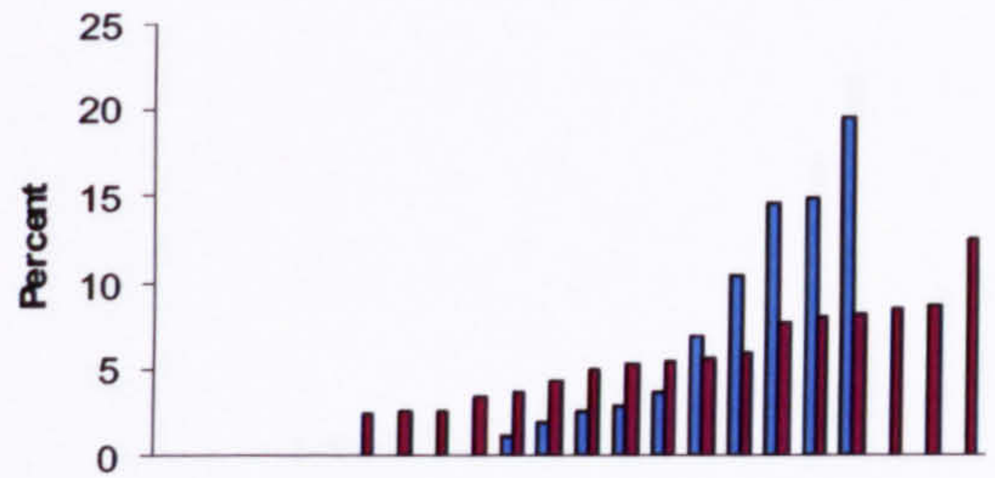
d) Score 2 to score 1



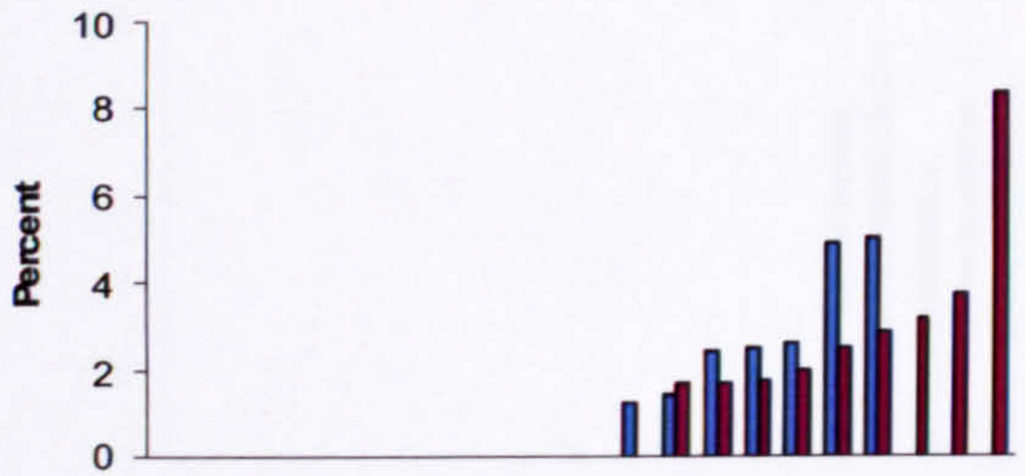
e) Remaining score 2



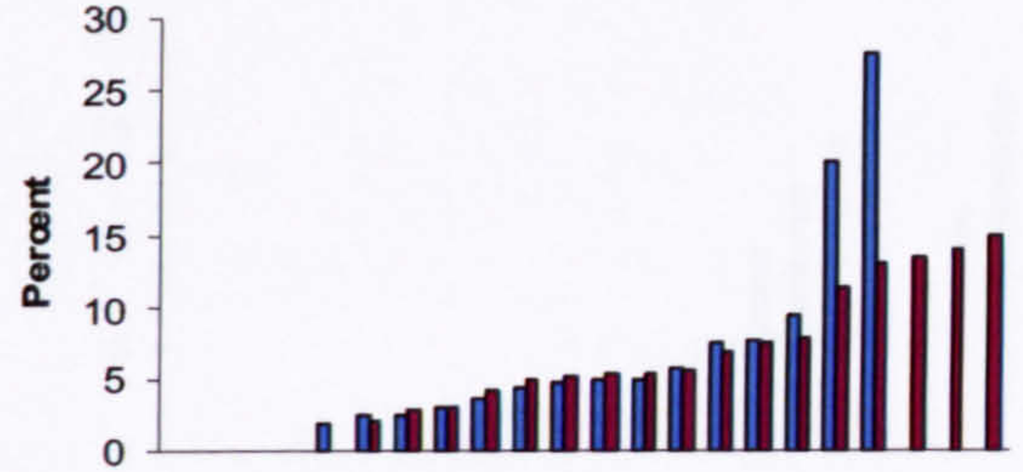
f) Score 2 to score 3



g) Score 3 to score 1



h) Score 3 to score 2



i) Remaining score 3

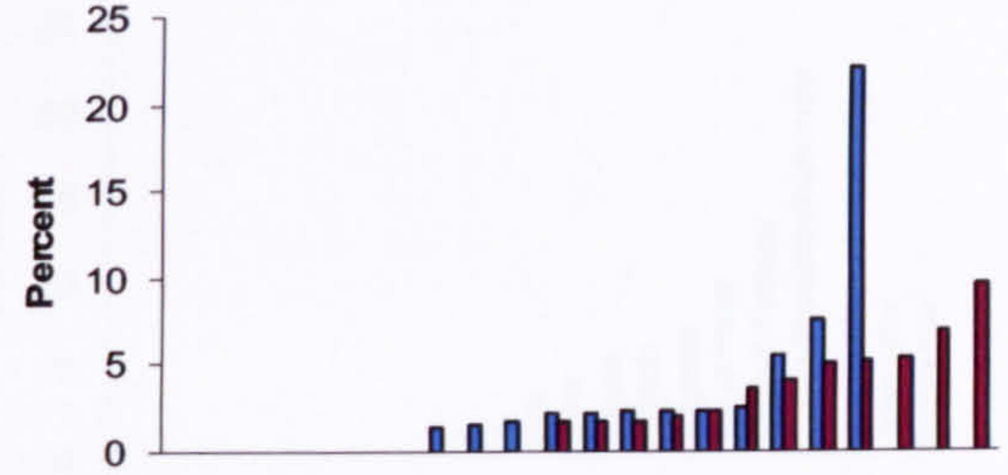
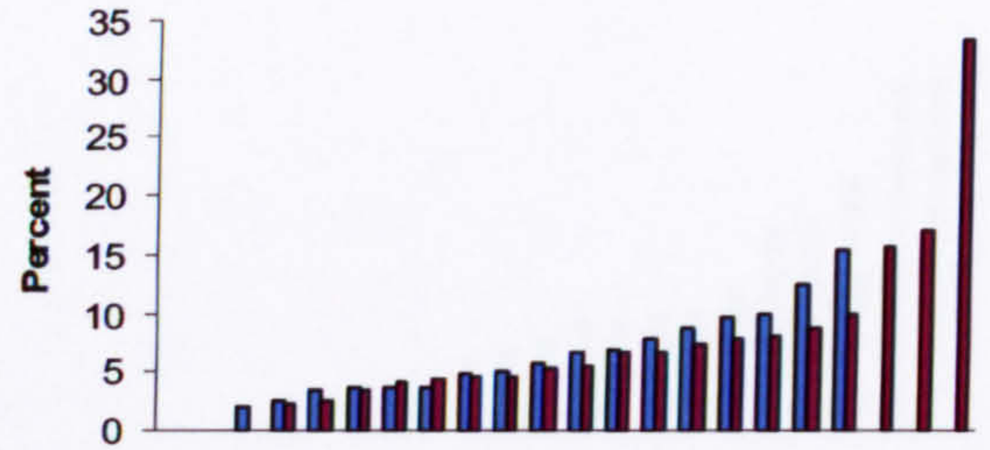
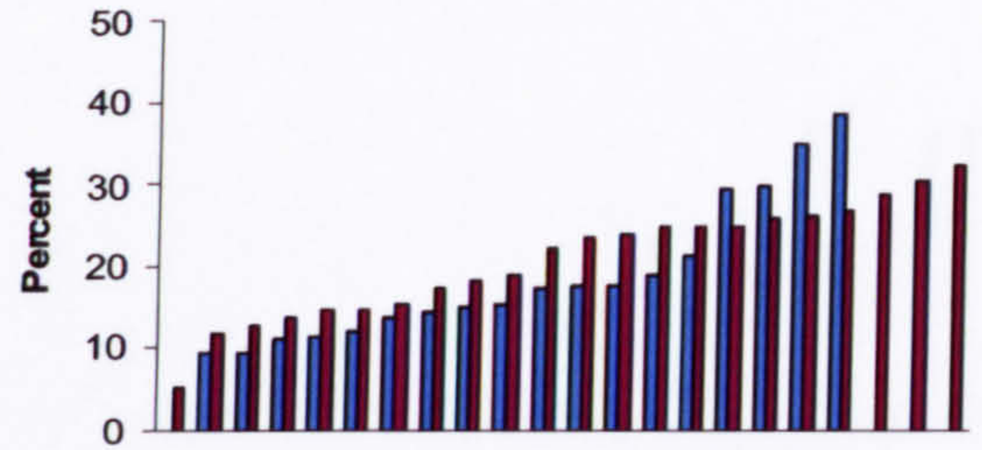


Figure 6.16 Percentage of cows per farm with each locomotion score combination between visits 6 and 7 (control=blue, intervention=red)

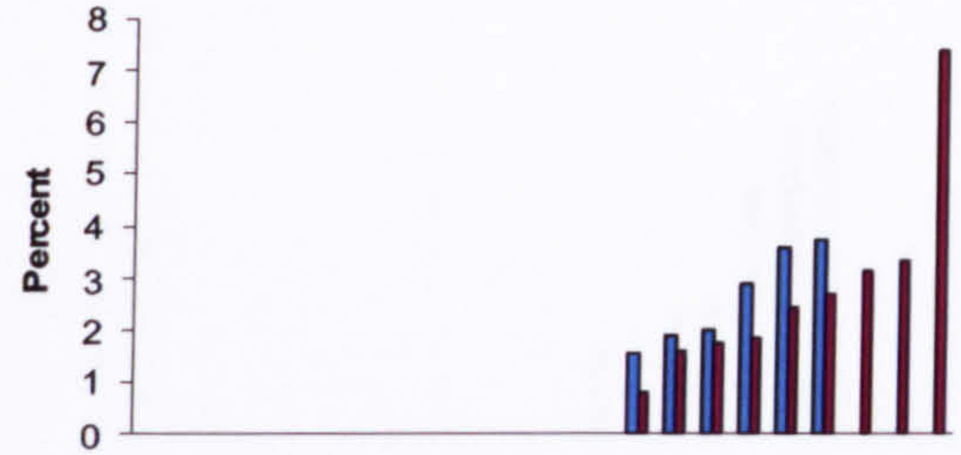
a) Remaining score 1



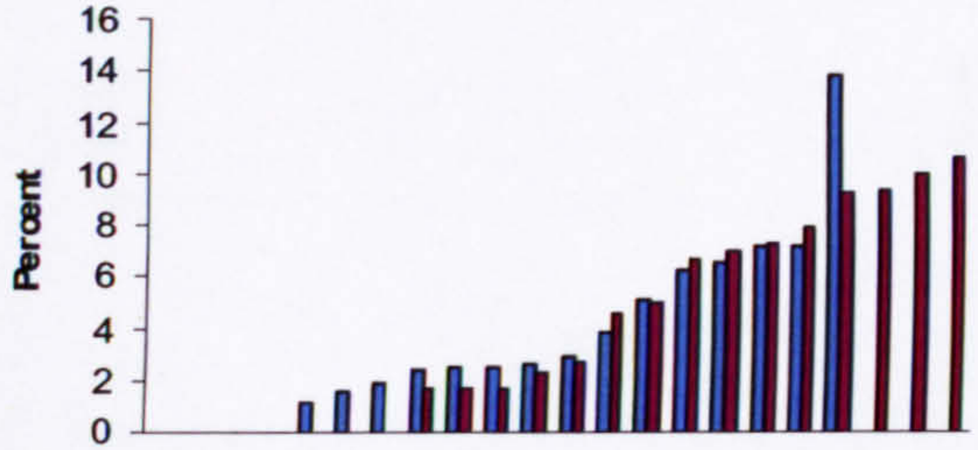
b) Score 1 to score 2



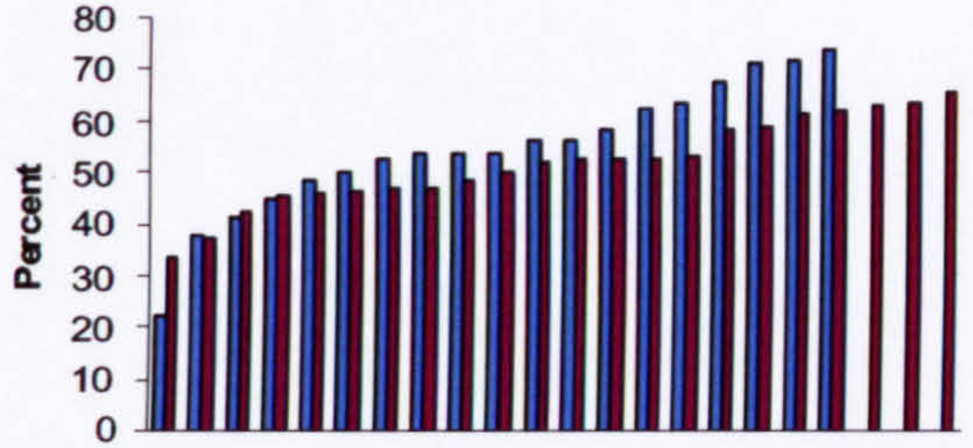
c) Score 1 to score 3



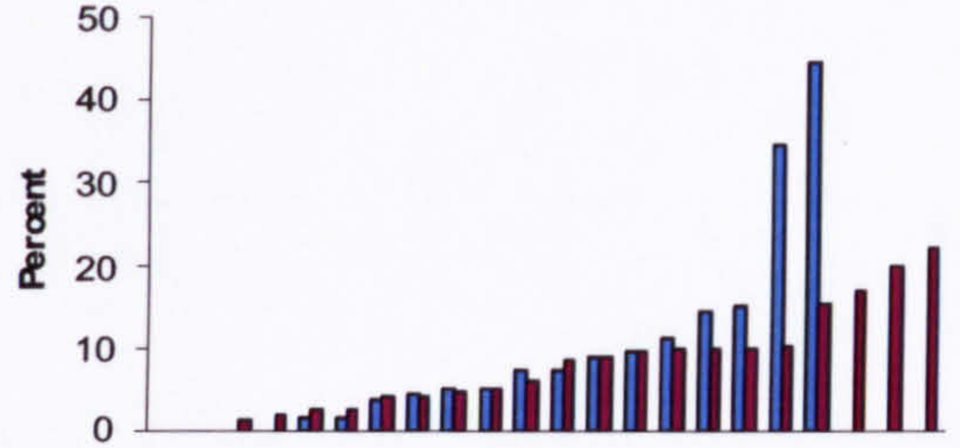
d) Score 2 to score 1



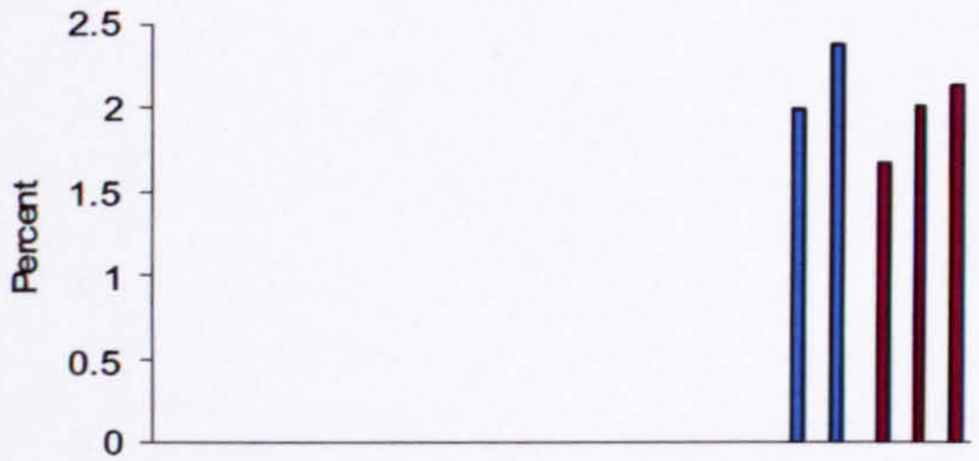
e) Remaining score 2



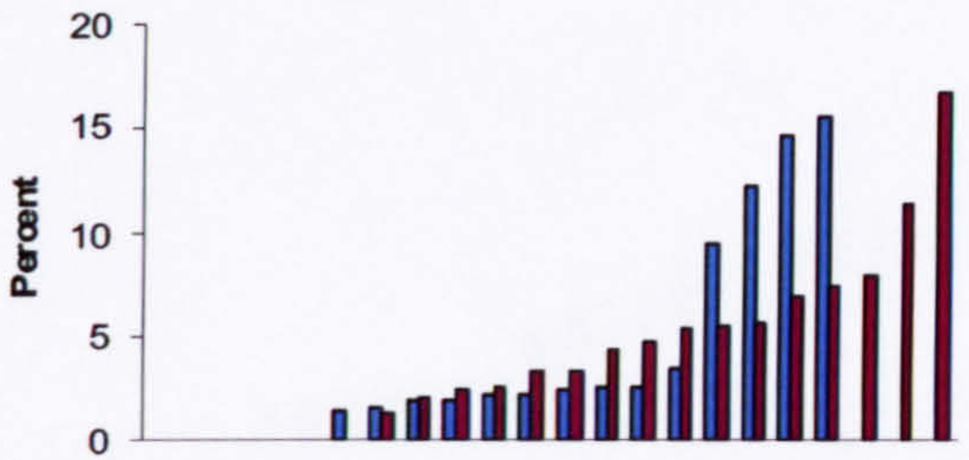
f) Score 2 to score 3



g) Score 3 to score 1



h) Score 3 to score 2



i) Remaining score 3

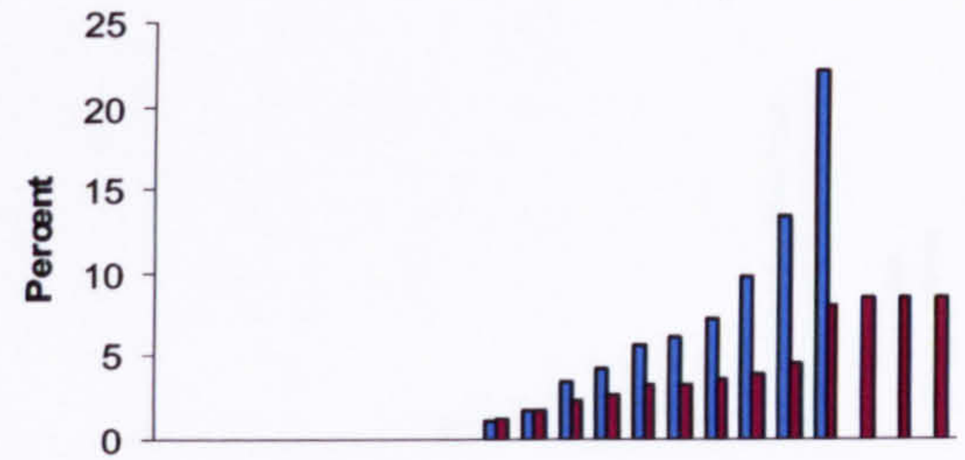
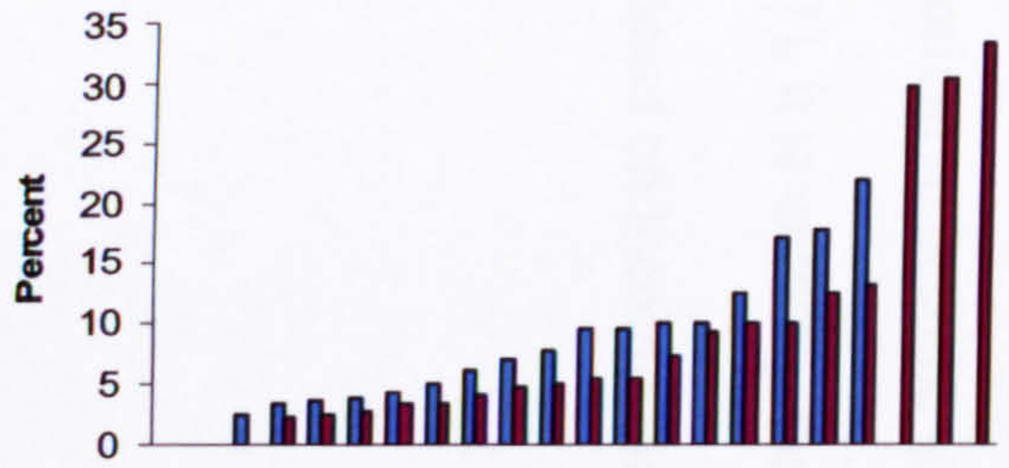
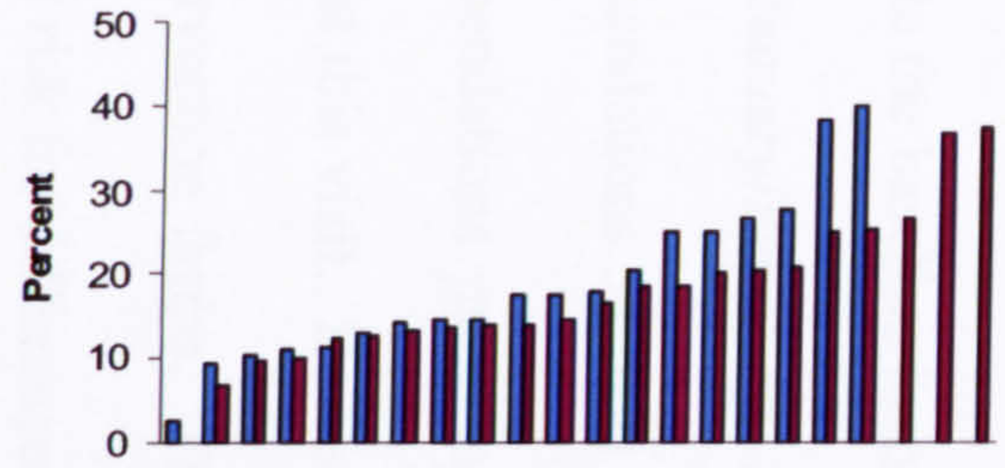


Figure 6.17 Percentage of cows per farm with each locomotion score combination between visits 5 and 7 (control=blue, intervention=red)

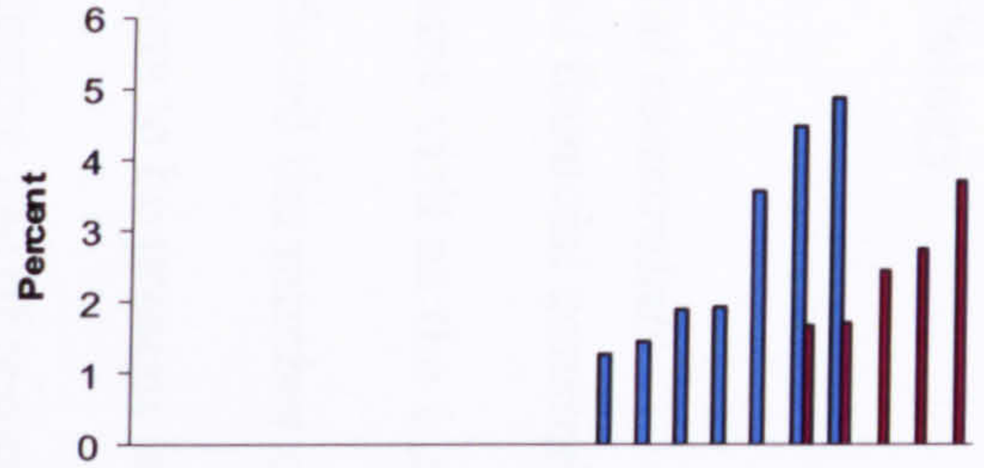
a) Remaining score 1



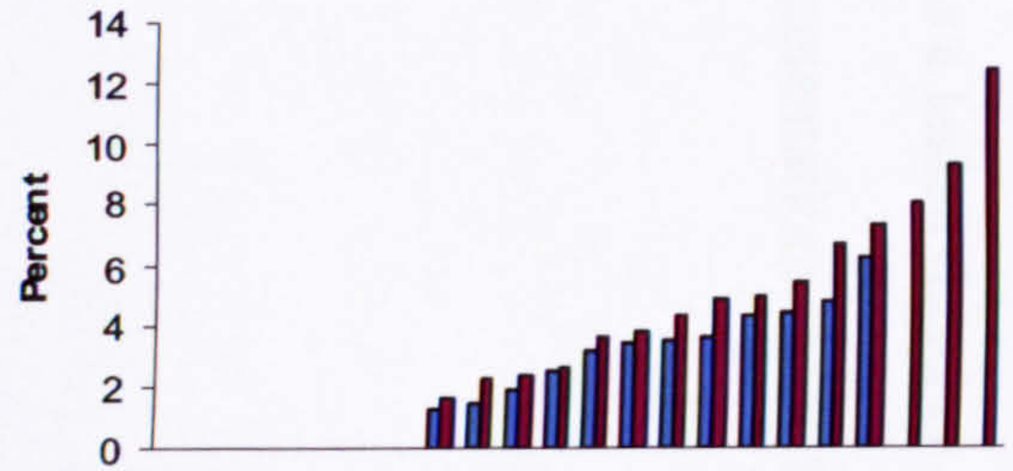
b) Score 1 to score 2



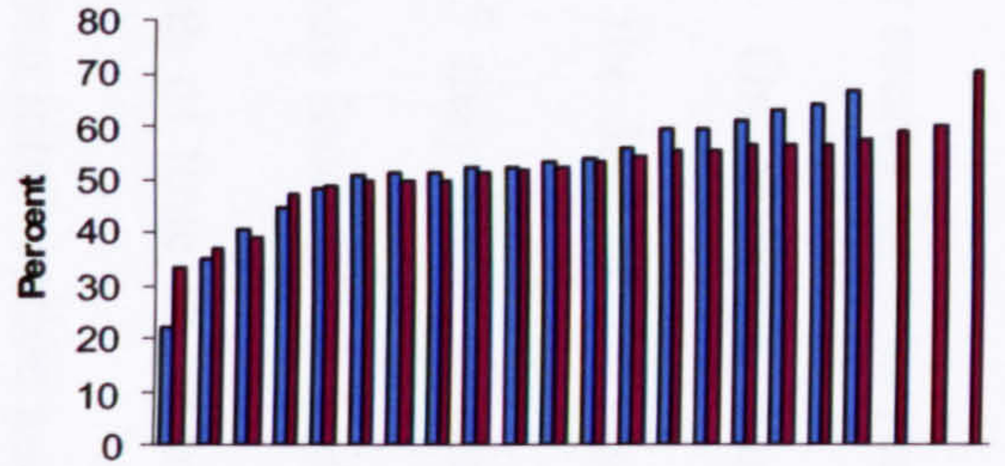
c) Score 1 to score 3



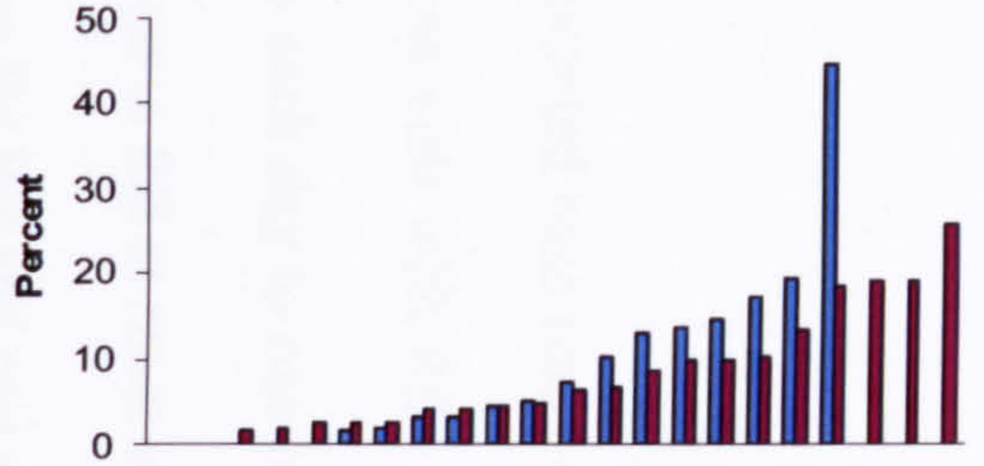
d) Score 2 to score 1



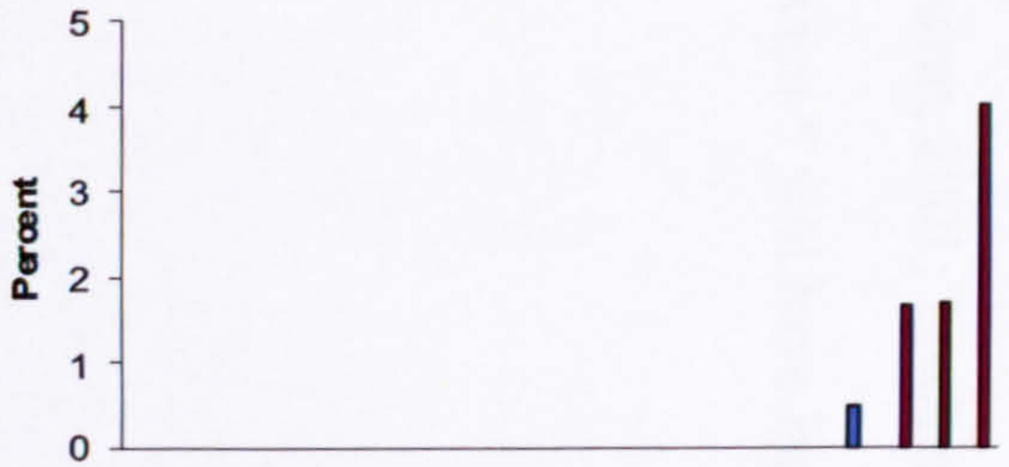
e) Remaining score 2



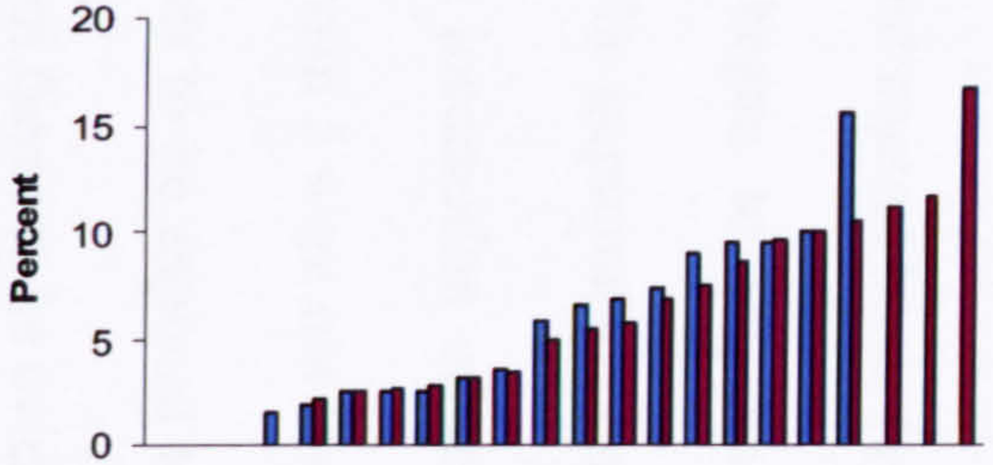
f) Score 2 to score 3



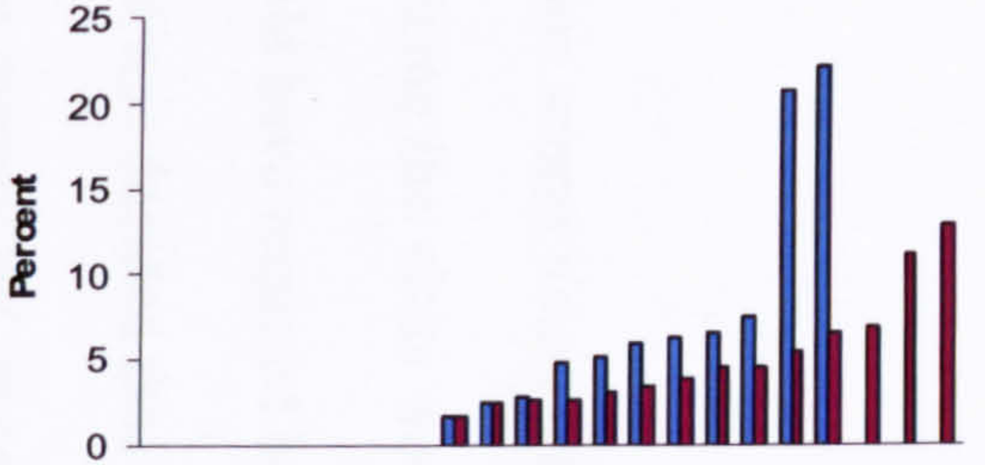
g) Score 3 to score 1



h) Score 3 to score 2



i) Remaining score 3



Discussion

Methodology

Logistical constraints

Time and financial constraints prevented base line locomotion scores being taken at the same visit as the intervention visit with RB. Combining the visits would have reduced the number of visits each day to one but would have required both researchers to be present in addition to RB at most visits. It was decided that the most effective use of resources was for RB and one recorder, mainly JW, to carry out intervention visits in November and December 2004 and for both recorders to complete the baseline locomotion scores for intervention and control herds (visit 5) in January/February 2005. On average, farmers began to implement recommendations 58 days before the date of the visit 5. The implementation of recommendations prior to visit 5 may have affected the locomotion of cows scored at this visit. However, mean locomotion scores at visit 5 were not lower for intervention farms. The length of time an animal needs to be exposed to a reduced risk for differences between intervention and control farms to be evident is unknown. However, given that it takes around two to three months for damage to the corium to become visible as a lesion (Lischer and Ossent, 2001; Lischer et al., 2001), it is unlikely that implementations made before visit 5 will have had a large impact on locomotion.

Using an expert

Using RB in combination with a researcher allowed us to take advantage of the experience and knowledge of a practicing veterinarian whilst the presence of an experienced researcher ensured the visits were standardised. RB was successful at communicating new ideas to dairy farmers. However, as RB was not used to working to a formal visit structure, it was necessary for the researchers to remind RB to take measurements rather than visual assessments and also to ensure all recommendation areas were covered on all farms. A small number of measurements were missed where no recommendation had been given to the farmer; these were recorded at visit 5 by the researchers to complete the data set.

Prior to the intervention visits the standard recommendation for feed space per cow was agreed at 0.8m/cow. However during the visits RB suggested that 0.6m/cow was adequate and made recommendations to farms with feed space less than 0.6m/cow. Although recommendations were not made to those farms with a feed space per cow of between 0.6 and 0.8m this is unlikely to have impacted on the results given that of seven recommendations to increase feed space only one farmer did so.

Uptake of interventions

Higher completion of interventions was achieved in footbathing, other, and socialisation and integration target areas. Farmers also responded with a higher proportion of 'yes' and lower proportion of 'no' answers for these target areas. This is probably because a greater number of the recommendations made under

these target areas involved management changes, nutrition changes or small "one off" jobs. Large structural changes were major hurdles to implementing changes due to the large financial investment required. Such recommendations almost always elicited a 'no' response from the farmer. Unless improvements had already been planned, farmers were unwilling to consider such changes within the time scale of the project. Many farmers expressed a desire to renew their facilities if the funds were available. However, the current economic situation in UK dairying prohibits investment for many farmers.

Farm variation

Interpretation of the results is complicated by the amount of variation between individual farms. In both control and intervention groups there were farms with large improvements in locomotion scores and rates of lesions. There were also farms where locomotion and rates of lesions deteriorated in both groups. This variation may be partially explained by the number, type and potential impact of the recommendations implemented. Farmers in the intervention group usually selected those recommendations that were cheapest and easiest to implement regardless of the likely impact of the recommendation. Therefore the success for individual farmers may have been affected by their choice of interventions. Although control farms were not given recommendations they were not prevented from making changes on their farms which may have affected lameness. This may explain some of the variation in locomotion scores and lesion rates on control farms.

Effect of interventions on lameness and rates of lesions

The incidence of sole ulcer was lower for intervention than control farms. The following recommendations aimed at reducing sole ulcer were implemented by farmers: increasing the quantity of bedding material, addition of a brisket board to improve the lying position of cows in cubicles, increasing feed space, reducing the time cows stand for milking and changes to diet, especially in the transition period. Further investigation is required into the effect each of these recommendations on incidence of sole ulcer on individual farms. Milk loss associated with sole ulcer is around 560kg per cow per lactation (Amory et al., submitted). It is necessary to calculate whether the reduced milk loss and treatment cost associated with these small reductions in sole ulcer incidence justify the cost of implementing the recommendations.

Comparison of the control and intervention groups did not reveal a clear reduction in the rate of white line disease associated with interventions. However, there was some evidence that interventions may be affecting the rate of white line disease at the individual farm level. A greater level of compliance may be required to reduce the incidence of white line disease than for sole ulcer. The hypothesised risks for white line disease are largely exposure to noxious stimuli such as an area of poor quality floor. If one such hazard for white line disease on a farm is eliminated but a second is still present then there is still a risk to every cow. However, the incidence of sole ulcer is affected by factors which either force cows to stand or prevent them from lying down. Removing one of these restrictions would reduce standing time by a certain amount reducing the risk by a small amount. Removing a second restriction would

reduce standing time further and reduce the risk of sole ulcer further. Impatient handling of cows by the farmer is an important risk for lameness (Chesterton et al., 1989; Clackson and Ward, 1991). When handled patiently cows avoid hazards in their path, therefore the risk from a poor floor surface is reduced. The unmeasured variation in the handling of cows on different farms may further explain the lack of association between the incidence of white line disease and implementation of interventions. Finally it must also be considered that the recommendations made to farmers were incorrect or at least not the major risks. For example, in the multi-level modelling grooved flooring was associated with increased odds for white line disease and other lesions. Perhaps this suggests that grooving slippery floor surfaces is not cost effective and it is more beneficial to recommend replacing such floors.

The incidence of digital dermatitis decreased for farms in both the control and intervention groups. A similar decrease was reported by Laven, (2006). The reduction in digital dermatitis may be because farmers in general are more aware of digital dermatitis and their treatment strategies have improved. A second explanation is that digital dermatitis is endemic on many farms and controlled using whole herd treatments. Where more treatments are made at the herd level fewer treatments are made at the individual cow level. Reporting of digital dermatitis treatments may therefore be reduced. The incidence of digital dermatitis is lower for farms in the intervention group than the control after the recommendations were made to farmers. However, this followed a very low incidence of digital dermatitis in the summer months prior to intervention which may have reduced the disease challenge during the winter. The incidence of

digital dermatitis did not differ between control and intervention farms in the final three months of the study. Uptake in the footbathing and lameness control target area was third highest. However, there was only moderate uptake of the main digital dermatitis control strategies (increased footbathing, 22%; treat and bandage open lesion, 33%) despite their relatively low cost. It is also possible that the footbathing procedures were not optimal for example frequency was less than stated by the farmer or the reagents were not accurately measured. Again, the possibility that the recommendations were incorrect must be considered. But the rates of treatment were so low that differences between the groups were not obvious.

The mean locomotion score and percentage of severely lame cows were lower in herds in the intervention group after intervention than before. There was also a general trend towards a greater number of cows on the intervention farms with locomotion score improving to a score 1 and fewer increasing to score 3. It is probable that the improved locomotion scores resulted from a lower incidence of sole ulcer. These small improvements in overall locomotion indicate that implementation of recommendations may be beneficial and require further investigation.

Future analyses

The five target areas for intervention were based on the hypothesised aetiologies of sole ulcer, white line disease and digital dermatitis. The effect of recommendations made under each target area on locomotion and incidence of

lesions causing lameness are to be investigated. Where a number of farmers implemented a specific recommendation (e.g. increased quantity of bedding, reduced standing time at milking, increased footbathing frequency) the effect on locomotion and lesions will also be investigated. A small number of farmers in the control group made interventions on their farms. The effect of making one or more interventions on the farm will analysed irrespective of treatment group. The data will also be analysed in terms of the proportion of interventions implemented by each farmer to investigate any potential threshold effect. Finally the effect of intervening on risk factors on the locomotion and lesion incidence of first lactation cows will be investigated because cows which have suffered a previous lesions event are predisposed to lesion in subsequent lactations (Hirst et al., 2002).

Conclusions

Although there was evidence for a small reduction in incidence of sole ulcer and improved locomotion score, it was not possible to demonstrate a successful strategy for the overall control of lameness. The multi-factorial nature of lameness means that lameness control strategies must also be complex. It may be that significant reductions in the incidence of claw lesions and lameness may only be achieved if a high proportion of the risk factors are eliminated. Methods of increasing the compliance of farmers are therefore essential to differentiate poor strategy from poor uptake.

Chapter 7

General Discussion

Introduction

This aim of this study was to increase our current understanding of management risk factors for lameness in dairy cows and to identify relationships between risk factors and lesion specific causes of lameness. This was successful. The relationships between poor locomotion, lesions causing lameness and management risks measured were estimated and some clear associations were identified. A second aim was to test whether implementation of changes in known risk factors would reduce the prevalence of lameness using the same outcomes as above on commercial dairy farms. There was some success in this part of the project and interesting hypotheses arose from it.

Relationships of lameness, lesions and risk factors

Figure 7.1 is a flow diagram which highlights the relationships between known associations from this thesis (chapters 4 and 5) and hypothesised associations also included in the intervention study (chapter 6). The static risks are confounders that we know are associated with locomotion and lesions causing lameness but that are also a necessary part of the system. They do not confound all outcomes and management risks and so may assist in understanding the biology of these processes.

The associations illustrated in Figure 7.1 are clearly complex. The target areas within which interventions were made (chapter 6) are included in Figure 7.2. These illustrate the hypothesised associations. Standing time and cow flow target area is linked with the circuit of association between sole ulcers, poor locomotion and sparse bedding.

Intervening to reduce lameness

The initial findings from the intervention study suggest it may be possible to intervene on dairy farms to reduce the incidence of sole ulcers. Intervention strategies for lowering sole ulcers were aimed at reducing the time cows spent standing through reduced queuing and improved cow flow and through improved bedding comfort. The area that farmers implemented most was decreasing the standing time around milking followed by increasing the quantity of bedding used.

There was no apparent reduction in digital dermatitis or white line disease lameness in the intervention study. The hypotheses used to intervene to reduce these lesions were based on current knowledge. The lack of success could have occurred because of failure of farmers to implement changes, lack of power in the study, lack of time to see an effect or because the wrong interventions were suggested. The results from the models of risk factors for white line disease and digital dermatitis were not available when the intervention study started. These lesion specific models highlight that very few of the measured management factors appeared to influence either of these lesions. However, the recommendation to groove concrete would have been amended to recommend

resurfacing concrete in preference to grooving. Stronger emphasis would also have been placed on the quantity of bedding in cubicle beds.

A greater understanding of the risk factors associated with these lesions is required in order to develop a more successful control strategy. However, the lack of apparent association between the incidence of white line disease in cattle and mean farm locomotion score (chapter 3) may indicate that white line disease *per se* does not cause raised lameness on farms. This is a confusing finding; one explanation is that only severe cases of white line disease cause lameness and that an improvement in the case definition is required. The incidence of digital dermatitis is also likely to be underestimated since only lame cows were observed and many non-lame cows will have clinical signs of digital dermatitis. Analysis of the locomotion scores of individually identified cows and their subsequent treatments for lameness may demonstrate whether or when farmers treated lame cows and whether treatment improved locomotion score. For example, there may have been a lower proportion of cows becoming lame for the first time on intervention farms. This may be confounded by older cows predisposed to lameness due to lameness in the previous lactation (Hirst et al, 2002; chapter 5). Analysis of the effect of intervention on the prevalence and incidence of lameness in first lactation cattle is therefore also a likely further useful exploration.

Once we are sure we have the correct recommendations an improved uptake of interventions is almost certainly also required to reduce the prevalence of lameness and incidence the of claw lesions.

No previous studies have intervened on all types of lameness across a wide range of farms. The study design allowed the use of farm specific recommendations for multiple causes of lameness and is similar to that used by Green et al., (2007) to intervene on mastitis managements. Where a clinical trial is directed at a single risk greater effort may be made by the farmer in that area. However, if a number of other risks remain unchanged then this will fail to produce significant results if there is a threshold effect (i.e. several factors synergistically reduce lameness where one single factor may not). The study allowed the farmer to make a number of recommendations and therefore test of a threshold effect. Exploring this analytically is highly challenging but worthy of further investigation.

Possible shortcomings of the study

It was accepted at the beginning of the study that the recording of lesions by farmers was likely to underestimate the incidence of lesions causing lameness. This method of recording may be unsuitable for estimating the incidence of digital dermatitis. The use of whole herd treatments means that many individual treatments are not recorded. Regular assessments of the prevalence of digital dermatitis as cows are being milked in the parlour may have been more suitable.

The simple three point locomotion scoring system used did not distinguish between cows with no gait asymmetry and cows with an obvious limp as both could walk with an arched back. The proportion of cows with score two and three may overestimate the prevalence of lameness while the proportion of score

three cows only gives the prevalence of severely lame cows. Observer drift was not estimated. It is possible that locomotion score changed with time during the study.

The constraints on time had two main impacts on the study. Firstly, the intervention study started before the completion of the analysis of risk factors for claw lesions. Secondly, too little time was available to monitor the effects of interventions.

Conclusions

This thesis has contributed to our understanding of the risks factors associated with an increased prevalence of lameness and incidence of sole ulcer. From this study we propose that reduction in the occurrence of sole ulcer is possible and that reduced standing and increased cow comfort are key to this reduction. We propose that white line disease and digital dermatitis have different causal pathways that are as yet unclear. It is particularly interesting that studies have repeatedly failed to identify very clear risks for white line disease, yet it remains a common pathology. We hypothesise that one explanation is that white line disease may not be the underlying cause of lameness or may be over diagnosed. Digital dermatitis is an infectious condition and its infectious non-linear behaviour may indicate that management has only a small role to play in disease in infected herds. It may therefore be possible to develop successful control programmes for the reduction of lameness attributable to sole ulcer. To develop control programme for white line disease and digital dermatitis a greater understanding of the risk factors and their causality is required.

Figure 7.1 Schematic diagram of measured and hypothesised risk for poor locomotion and claw lesions in dairy cows

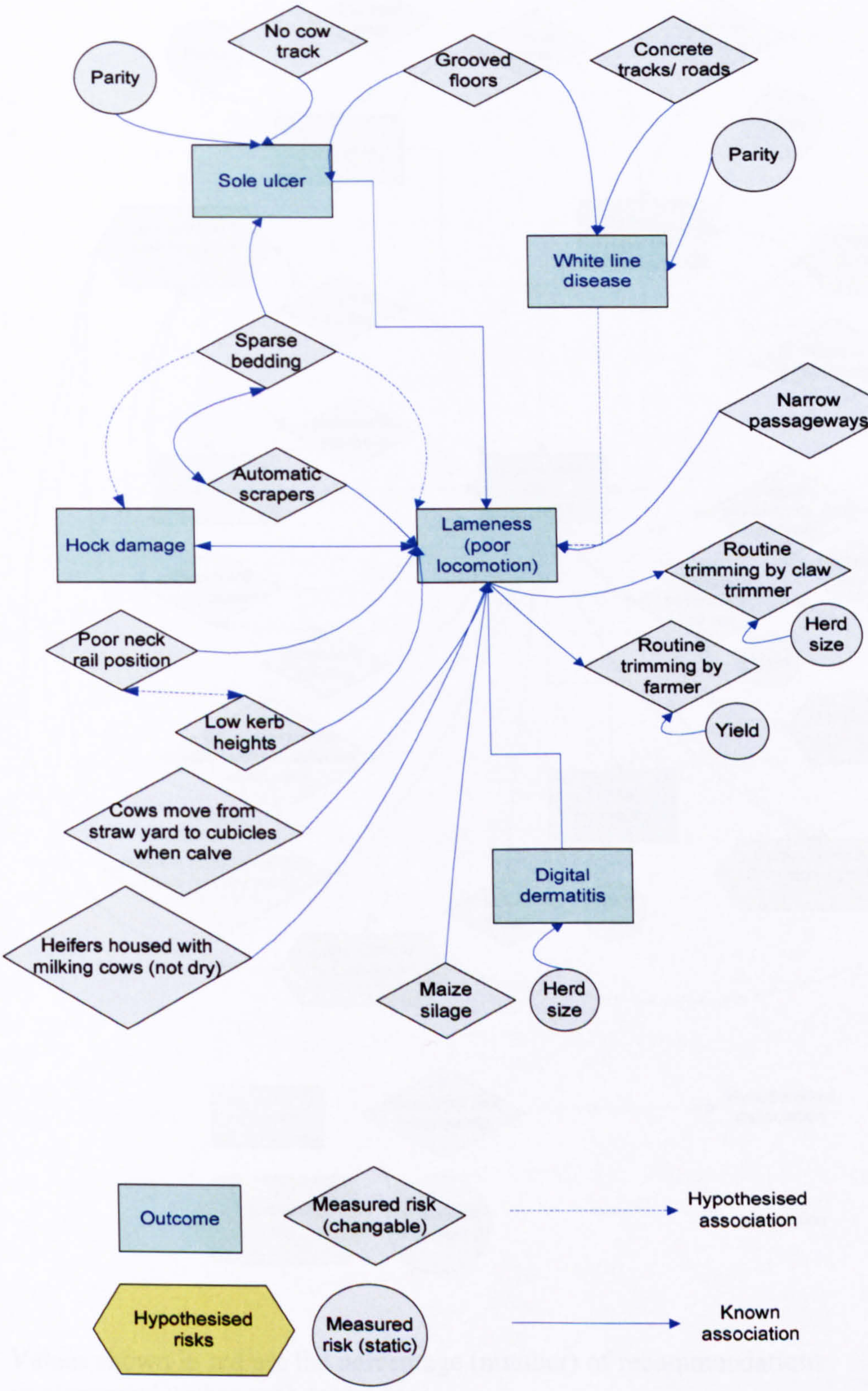
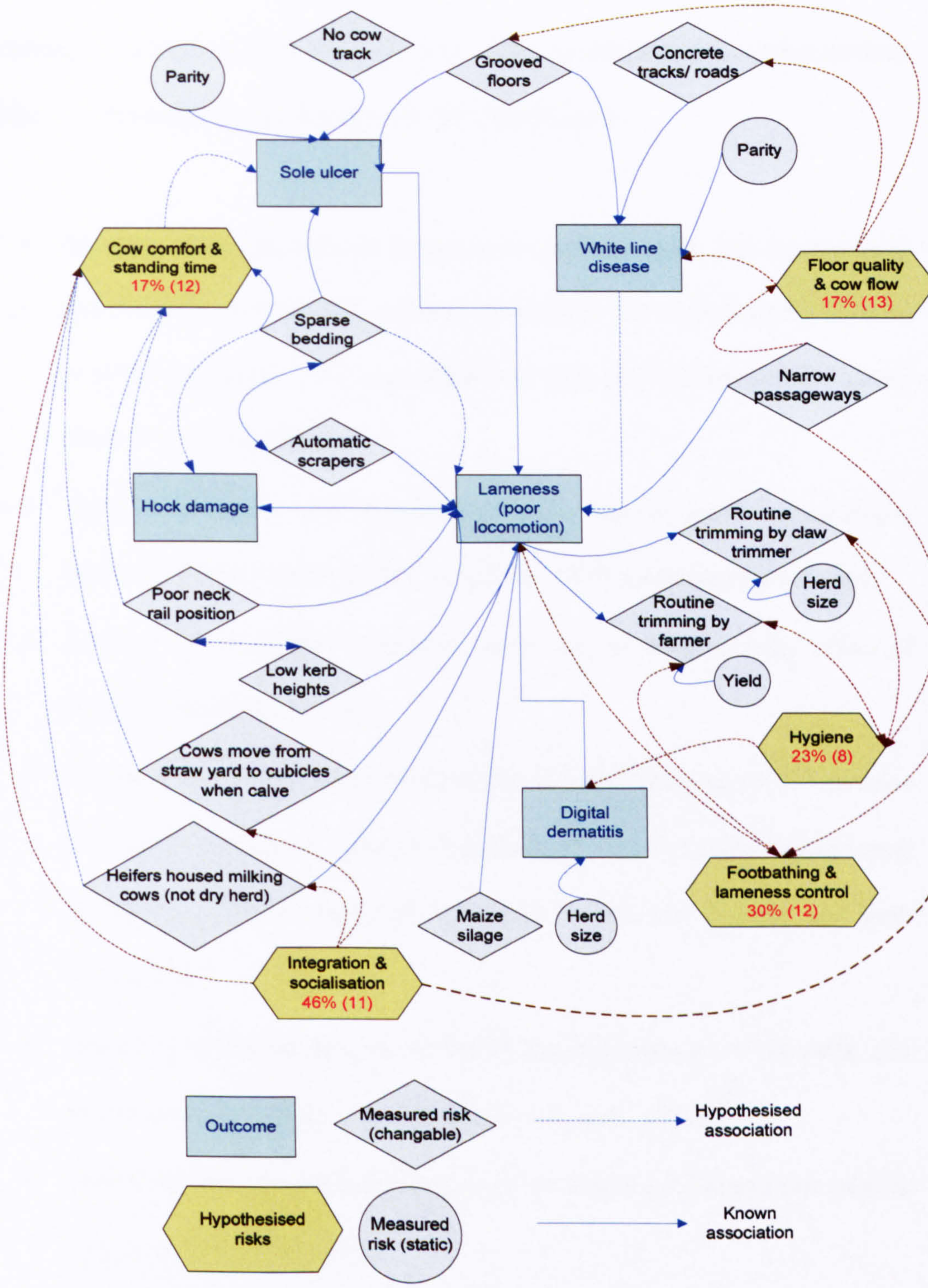


Figure 7.2 Schematic diagram of measured and hypothesised risks for poor locomotion and claw lesions and target areas for intervention in dairy cows



Values shown in red are the percentage (number) of recommendations implemented within each target area

Future work

Continued analysis of this data set may help to develop our understanding further. Considerations for future work are stated below.

- Analysis of the association between locomotion score and treatment of lesions at the cow level is required to quantify the time takes by farmers to treat lame cows. The same data may also provide information about lameness recovery time.
- Analysis of lesion and locomotion score data to assess associations between different types of claw lesion and different locomotion scores.
- Analysis of cow level locomotion score data to determine the effect of parity on locomotion score.
- Examination of the lesions not recorded as the primary cause of lameness to identify whether a common misdiagnosis of white line disease may explain the lack of association between white line disease and poor locomotion.
- Identify associations between different lesions occurring in the same cow and examine the progressions of different lesions with time.
- Determine the effect of intervention on locomotion score and rate of claw lesions in first parity animal.
- Analysis of data on cows with multiple parities from the time of first calving to identify predisposing factors for lameness such as previous lameness events and milk yields.

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APPENDIX A: FIRST FARMER RECRUITMENT LETTER

LAMECOW – an EU funded project to reduce lameness in dairy cows

Dear Sir / Madam 15/1/2003

A couple of years ago you kindly helped us with a project looking at the impact of low cell counts in cows and their associations with mastitis. You were one of 500 farmers who recorded cases of mastitis throughout one year. We really appreciate your commitment to doing this.

We are asking for your help again. Lameness is another serious problem in dairy cows causing milk loss and early culling. The EU has recently funded a partnership of researchers to study lameness in dairy cows and to design 'Best Practice', a scheme with recommendations to reduce lameness in dairy cows.

With this in mind we would like to ask you to record all cases of lameness that you have in your herd (pregnant heifers, milking cows and dry cows) over the next year, starting on 1st February 2003, on the attached forms. At the end of the year we will send you a questionnaire asking about the management of your cows.

Also, if you trim your cows' feet routinely e.g. at drying off, we ask that you record what you or your foot trimmer see on these forms. As with the mastitis study we will send you new forms every 2 – 3 months and ask that you send in completed forms in the enclosed stamped return address envelope.

At the end of the year (allowing a few months for analysis of data) we will send you a report of how much lameness and of what type you had in your herd and a summary of all the farm results combined to show how your herd compares.

At a later date we will send you our findings of which management practices reduced lameness most. All results will of course be anonymous and no-one will trace results to your farm.

Finally, we are recruiting 60 farms that we will visit 3 – 4 times over the next year. We would like these farmers to come and spend one day with Roger Blowey to have a training session on foot trimming and recognising lesions. You are invited to participate as one of these 60 farms.

If you are interested in being one of the 60 farms we ask you to

- record lame cows
- record foot trimmed cows
- allow US to visit you so that we can
    - record the locomotion of your cows
    - record the environment
    - ask you about your management at the first visit
    - ask you about changes in management at subsequent visits.

You will be part of a study that is also occurring in The Netherlands, Germany, and Poland. At the end of the study we aim to minimise lameness in dairy cows throughout Europe.

Your support of this project is invaluable. We are looking to enrol all herds, whether or not you have a problem with lame cows at the moment.

Please will you complete the attached form if you do NOT wish to be involved in this study at all or if you would like to attend the training day. If we do not hear from you we will assume that you will record lameness on the attached forms.

We will send you the next set of forms in March.

Should you need more forms, please photocopy or contact Dr Laura Green who will send you more.

Please contact me using the details below if you have any queries.

With many thanks

Yours sincerely

Laura Green BVSc MSc PhD MRCVS

Jonathan Amory BSc MSc PhD

Tel: 024 765 23797
Fax: 024 765 24619
Email: laura.green@warwick.ac.uk

See our website at

http://www.abdn.ac.uk/~agf102/Lamecow/

LAMECOW – an EU funded project to reduce lameness in dairy cows

I am NOT interested in participating in this study

I am interested in attending the one day meeting with Roger Blowey and participating as one of the 60 farms in this study.

Please circle as appropriate

Are your address details correct? Yes No

Please amend any errors

LAMECOW – an EU funded project to reduce lameness in dairy cows

Dear Sir / Madam 24/2/2003

Thank you very much for participating in our study for the first month. The study is also progressing in Germany, The Netherlands and Poland.

Please find enclosed the new set of forms for recording the lesions and a stamped, addressed envelope for returning those you have used already. If you have had no cases of lameness in the past month could you still return one of the blank forms and indicate on it that you have had no lame cows this month.

You will also find enclosed a colour atlas of the different lesions that may help you to identify the lesions you see.

Finally, please find enclosed a form regarding the training events with Roger Blowey. Could you please tick the appropriate box to say which evening you would prefer to attend and put this in the stamped, addressed envelope provided along with any completed lesion recording forms. We have put a section on this form so that you can give us more immediate contact details, such as telephone numbers, email or fax and also some information regarding the size of your herd and your expected turnout date. This information will be very useful for us to coordinate your farm visit, which will be in March/April.

Should you need more forms, please photocopy or contact Dr Jon Amory who will send you more.

Please don't hesitate to contact us using the details below if you have any queries.

With many thanks

Yours sincerely

Laura Green BVSc MSc PhD MRCVS

Jonathan Amory BSc MSc PhD

Tel: 024 765 28368
Fax: 024 765 24619
Email: jonathan.amory@warwick.ac.uk

See our website at: http://www.abdn.ac.uk/~agf102/Lamecow/

LAMECOW – an EU funded project to reduce lameness in dairy cows

Training event with Roger Blowey

"A practical session on the recognition and treatment of cattle foot conditions" 6-9pm – *first foot lifted at 6.05pm!!*

(Protective clothing and clean boots must be worn)

I am not interested in a training event with Roger Blowey ☐

I would like to attend the following training event:

Date	Venue	(✓)
Thursday 1st May 2003	Hartpury College, nr. Gloucester	☐
Thursday 8th May 2003	Myerscough College, nr. Preston	☐
Friday 9th May 2003	Reaseheath College, nr. Nantwich	☐
Wednesday 28th May 2003	Seale-Hayne Agricultural College, nr Newton-Abbott	☐
Thursday 29th May 2003	Seale-Hayne Agricultural College, nr Newton-Abbott	☐

Your contact details

Telephone numbers: (day)_____
(evening)_____
(mobile)_____

Best time to call:_____

Fax number:_____
Email address:_____

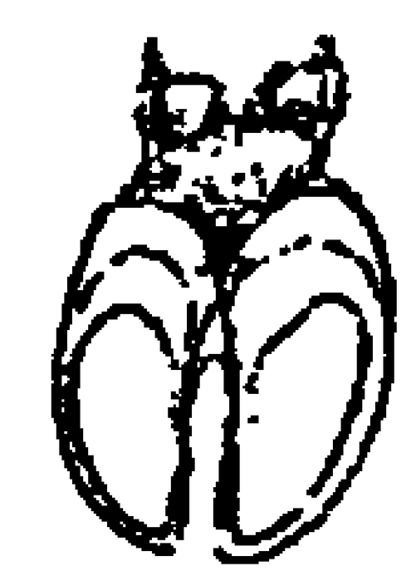
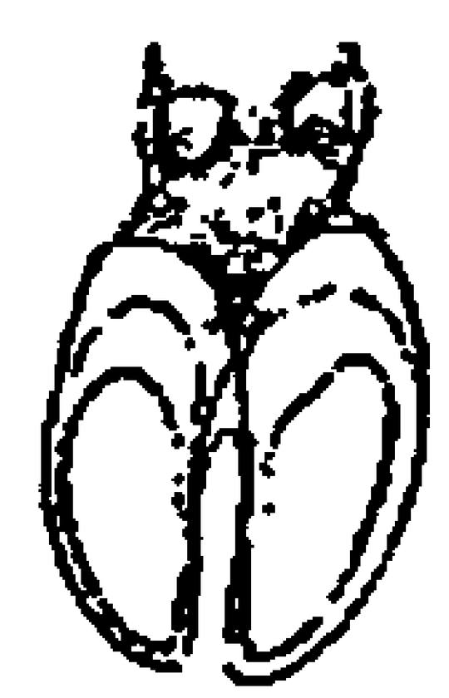
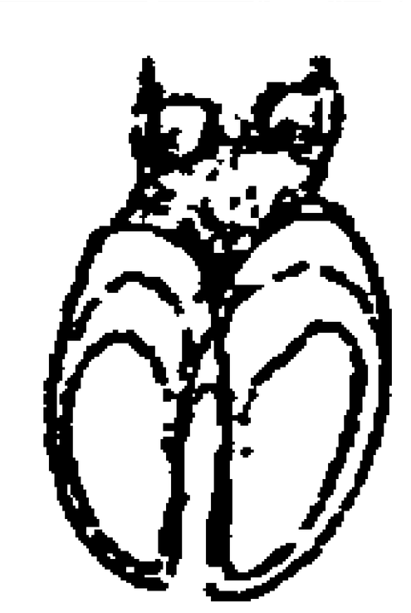
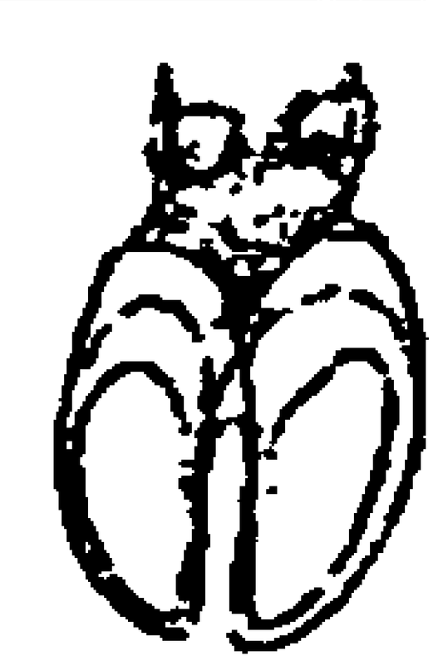
FARM INFORMATION

Please could you tell us:
your total number of milking cows at the moment:_____
the expected first day that your cows will be at grass (even just daytime):

(best guess!) _____

APPENDIX C: LESION RECORDING FORM

Name: ____________ **Farm:** ____________ **Postcode:** ____________

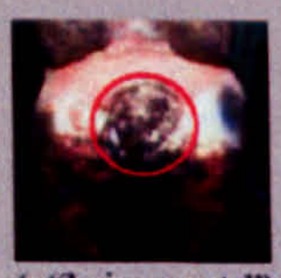
Cow number/ identity	Site of lesion (place a cross)	Foot affected (circle one only)	Lame (circle one)	Lesions seen (circle all appropriate, star * cause)	Date today (dd/mm/yy)	Calving Date (dd/mm/yy)	Lactation No.	Who trimmed foot (circle all appropriate)	Treatment given (if antibiotics given please state dose)	No of Repeat Treat-ments
		LF RF LH RH	Sound Not sound Definitely lame Hobbling	Sole ulcer White line Digital dermatitis Foul Other (please state)				Farmer Foot Trimmer Vet	*e.g. trim, excenol, block*	
		LF RF LH RH	Sound Not sound Definitely lame Hobbling	Sole ulcer White line Digital dermatitis Foul Other (please state)				Farmer Foot Trimmer Vet		
		LF RF LH RH	Sound Not sound Definitely lame Hobbling	Sole ulcer White line Digital dermatitis Foul Other (please state)				Farmer Foot Trimmer Vet		
		LF RF LH RH	Sound Not sound Definitely lame Hobbling	Sole ulcer White line Digital dermatitis Foul Other (please state)				Farmer Foot Trimmer Vet		

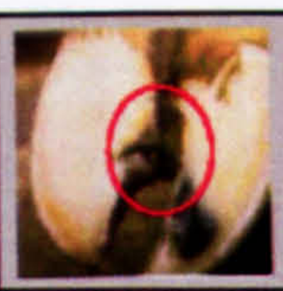
APPENDIX D: COLOUR ATLAS

Reference list for claw lesion diagnoses:

LAMECOW

AN EU FRAMEWORK 5 PROJECT

No	TITLE	DESCRIPTION	PICTURE
1	Haemorrhage / Laminitis	Blood-stained hoof horn seen on the sole surface but *not* including haemorrhage at the white line (4), sole ulcer (5) or toe ulcer (10) sites.	
2	Digital Dermatitis (DD)	Inflammation of the skin at the heel, interdigital cleft and other sites. Usually moist and painful. Can be raised and papilliform (="hairy warts")	   (="hairy warts")
3	Interdigital Dermatitis (IDD)	Moist inflammation of the interdigital space. Many consider that this is DD in ID space.	  
4	White Line Disease (WLD)	Haemorrhage, fissure or foreign body in the white line. Advanced lesions may discharge at coronary band or may under run the sole.	  
5	Sole ulcer	Haemorrhage, perforation and/or protrusion of granulation tissue through the sole horn at the "typical site"	  
6	Rotation	Rotation / overgrowth of the medial claw	 
7	Interdigital growth	Lump of hard tissue protruding into interdigital space, often with DD (2) or "foul" (13) on the surface.	 
8	Thick hock	Enlargement of the hock, often with area of superficial abrasion.	

9	Axial wall fissure	Fissure and under run horn along axial (inner) wall of hoof, sometimes with prolapse of granulation tissue.	 
10	Toe ulcer	Haemorrhage into or total ulceration of sole at toe ("A")	
11	Sandcrack (vertical fissure)	Vertical fissure through hoof wall which may or may not be under run and causing lameness.	 
12	Heel ulcer	Typical black lesion in centre of sole towards heel, which may run into underlying abscess in heel.	 
13	Foul (Interdigital necrobacillo-sis)	Fissure in the interdigital skin often exposing necrotic tissue beneath. "Super foul" produces extensive necrosis.	 
14	Horizontal wall fissure	Horizontal fissure running around hoof wall. Mild lesions may be called "hardship grooves". Deep lesions lead to lameness due to movement of toe horn ("thimbling").	
15	Toe Necrosis (pedal bone necrosis)	Deep penetration and under run horn at toe with pungent odour. May be secondary to white line lesion or ulcer	
16	Foreign Body penetration	Penetration of sole by nail, stone, thorn, tooth etc. usually producing under run sole (but if in white line, enter as "category 4").	
17	Other		

APPENDIX E: FARMER INTERVIEW

FARMER'S NAME:_____ FARM NAME:_____

DATE:_____ INTERVIEWER:_____-

FARMER INTERVIEW QUESTIONNAIRE INSTRUCTIONS

This questionnaire records data concerning factors in the farm environment and animal management to be ascertained by an interview with the farmer. In addition to this, the Direct Observations Questionnaire is needed to record data relating to observable features within the farm's physical environment. The On-farm S.O.P. is also necessary to complete the on-farm data collection.

LAMENESS QUESTIONNAIRE

Thank you for giving up the time to enable us to collect these data for the lame cow project.

First I'd like to ask some questions about your herd numbers and stock. After that I have some questions about lameness and health management. Then I have some questions about housing and pasture management. Finally, I would like to ask you a few details on replacements and care of your cows.

BUILDINGS

Q1.1 Please can we fill in the table below with information about all buildings and yards used to house in-calf heifers, all groups of lactating cows and dry cows in the plan? *(answers to be recorded in TABLE A below)*

TABLE A. Building details.

Building area/ yard name	Age of building (years)	Have there been any recent refurbishments?	Which stock used this building last winter 2002 - 3 Max. no. animals? Min. no. animals?	Which stock used this building the previous winter (2001-2002)? *If same write SAME*	Did any stock use this building at any other time? *Give type of stock and dates for this year and/or last year*	Was this building cleaned out last year (2002) once the cows were out? *If so,* how and how many times?

For all groups housed in cubicles:

Q1.2 Last winter (2002-2003) did you observe any of the following behaviours listed in TABLE B in any of the groups of cattle housed in cubicles?

If so, could you indicate whether you consider the level as a little, some or a lot.

TABLE B.

(please indicate score with low✓, moderate✓✓, high✓✓✓ or X if there is none)

Observed behaviour in 2002-2003	In-calf heifers	High yielders	Low yielders	Dry cows
Lying in passageway				
Reverse lying				
Standing with back legs in passageway				
Legs trapped in cubicles				

Q1.3 Would you consider that this was the same level as the year before (2001-2002)? *(circle appropriate answer)*

YES NO *(If NO indicate behaviour in TABLE B2 below)*

(please indicate score with low✓, moderate✓✓, high✓✓✓ or X if there is none)

Observed behaviour in 2001-2002	In-calf heifers	High yielders	Low yielders	Dry cows
Lying in passageway				
Reverse lying				
Standing with back legs in passageway				
Legs trapped in cubicles				

FIELD USE

Q2.1. What is the total area of land grazed by your milking cows this year (2003)?
_____ acres / hectares *(please circle appropriate unit of measurement)*

Q2.2. What was the total area of land grazed by your milking cows last year (2002)?
_____ acres / hectares *(please circle appropriate unit of measurement)*

Q2.3. How many fields are used by the cows for grazing this year (2003)?
_____no. fields

Q2.4. How many fields were used by the cows for grazing last year (2002)?
_____no. fields

Q2.5. How are you grazing your cattle this year (2003)?
(Indicate answers in table C below)

TABLE C. Grazing management this year (2003)

Type of grazing	*(Tick all that apply – if only one group of milking cows use high yielders column only)*		
	High yielders	Low yielders	Other group *(please state)*
Set stocked			
Rotational			
Strip grazing			
Zero grazing			
Other			

Q2.5b Is this the same as last year? *(circle answer)*

YES NO (*If NO indicate changes in TABLE C2 below)*

TABLE C2. Grazing management last year (2002)

Type of grazing	*(Tick all that apply – if only one group of milking cows use high yielders column only)*		
	High yielders	Low yielders	Other group *(please state)*
Set stocked			
Rotational			
Strip grazing			
Zero grazing			
Other *(please state~)*			

Q2.6. Please can we fill in the following table about the approximate dates of turnout and housing for this year (2003) and last year (2002) for each group of cattle listed in TABLE C. *(answers to be recorded in TABLE C below).*

TABLE C. Turnout dates and housing dates.

2003	First at pasture	24 hrs at pasture
Milking cows (high yield)		
Milking cows (low yield)		
Dry cows		
Pregnant heifers		
Non- pregnant heifers		
Other group *(please state)*		

2002	First at pasture	24 hrs at pasture	First housed	24 hrs housed
Milking cows (high yield)				
Milking cows (low yield)				
Dry cows				
Pregnant heifers				
Non- pregnant heifers				
Other group *(please state)*				

Q2.7. How have the cows generally been moved to and from the fields this year (2003) and how were they moved last year (2002)?

(tick all that apply)

Method	This year (2003)	Last year (2002)
By tractor		
By quad bike/ All Terrain Vehicle		
Herdsperson using dog		
Herdsperson walking in front		
Herdperson walking behind		
Other *(please specify)*		

Q2.8. Since turn out in 2003 what is the maximum distance the cows have walked to be milked?

_____yards *OR* _____metres

Q2.9. What surfaces do your cows walk on to and from milking this year (2003) and what did they walk on last year (2002)?

(tick all that apply)

	This year (2003)	Last year (2002)
Dirt		
Grass verge		
Sand		
Stones / hardcore		
Concrete		
Tarmac and/or road surface		
Wood chippings		
Rubber mats		
Other *(specify)*		

Q2.10. Do the cows prefer to use any part of the track more than other parts?
(circle answer)

YES NO Don't know

If "YES":
Which parts?_____

Q2.11. Do you have man-made tracks for your cows going out to pasture?
(circle answer)

YES NO

If "YES": What year were these tracks made? _____

Q2.12. Do the main walking routes (man-made or not) have extra drainage provided?
(circle answer)

YES NO

If "YES": What year was this drainage laid? _____

Q2.13. Do the gateways to fields have extra drainage provided?
(circle answer)

YES NO

If "YES": What year was this drainage laid? _____

Q2.14. Do you have any other comments on tracks and gateways?

LAMENESS IN YOUR HERD
(SEE END SHEET TO LEAVE WITH FARMER)

Q3.1. Did you keep a written record of lameness in your cattle in 2002?
(circle answer)

YES NO Sometimes

Q3.2. This year (2003) have you carried out specific checks to assess whether your cows were lame?
(circle answer)

YES NO

If "YES", how often did you carry these checks out? ____per month; ____per year

Q3.3. Last year (2002) did you carry out specific checks to assess whether your cows were lame?
(circle answer)

YES NO

If "YES", how often have you carried these checks out? ___per month; ___per year

Q3.4. This year (2003) have you routinely trimmed your cows' feet?
(circle answer)

YES NO Some

If "YES", when?_____

If "SOME", what proportion?_____%

Q3.5. Last year (2002) did you routinely trim your cows' feet?
(circle answer)

YES NO Some

If "YES", when? AS LAST YEAR or:_____

If "SOME", what proportion?_____%

Q3.6. This year (2003) and last year (2002) who carried out hoof-trimming on the farm?

(tick all that apply)

Who	This year (2003)	Last year (2002)
Farmer / herdsman		
Specialist hoof trimmer		
Veterinary surgeon		
Farm staff - who?_____		
Other *(please specify)*		

Q3.7. Do you, or any of the staff on your farm have a formal foot trimming qualification or have previously attended a relevant course?
(circle answer)

YES NO

Please fill in ID of qualified staff and qualifications/courses below

ID of staff	Qualification	Course (who by and what year)

Q3.8. This year (2003) and last year (2002) where did you examine lame cows feet?
(tick each that applies)

	This year (2003)	Last year (2002)
Crush with foot lifting facilities		
Crush without foot lifting facilities		
A.I. stand and winch		
Other *(please specify)*		

FOOTBATH INFORMATION

Q3.9. Do you have a footbath?
(circle answer)

YES NO **(*If "NO"* go to Q3.28 - washing feet)**

Q3.10. **If *"YES":*** When did you get a foot bath
_____ months / years ago

Q3.11. ***If "YES"***, What are the dimensions of the footbath?
Length_____ Width_____ Depth_____

Q3.12. ***If "YES"***, is it permanently sited?
(circle answer)

YES NO

Q3.13. Where is it situated?
(tick each that applies)

Parlour entrance	
Parlour exit	
Cubicles	
Collecting yard	
Race	
Other *(please state)*	

Q3.14. This year (2003) how many times do your cows walk through the footbath each time it is used?
_____number of walkthroughs/bath

Q3.15. Last year (2002) how many times did your cows walk through the footbath each time it was used?
_____number of walkthroughs/bath

Q3.16. How frequently do your milking cows use the footbath this year (2003)?

_____per day *or* _____per week *or* _____per month

Q3.17. How frequently did your milking cows use the footbath last year (2002)?

_____per day *or* _____per week *or* _____per month

Q3.18. Last year (2002) did the milking cows use the footbath all year?
(circle answer)

YES NO

If "NO", when did they use it in 2002?_____

_____

DRY COWS

Q3.19. How frequently do your **dry cows** use the footbath **this year** (2003)?

_____per day *or* _____per week *or* _____per month

Q3.20. How frequently did your **dry cows** use the footbath **last year** (2002)?

_____per day *or* _____per week *or* _____per month

Q3.21. Did the dry cows use it throughout last year (2002)?
(circle answer)

YES NO

If "NO", when did they use it in 2002?_____

_____

Q3.22. This year (2003), what solutions do you use in your footbath and at what concentration?
(Please write answers in 1st column of TABLE E below)

Q3.23. Is this the same as last year?

YES NO ***(If "NO"** indicate changes in 2nd column of table E below)*

TABLE E. Footbath solutions and concentrations.
(Please write concentration of any solutions used in)

Solution	**This year (2003)**	**Last year (2002)**
	Concentration	Concentration
Formalin		
Copper sulphate		
Zinc sulphate		
Organic acids		
Antibiotic solution (name:)		
Other *(please specify)*		

Q3.24. **This year** (2003), how often do you change the solution in the footbath?

AFTER EACH USE *or* _____per week *or* _____per month

Q3.25. **Last year** (2002), how often did you change the solution in the footbath?

AFTER EACH USE *or* _____per week *or* _____per month

Q3.26. **Do you wash the cows' feet before they use the footbath?**
(circle answer)

YES NO Sometimes

If "YES", how did you wash the feet this year and last year *(tick all that apply)*

	This year (2003)	**Last year (2002)**
Footbath of water		
Manual hosing in parlour		
Manual hosing in yard		
Other *(please specify)*		

Q3.27. Did you use any of the following in the base of the footbath?
(tick all that apply)

	This year (2003)	**Last year (2002)**
Straw		
Sponge mattress		
Rough matting		
Ridged base		
Other *(please specify)*		

Q3.28. Do you wash the cows' feet at any other time?
(circle answer)

YES NO

If "YES", how do you wash the feet *(tick all that apply)*

	This year (2003)	**Last year (2002)**
Footbath of water		
Manual hosing in parlour		
Manual hosing in yard		
Other *(please specify)*		

REPLACEMENTS

Q4.1. What was the calving pattern of your herd last year (2002)? *(circle answer)*

All year Seasonal

If "Seasonal":
Between which months did your cows calve in 2002? _____ to _____

Between which months did your cows calve in 2003? _____ to _____

Q4.2. What percentage of your own dairy replacements do you rear? _____%

If not 100% replacements:

Q4.3. How many of the following aged replacements age did you purchase in 2002/2003?

	Number purchased this year 2003	Number purchased last year (2002)
3 months		
4 months to one year		
13 months to 1st service		
In-calf heifers		
Fresh calved with first calf		
Older cattle		

Q4.4. Do you select for any particular characteristics when breeding replacements?

YES NO *(circle answer)*

If "Yes", Please indicate from the following list your top five priorities for breeding characteristics (*write 1,2,3,4 or 5 by one answer - 1 being most important*)

Milk yield		Udder quality	
Milk quality		Legs and feet	
Fertility		Body conformation	
Ease of calving		Profit Index	
Somatic cell count		Lifetime Profit Index	
Other *(please specify):*		Other *(please specify):*	

Q4.5. How long have you selected for these particular characteristics?

_____(years)

IN-CALF HEIFER MANAGEMENT

If no in-calf heifers present on farm then go to Dry Cow section below (Q6.1)

Q5.1. What is the youngest age that your heifers calve?
_____(months)

Q5.2. What is the oldest age that your heifers calve?
_____(months)

Q5.3. How many pregnant heifers have you had so far this year (2003)?
_____(total number)

Q5.4. How many pregnant heifers did you have last year (2002)?
_____(total number)

Q5.5. Where and with which groups of cows were the bulling and pregnant heifers housed during the winter and summer of this year and last year?
(answers to be recorded in the TABLE F below)

TABLE F. Housing and grouping of the bulling and pregnant heifers

This year (2003)	Bulling heifers Winter	Bulling heifers Summer	Pregnant heifers Winter	Pregnant heifers Summer
Straw yard for heifers only				
Straw yard with dry cows				
Straw yard with milking herd				
Cubicle shed for heifers only				
Cubicle shed with dry cows				
Cubicle shed with milking herd				
Pasture *(with _____)*				
Other *(please specify)*				
Last year (2002)				
Straw yard for heifers only				
Straw yard with dry cows				
Straw yard with milking herd				
Cubicle shed for heifers only				
Cubicle shed with dry cows				
Cubicle shed with milking herd				
Pasture *(with _____)*				
Other *(please specify)*				

Q5.6. **This year** (2003) where are the in-calf heifers kept one week **before** they are put into the area where they calve down?
_____

Q5.7. How many weeks are they kept there before calving?
_____(weeks)

Q5.8. Where do the first-calving heifers calve down?
_____(calving accommodation)

Q5.9. How long do they stay there after calving?

Q5.10. Is this the same management procedure as last year (2002)?

YES NO

Please record differences

Q5.11. Where and with which groups of cows were the heifers housed after their first calving this year (2002/3) and last year (2001/2)?

(answers to be recorded in the TABLE G below)

TABLE G. Housing and grouping of first-calved heifers.

(tick each answer that applies)

Housing immediately post-calving	This year		Last year	
	Winter (2002/3)	Summer (2003)	Winter (2001/2)	Summer (2002)
Straw yard for heifers only				
Straw yard with milking herd				
Cubicle house for heifers only				
Cubicle house with milking herd				
Pasture				
Other *(please specify)*				

If applicable:

Q5.12. **This year** (2003) how long are they kept here before entering the main milking herd?

_____(weeks)

Q5.13. **Last year** (2002) how long were they kept here before entering the main milking herd?

_____(weeks)

Q5.14. Which of the following forages were used for the in-calf heifer ration, and what was the level of inclusion of each (as a proportion of the total forage).

(tick each that applies and indicate proportion)

	This year (Winter 2002/3)		Last year (Winter 2001/2)	
Forage	Tick if used	Proportion (%)	Tick if used	Proportion (%)
Grass silage				
Maize silage				
Whole crop wheat silage				
Fodder beet				
Hay				
Wheat Straw				
Barley straw				
Other *(please specify)*				

Q5.15. Do you/ did you provide any dietary supplements this year or last year?

(tick each that applies)

	This year (Winter 2002/3)		Last year (Winter 2001/2)	
Supplement	Tick if used	Proportion (%)	Tick if used	Proportion (%)
General minerals and vitamins				
External mineral lick				
Other:_____ *(please specify)*				

Q5.16. This year (2003) do you feed your in-calf heifers concentrate?

(circle answer)

YES NO

If "YES" What is the maximum concentrate level given to an in-calf heifer per day?:_____(kg)

Q5.17. Is this level of concentrate the same as last year?

(circle answer)

YES NO (***If "NO"*** *What was it last year (2002)*_____)

Q5.18. This year (2003) do you give your in-calf heifers a special transition diet prior to calving?

(circle answer)

YES NO

If *"YES"*, how long before calving is this diet provided?:_____(weeks)

Q5.17a What is this diet?

(tick answer in table below)

Same ration as fresh calving group	
Special heifer transition mix	
Other *(please specify)*	

Q5.17b Is this the same as last year

(circle answer)

YES NO

If no how is this different

e

For in-calf heifers going into cubicle yards only: (OR go to Q6.1 - Dry Cows)

Q5.19. This year (2003) have you provided any cubicle training for your in-calf heifers?
(circle answer)

YES NO

If "YES", how were they trained?_____

For how long? _____ days / weeks

Q5.20. **Last year** (2002) did you provide any cubicle training for your in-calf heifers?
(circle answer)

YES NO not applicable

If "YES", how were they trained? SAME AS BEFORE or _____

For how long?_____(weeks)

DRY COW MANAGEMENT

Q6.1. Do you/ did you carry out any of the following procedures at drying off this year (2003) or last year (2002)?
(tick all that apply)

	This year (2003)	Last year (2002)
Dry cow therapy (long-term antibiotic treatment)		
Teat seal *(which make?)*_____		
Hoof trimming		
Body condition scoring		
Other *(please specify)*		

Q6.2. Were your dry cows housed separately to the milking cows this year or last year?
(circle answer)

YES NO Sometimes

If "YES":
What sort of housing were the dry cows kept in? *(tick one answer)*

	This year (Winter 2002/3)	Last year (Winter 2001/2)
Strawyard		
Cubicle house		
Barn		
Tiestall house		
Outdoors		
Other *(please specify)*		

Q6.3. This year (2003), do you provide a transition diet for your dry cows as they are about to enter the milking herd?
(circle answer)

YES NO

If *"YES"*, How long before calving is this diet provided? _____(weeks)

Q6.4. How would you describe this diet?
(tick appropriate answer)

Ration description	This year (2003)
Same ration as fresh calving group	
Special dry cow transition mix	
Other *(please specify)*	

Q6.5. Was this the same last year?
(circle answer)

YES NO

If no how is this different

Q6.6. When do/did the second-plus lactation dry cows rejoin the main milking herd?

(tick appropriate answer)

Rejoining herd	This year (2003)	Last year (2002)
Never left main milking group		
Immediately after calving		
Kept apart for a period *(please specify how long)*		

LACTATING COW MANAGEMENT

Q7.1. How do/did you calculate the lactating cows' ration this year (2003) and last year (2002)?

(tick appropriate answer)

	This year (2003)	Last year (2002)
Feeding individual cow to yield		
Flat rate feeding to group		
Stepped feeding curve to group		
Feed whatever is available		
Other *(please specify)*		

Q7.2. What proportion of the following ingredients *(READ OUT FROM TABLE H BELOW)* made up the forage fed to your high-yielding milking cows this year (2003) and last year (2002)?

TABLE H. High yielders forage proportions *(tick each that applies)*

	This year (2003)		Last year (2002)	
Type of forage	Tick if used	Proportion (%)	Tick if used	Proportion (%)
Grass silage				
Maize silage				
Whole crop wheat silage				
Other *(please specify)*				

If separate low-yielding group:

Q7.3. What proportion of the following ingredients *(READ OUT FROM TABLE H2 BELOW)* made up the forage fed to your low-yielding milking cows this year (2003) and last year (2002)?

TABLE H2. Low yielders forage proportions *(tick each that applies)*

	This year (2003)		Last year (2002)	
Type of forage	Tick if used	Proportion (%)	Tick if used	Proportion (%)
Grass silage				
Maize silage				
Whole crop wheat silage				
Other *(please specify)*				

Q7.3. Do/did you provide any dietary supplements this year (2003) or last year (2002)?

(tick each that applies)

	This year (2003)		Last year (2002)	
Supplement	Tick if used	Proportion (%)	Tick if used	Proportion (%)
General minerals and vitamins				
External mineral lick/ Salt lick				
Extra copper				
Vitamin E				
Biotin				
Yeast culture				
Protected fat				
Dietary buffer such as bicarbonate				
Other:_____ *(please specify)*				
Other:_____ *(please specify)*				

Q7.4. How did you deliver the concentrate/straights to the milking cows this year (2003) and last year (2002)?

(tick one answer)

	This year (2003)	Last year (2002)
All fed in parlour		
Out of parlour feeders		
All in Total Mixed Ration		
Part in parlour / part in T.M.R.		
Part out of parlour feeders/ part in T.M.R.		
Added on top of silage		
Other *(please specify)*		

Q7.5. This year (2003) what is the maximum amount of concentrate a cow will receive in the parlour in a single milking?

_____kg

Q7.5a Is this the same as last year?

(circle answer)

YES NO:_____kg

Q7.6. What is the minimum amount of concentrate a cow will receive in the parlour?

_____kg

Q7.6a Is this the same as last year?

(circle answer)

YES NO:_____kg

Q7.7. Do you have out of parlour feeders for concentrate?

(circle answer)

YES NO **(If "NO" go to Q8.1)**

If out of parlour feeders present:

Q7.8. What is the maximum concentrate that is delivered by an out of parlour feeder **in one meal?**

_____kg

Q7.9. : What is the maximum concentrate that is delivered by an out of parlour feeder **in one day?**

_____kg

SICK OR LAME COWS

Q8.1. This year (2003) and last year (2002), do/did you have any separate housing facilities for sick or injured cows? *(circle answer)*

YES NO

If "Yes" what were they? *(please tick appropriate answer and state what floor surface was provided)*

	This year (2003)	Bedding material	Last year (2002)	Bedding material
Individual pen in main building				
Group pen in main building				
Individual pen in separate building				
Group pen in separate building				
Housed with dry cows				
Other *(please specify)*				

PARLOUR MANAGEMENT

Q9.1. How many times per day are the cows milked **this year** (2003)? *(circle answer)*

ONE TWO THREE Robotic

Q9.2. At what times of the day are they milked **this year** (2003)?

_____am _____pm (hh:mm)
If "Robotic", how many milkings per day?_____

Q9.3. How many times per day were the cows milked **last year** (2002)? *(circle answer)*

ONE TWO THREE Robotic

Q9.4. At what times of the day were they milked **last year** (2002)?

_____am _____pm (hh:mm)
If "Robotic", how many milkings per day?_____

Q9.5. How many of the following different people milked the cows this year and last year? *(READ OUT FROM TABLE I BELOW)*
(*Fill in TABLE I below*)

TABLE I. Regular and temporary milkers

How many?	This year (2003)	Last year (2002)
Regular milkers		
Relief/temp milkers		

Q9.6. This year (2003), what is the maximum time that any cow would stand in the collecting yard **BEFORE** milking?

_____(minutes)

Q9.7. Last year (2002), what was the maximum time that any cow would stand in the collecting yard **BEFORE** milking?

_____(minutes)

Q9.8. **This year** (2003), what is the maximum time that any cow would stand in the collecting/standing yard **AFTER** milking before returning to housing/pasture?

_____(minutes) (*write 0 if they don't have to stand after milking)*

Q9.9. **Last year** (2002), what was the maximum time that any cow would stand in the collecting/standing yard **AFTER** milking before returning to housing/pasture?

_____(minutes) (*write 0 if they don't have to stand after milking)*

Q9.10. **This year** (2003), what is the average annual yield (rolling average) per cow in your herd?

_____kg

Q9.11. **Last year** (2002), what was the average annual yield (Jan-Dec) per cow in your herd?

_____kg

Q9.12. Is your herd conventional, organic or in transition to organic? *(circle answer)*

Conventional Organic In transition

Q9.13. Which of the following did you routinely record for individual cows this year and last year?
(tick all that apply)

	This year (2003)	Last year (2002)
Milk yield		
Milk fat		
Milk protein		
Somatic cell count		
Mastitis		
Use of antibiotics		
Lameness		
Other		

Q9.14. Do you/ did you subscribe to a milk recording scheme this year or last year?
(circle answer)

YES NO

If "YES", which scheme? *(please tick answer on table below)*

Scheme	**This year (2003)**	**Last year (2002)**
NMR		
On merit		
Genus		
Other		
Other		

Can we have your permission for access to this information?
(circle answer and signature required)

YES *Signature:*_____

NO

Q9.15. **This year** (2003), do you have a nutritional advisor?
(circle answer)

YES NO

Q9.16. **Last year** (2002), did you have a nutritional advisor?
(circle answer)

YES NO

Q9.17. Are you / were you a member of any farm assurance schemes this year or last year?
(circle answer)

YES NO **(If "NO" go to Q9.18)**

If "YES", which scheme? *(please tick answer on table below)*

Scheme	**This year (2003)**	**Last year (2002)**
National Dairy Assurance Scheme		
RSPCA Freedom Foods		

Q9.18. Does it have a herd health management plan?
(circle answer)

YES NO DON'T KNOW

Q9.19. Does this plan include a protocol for the **prevention** of lameness?
(circle answer)

YES NO DON'T KNOW

Q9.20. Does this plan include a protocol for the **treatment** of lameness?
(circle answer)

YES NO DON'T KNOW

Q9.21. When was the last time this plan was updated?
_____(month:year)

Any comments from farmer

Thank you very much for your assistance in completing this questionnaire.

APPENDIX F: EXIT QUESTIONNAIRE

LAMECOW Exit questionnaire

Lameness on your farm

Q1. Would you describe lameness as a problem in your herd? *(please circle answer)*

Yes No Don't know

Q2. How would you describe the level of lameness on your farm? *(please circle answer)*

Much more than average

More than average

Average

Less than average

Much less than average

Q3. How important would you rate the following factors in causing lameness on your farm? (1= not very important, 5 = very important) *(please circle one answer per line)*

	Not important				Very important
Genetics/breeding.....	1	2	3	4	5
Milk yield..,,,,.....	1	2	3	4	5
Diet.....	1	2	3	4	5
Slurry.....	1	2	3	4	5
Flooring.....	1	2	3	4	5
Cubicle.....	1	2	3	4	5
Infectious disease.....	1	2	3	4	5
Anything else that you think is important?:					
Other (*please state*:_____)	1	2	3	4	5
Other (*please state*:_____)	1	2	3	4	5

Controlling lameness on your farm

Q4. Has a professional hoof-trimmer visited the farm this year? *(please circle correct answer)*

Yes No

Q4a If Yes: How many times? _____visits between 1/1/03 and 1/1/04

Trimmed how many cows? _____cows

What cost per cow? £_____/cow

Q5. Please indicate in the table below the treatments given and time taken to lift a cow's foot. If a second stockman is involved please include time he/she might spend assisting.

Foot Lifting	Drugs used	Dose	Other treatments e.g. blocks, dressings	Cow Movement Time (mins/person)	Cow Treatment Time (mins/person)
Routine trim					
Overgrowth					
Sole Ulcer					
White line disease					
Foul					
Digital Dermatitis					
Other					

Q6. Please indicate in the table below any treatments given to cows in the parlour and the time taken, e.g. washing feet or using antibiotic spray.

Procedures in Parlour	Drugs used	Dose	Cow Treatment Time (mins/person)

Q7. Please indicate in the table below the solutions used and the time taken during the foot bathing process.

Foot Bathing	Concentration	Frequency of use	Footbath preparation time (mins/person)	Number of cows through footbath	Time taken
Solution 1 Name:					
Solution 2 Name:					
Solution 3 Name:					

Vet Call Outs

Q8. Do you have routine veterinary visits? *(please circle correct answer)*

Yes No

Q8a. If Yes: Every how many weeks? 1 2 3 4 >4

Q8b. If No: How many times has the vet visited this year? _____visits between 1/1/03 and 1/1/04

Q9. How much were your vet fees for the past 12 months? £_____

Q10. Do your vet fees include milk recording? *(please circle correct answer)*

Yes No

Q11. Approximately how many lame cows did the vet examine this year? _____cows

Q12. How many visits were to treat lame cows only? _____visits

Q13. What is the call out cost of your vet? £_____/call out

Culled Animals

Q14. Could you provide details of all animals from the milking herd culled and reasons for doing so for the past 12 months?

a. Number culled for poor production performance: _____cows

b. Number culled for infertility: _____cows

c. Number culled for mastitis: _____cows

d. Number culled for temperament: _____cows

e. Number culled for other – (*please state*_____): _____cows

f. Number culled for lameness: _____cows

(Could you please fill in the attached table with details of those cows culled for lameness only)

CULLED LAME COWS

Freeze brand/name of cow	Ear tag number (if freeze band is a duplicate)	Number of last lactation	Number of weeks in milk

APPENDIX G: WINTER OBSERVATIONS RECORDING FORM

FARM BUILDINGS TABLE

Farmer name	Farm Name	Date

Please record details for all buildings/ accommodation areas containing **in-calf heifers, all milking cows and dry cows**

Building ID	Building Size (m)			Type of building	Pen floor Base and Bedding Material	Walkway floor material	Type of ventilation	How cleaned?	Method of feeding	Length of feeding space (m)
	L	B	H	Cubicle house (CH) Loose pen (LP) Tethered system (TS)	**Base:** Concrete (C) Soil (So) Rubber mat (RM) Cow mattress (CM) **Bedding:** None Straw Sand Sawdust Shredded paper	Smooth concrete (SC) Grooved concrete (GC) Textured concrete (TC) Dirt (D) Rubber mat (RM)	Open ridge (open) Open ridge (with cover) Vents (*how big?*) Other (*please specify*)	Tractor scraper (TS) Automatic scraper (AS) Fully-slatted (FS)	Feed passage (FP) Trough (Th) Clamp (C) Ring feeder (R) Floor (same site) (FS) Floor (different site) (FD) Transponder (Tr)	

Farmer name	Farm Name	Date

HOUSE LAYOUT RECORDING SHEET **HOUSE NAME:**_____

Please fill in a separate form for each cubicle house:

Sketch the layout of the house including entrance/ exit points, bedded areas, cubicles if present, loafing and feeding areas and water troughs.

Please record:
Dimensions of lying areas (length x width)
Dimensions of passages (length x width)
Dimensions of feeding/loafing areas (length x width)

CUBICLE HOUSE **HOUSE NAME:**_____

Please fill in a separate form for each cubicle house:

1. What is the total number of cubicles available for use in this house? _____

2. Please could you draw the side profile of EACH cubicle type present in this house in the table below and indicate the number of cubicles of each type below:

TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5
cubicles	ubicles	Cubicles	Cubicles	Cubicles

3. Please complete the cubicle dimensions table below for all cubicle types in this house *(Use diagrams on Cubicle Dimensions Diagrams sheet to fill in following section)*

CUBICLE DIMENSIONS TABLE

Cubicle type	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5
Cubicle design					
Does the cubicle have a:					
Head rail, Is it rigid or flexible (R/F)	R / F	R / F	R / F	R / F	R / F
Neck rail, Is it rigid or flexible (R/F)	R / F	R / F	R / F	R / F	R / F
Brisket board					
Bedding retainer					
Side rail, Is it rigid or flexible (R/F)	R / F	R / F	R / F	R / F	R / F
Cubicle measurements					
What is the distance between the following (cm)?					
Front and back of cubicle (A)					
Front of cubicle and head rail (B)					
Front of cubicle and neck rail (C)					
Brisket board and back of cubicle (D)					
Width of cubicle (average of two) (E)					
Height of lowest rail at rear of cubicle (G)					
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5
Height of neck rail (H)					
Height of head rail (I)					
Height of bedding retainer					
Minimum kerb height Maximum kerb height					

Cubicle maintenance

4. How many of the cubicles in the house?

Are NOT perpendicular to the kerb_____

Of these how many are Wider at the head end_____

Wider at the tail end_____

Have broken side rails With protrusions_____

Without protrusions_____

Have broken head rails With protrusions _____

Without protrusions_____

Have broken neck rails With protrusions _____

Without protrusions_____

Are NOT broken but have protruding parts_____

Have incorrectly positioned mats_____

Contain foreign objects_____(examples of foreign objects)

PARLOUR AND COLLECTING YARD

Collecting Yard

What is the size of the collecting yard?

Length_____(m) x Width_____(m)

Describe the floor surface of the collecting yard (estimate proportion of surface area)

Smooth and slippery _____%
Good non-slip surface _____%
Rough and damaged surface _____%

What is the gradient of the collecting yard? (tick one answer)

Flat
Sloped
Flat area and sloped area
Stepped and flat areas

Record the presence of any foreign objects on the surface of the collecting yard and how many (e.g. nails, stones, litter, etc.)

Parlour

What is the size of the parlour?

Number of clusters:_____
Number of places:_____

What type of parlour is it? (tick one answer)

Herringbone
Rapid exit
Side by side (abreast)
Side by side step-up
Rotary
Tandem
Robotic
Tethered Stalls (Byre)
Other *(please specify)* _____

Type of floor surface in parlour (tick one answer)

Concrete (no stones visible)
Concrete with small round stones protruding
Concrete with large round stones protruding
Concrete with small sharp stones protruding
Concrete with large sharp stones protruding
Concrete slats
Other *(please specify)*

_____

Describe the floor surface of the parlour (estimate proportion of surface area)

Smooth and slippery _____%
Good non-slip surface _____%
Rough and damaged surface _____%

Is there a backing gate? (circle one answer)

Yes No

If "Yes": Record the presence of any of the following (tick all appropriate answer)

Rigid gate
Flexible gate
Electric wire
A bell/buzzer

Record the presence of any of the following (tick all appropriate answer)

Step at collecting yard
Step at parlour entrance
Step at parlour exit
Sharp turn at entrance
Sharp turn at exit
Multiple exits to parlour

FEEDING / LOAFING AREA **HOUSE NAME:_____**

Is the area?

Feed and loafing area
Feeding area only
Loafing area only

Is the area?

Separate yard outside house
Yard within house
Feed passage in cubicle house

What is the size of the feeding area? (if not already measured as a passage)

Length_____(m) x Width_____(m)

Describe the floor surface of the feeding area (estimate proportion of surface area)

Smooth and slippery _____%
Good non-slip surface _____%
Rough and damaged surface _____%

What is the gradient of the feeding area? (tick one answer)

Flat
Sloped
Flat area and sloped area

Record the presence of any foreign objects in the feed area (type and number)

Is there any mouldy/old food in the trough/feeding site? (Circle one answer)

Yes No

CONSERVED FORAGE RECORDING SHEET

Environmental temperature_____°C

Date_____

Weather conditions at the clamp face

Direct sunlight
Shaded
Raining
Dry

Clamp Silage

Please complete the table below for each clamp (e.g. grass, maize or whole crop silage)

CLAMP (contents)	*1.*	*2.*	*3.*
Type of clamp *(Through, covered, in building)*			
Dimensions *(m)* Height Width Length			
Depth silage exposed *(m)*			
Depth of dark layer at top of face *(cm)*			
Presence of mould on clamp face *(1=None, 2=Few/small patches, 3= lots/large area)*			
Firmness of silage face *(1=Hard, compact, 2= Soft, loose)*			
Tidiness of clamp floor area *(1=no loose silage, 2=little loose silage, 3=some loose silage, 4=large quantity loose silage, some old, 5= excessive loose silage, lots old and rotten)*			
Temperature measurement 1			
Temperature measurement 2			
Temperature measurement 3			
Temperature measurement 4			
Temperature measurement 5			
Average temperature (˚C)			

Big bale silage

Please record proportion bales with damaged plastic %

Other points of note (please specify):

APPENDIX H: SUMMER OBSERVATIONS RECORDING FORM

Summer Direct Observation Form
Visit 2

TRACKS

How far do the purpose built tracks used by the cows extend from the farm yard *(if there are none put 0 m).*

Track length: _____ (m)

What is the average width of the 100m closest to the farmyard of the purpose built track

Track width: _____ (m)

(For purpose built track only in first 100m from farm yard)

How would you describe the crowning/camber of the track surface?

(tick one answer)

Flat surface

Clear crowning of surface

Evidence of poor drainage (pits, puddles, etc.)

What is the surface of these tracks made from?

	(tick each answer that applies)	Proportion of track (%)
Dirt		
Grass verge		
Sand		
Stones/hardcore		
Concrete		
Tarmac, including road		
Wood chippings		
Rubber mats		

Other *(please specify)* _____

Are there any stones/broken concrete pieces present on the tracks/walking surfaces within the nearest 100m to the farm yard?

(tick each answer that applies)

None present

Small rounded stones (<3cm diameter)

Small sharp stones (<3cm diameter)

Large rounded stones (>3cm diameter)

Large sharp stones (>3cm diameter)

How would you describe the condition of the cow tracks/walking surfaces?

(tick one answer)

Generally good condition

Average condition

Generally poor condition

Record the presence of any of the following in the nearest 100m to the farm yard

(tick one answer)

Stone traps

Unexpected episodes of cow dunging

Sharp turns on track

Sketch the layout and give dimensions for the first 100m of cow walkways below indicating man-made tracks, gateways, turnings, water troughs, damaged areas, etc.

GATEWAYS

Check three gateways for their condition

Are there any stones/broken concrete pieces present in the gateways?

(tick each answer that applies)

None present
Small rounded stones (<3cm diameter)
Small sharp stones (<3cm diameter)
Large rounded stones (>3cm diameter)
Large sharp stones (>3cm diameter)

How would you describe the condition of the gateways?

(tick one answer)

Generally good condition
Average condition
Generally poor condition

FIELDS

How are the fields divided? *(tick each answer that applies)*

By fences/walls
By hedges
Do hedges contain thorns? **Yes** **No**
By electric fence
Ditch

Other *(please specify)* _____

What are the gradients like in the fields on average? *(tick one answer)*

Flat
Most of field flat
Some flat and some sloped
Most of field sloped
All field on gentle slope
All field on steep hill

Other points of note *(please specify):*

N.B. IT IS ESSENTIAL THAT OTHER IMPORTANT QUESTIONS SUCH AS GROUP SIZES, BREEDS, MANAGEMENT PROCEDURES, ETC. SHOULD BE RECORDED ON THE REC SOP RECORDING SHEET

APPENDIX I: LETTER TO VET

West Hill Veterinary Practice
West Hill
North Moor
Warwickshire
CV1 2AB

16 May 2007

Dear Sir/Madam

RE: EU Lamecow Project

As you are probably aware, your client Mr Farmer has been recording cases of lameness for the Project for the past 3 years. The farm has also been visited on 7 occasions to assess the risks for lameness and locomotion score the cattle.

The second part of the programme is to instigate the findings of the first years of the project and in addition to make recommendations to reduce lameness in the future. The Warwick team, including Roger Blowey, will visit your client's farm over the next six months to do this. A list of recommendations will be left on the farm.

The purpose of this letter is to ensure you are aware of what is happening. Our recommendations should in no way influence any of the advice you would normally give in your daily work.

If you have any queries, please contact any members of the Warwick team on the phone numbers given below.

Yours faithfully

Zoe Barker
Roger Blowey
Joanne Wright
Jonathan Amory
Laura Green

Ecology and Epidemiology Group
Department of Biological Sciences
University of Warwick
Coventry, CV4 7AL

Tel: 024 765 28368
Fax: 024 765 24619
Email: z.e.barker@warwick.ac.uk

APPENDIX J: PRE-INTERVENTION VISIT INFORMATION

Farmer/Herdsman: Mr Farmer
Farm Name: Church Farm
Address: East Hill, North Moor, Warwickshire, CV1. 2CD

Farm Level Data

	Avg Herd Size	Mean Loco Score	Mean Clean Score	Mean Hock Score	Propn Loco Score 3	SU Rate	WLD Rate	DD Rate
Farm Avg	254	1.91	2.55	1.40	17.50	15.42	25.80	9.75
Study Avg	107.30	1.75	2.26	1.28	9.57	6.69	6.15	6.531

Parlour Type: Herringbone 18/18
Current footbathing routine: $CuS0_4$ Once a week
Cubicle training: Hf Reared in cubicles
Standing time at milking: 210mins

Group Level Data

Area Name	No. Cows in house	No. Cubicles	No. Cubicle/ Cow	Cubicle Base	Bedding Type	Min Passage Width	Max Passage Width	Auto Scrapers Y/N
High Yield	189	172	0.91	Concrete	Sawdust	2.12	4.1	No
Low Yield	23	27	1.17	Concrete	Sawdust	2.71	4.71	No
Dry Cows	32	27	1.19	Concrete	Sawdust	2.71	4.71	No

Area Name	Tot Space (sqm)	Tot Space/ Cow (sqm)	Lying Space (sqm)	Lying Space/ Cow (sqm)	Non Lying space (sqm)	NonLying Space/ Cow (sqm)	Separate Loafing Yards
High Yield	780	4.14	475	2.52	411	2.18	Yes
Low Yield	240	10.43	68	2.96	135	5.87	No
Dry Cows	240	7.50	68	2.13	135	4.22	No

Area Name	Feed Space (m)	Feed Space/ Cow (m)	Average Faecal score	Footbath Used Y/N
High Yield	135	0.72	2.47	Yes
Low Yield	17.5	0.76	2.3	Yes
Dry Cows	17.5	0.55	2.38	Yes

Comments:

APPENDIX K: OVERALL IMPRESSIONS SHEET

Farmer/Herdsman	
Farm Name	
Date of Visit	
Name of Recorder	

General Farm Impressions

Target Area	Very Poor	Poor	Adequate	Good	Very Good
Hygiene					
Cow comfort					
Standing times					
Floor quality					
Animal movements					
Footbaths					
Transition period					

Comments:

Impressions of farmer/ herdsman and response to interventions

	Negative	Neither	Positive
General attitude of the farmer			
	No Control	Some Control	Total Control
Level of control of farmer/ herdsman spoken to			
	Enthusiastic detailed interaction	OK Some interaction	None or negative interaction
How well was recommendation received			
	Yes	Don't know	No
Does the recorder think the recommendations will be met			

Comments:

APPENDIX L: OVERALL IMPRESSIONS OF VISIT

EU LAMECOW – KEN HEDGES, MANOR FARM

The farm already has a very low incidence of lameness. The following points are made as an additional explanation of the main summary sheet.

1. Cows exiting from the parlour have to make a sharp turn and then step down. The combination of an increase in load bearing on the foot and a swivelling on the hoof will give additional pressure and this will predispose to hoof lesions. A strip of rubber belting would fit extremely well along the lower concrete on the exit from the parlour.

2. Digital Dermatitis. You are fortunate in that you are one of the few herds without digital dermatitis. The only way to be reasonably sure of not getting any infection is to stop buying in stock, or at least only buy from known digital dermatitis free herds (and there are very few of these!). General hygiene, i.e. visitors disinfecting boots and you disinfecting your own boots if you visit other farms, is also important. Sheep and contractors, especially slurry spreading, represent additional risks.

3. One of the causes of increased hoof lesions is trauma to the foot and this can be minimised by encouraging cows to lie down. Your mats are certainly good and will provide comfort, but I would prefer to see more bedding (e.g. a minimum of 15mm), to encourage cows to lie down even more. Any surplus straw would move out into the passageways, thereby soaking up some of the excess liquid and this would also be an advantage.

4. Treatment of lame cows. Use of blocks increases the speed of healing, it returns the cow more rapidly to normal milk production, minimises weight loss and the hoof produced on the non-weightbearing foot is of better quality. Use of blocks was discussed.

5. Increased use of cubicles by heifers might be achieved by:

   a. Removing the blind ending passage, by taking out the far end cubicle and allowing cows to move from the cubicle passage into the feed area at the far end of the shed. The missing cubicle could be made up by filling in the cubicle at the near end of the shed.

   b. Heifer cubicle training is a big advantage. The main hoof problems originate at calving, in that heifers that spend excessive time standing around the time of calving are likely to develop hoof lesions (sole ulcers and white line disease) 2-3 months later. If your heifers could be trained to use the cubicles well before calving, then this would be a big advantage. Suggestions made included:

- construction of cubicles in the heifer rearing shed
- bring heifers into the cubicles during the summer months, when the cows are not using them
- mix heifers with milkers for 2 months prior to calving, so that they will have already adapted to the cubicles (this was your preferred option).

6. The concrete track running out to the pasture was good, but as with any track, it is important that you keep it regularly brushed to ensure there are no stones on it.

    - if the field end of the track could be raised, so the cows had to step up onto it, that would also be an advantage, as it would reduce the number of stones carried onto the concrete when cows return from grazing.

    - there is enough space on the left-hand side of the gateway to construct a compacted chalk track for the cows. Tractors would have enough space to pass along beside it.

7. Use of biotin at 20mg/cow/day reduces white line lesions. This can be incorporated into the concentrates.

If any of the above recommendations are not clear, please phone the Lame Cow office on the above number and we will contact you.

APPENDIX M: RECOMMENDATIONS SUMMARY SHEET

Farmer/Herdsman:	Mr Farmer	Farm Name:	Church Farm	Date of Visit:	17 /11 /04

	Recommendations *(include detail on specific values)*		Strength of advice			Farmer response		
No	Recommendation	Aim/Target Area of Recommendation	Should Do	Must Do	Cow Group & House Name	No	May do	Yes definitely
1	Rubber belting along parlour exit.	Allowing cows to place their feet more carefully. Walking on rubber matting to reduce white line disease.	X		Milkers and parlour			X
2	Stop buying in any further animals.	As digital dermatitis is not present on the farm. Not buying in stock to prevent risk of getting digital dermatitis.	X		All groups		X	
3	Increase straw on mats to 15mm.	Increase cubicle comfort to increase lying times to reduce sole ulcers and hock lesions.	X		Milkers in cubicle house			X
4	Put blocks on cows with hoof lesions, applying block as described.	Reducing the spread of pathogenic organisms and improving healing, by applying a block. To increase healing and quality of hoof.	X		All groups			X
5	Remove blind ended passage ways, by removing a cubicle at the far end of the building, adding extra cubicle near loafing yard end.	Reducing standing time on concrete, by removing blind ended passage ways. Adding the extra cubicle to replace removed cubicle.	X		Milkers and cubicle house		X	
6	Add Biotin at 20mg/cow/day.	Reduce digestive upsets due to dietary change by adding biotin to decrease the level of white line disease in older cows.	X		All groups			X
7	Cubicle train heifers (summer calving) during the summer for 3-4 weeks. Or mix heifers with milkers a few months before calving (winter calvers).	Reducing trauma in freshly calved heifers due to concrete to reduce hoof lesions and hock sores.	X		Heifers			X
8	Improve track by scraping more often and have a strip of quarry belting or chalk.	To reduce sole ulcers and white line disease.	X		All groups		X	

APPENDIX N:SUMMER & WINTER RISKS

Winter risk factors

Farm Name

Date of Visit

Milking routine

Cow flow	Y/N
Parlour exit width is adequate for number of cows leaving parlour (6')	
Cows flow into collecting yard from the back and entrance is wide enough	
Width parlour entrance: Width CY entrance:	
Cows exit parlour in a straight line	

Floor Quality	Y/N
There is pooling in the collecting/dispersal yard	
There is rough concrete in collecting yard	
There is rough concrete in parlour	
Collecting yard floor is grooved	
Parlour floor is grooved	
Parlour exit is grooved	
There is rubber in the collecting yard	
There is rubber at the parlour exit	
There is rubber in the parlour	

Standing times	Minutes
How long are the cows shut in the collecting yard before milking	
How long are the cows shut in the dispersal yard after milking	
How long does milking take	
	Y/N
Are the cows milked in groups	
Hygiene	Y/N
Collecting yards are scraped before milking	

Feeding/loafing yards	Y/N
Loafing yard is present	

Floor quality	Y/N
There is rough concrete in loafing yard	
Feed/loafing yard floor is grooved	
There is pooling in the feeding/loafing yard	
There is rubber at the feed face	

Standing Times	Y/N
Out of parlour feeders are in and open area of yard and do not cause a blockage	
Cow Flow	
Feed passage/yard has 2m per cow standing plus 2m passing space.	

Milkers Cubicle House

Cow Flow	Y/N
Passage ways in milkers house are 10' (3m) or more wide	
There are no blind ended passage ways in the housing	
Cows can access all of house immediately after return from parlour *(i.e. no areas of the house are restricted causing blind ends etc)*	

Floor Quality	Y/N
Any slatted areas level and flush with surrounding concrete	
There is pooling in the cubicle house	
The milkers house floor is grooved	

Cow comfort	Y/N
Cubicles are free from foreign objects	
Cubicle base is level	
There are mats/mattresses in cubicle beds	
Milkers bedding depth is adequate.	
Loose straw, 10kg/cow; Straw on cubicle, 60mm; Straw on cubicle with mat, 15mm; Sawdust on cubicle with(out) matt, 10mm; Sand on cubicle, 100mm.	
Brisket board present at correct position (5'8"-5'10")	
Brisket board required (5'8"-5'10")	
Cubicles are correct length (~7'6")	
Lunging space is adequate (1.5m in front, less ok if space to lung at side)	
Side rail is at correct height (~20")	

Standing Times	Y/N
Feed space per cow is adequate (0.8m/cow) **measure amount again:*	
Number of cubicles per cow is adequate (10% more cubicles than cows)	
Number cubicles	
Number cows	
Stocking density in loose housing is adequate (above 7sqm/cow)	

Hygiene	Y/N
Scraping around OP feeders is adequate number of times/day:	
There are large quantities of slurry/manure at parlour exit.	
Milkers house is scraped at least twice daily	

Ventilation	Y/N
House doors are left open for ventilation	
Sides of house are open/semi- open	

Dry cow house

Floor Quality	Y/N
There is pooling in the dry cow house	
The dry cow house floor is grooved	

Cow comfort	
Dry cow bedding depth is adequate	Y/N
Loose straw, 10kg/cow; Straw on cubicle, 60mm; Straw on cubicle with mat, 15mm; Sawdust on cubicle with(out) matt, 10mm; Sand on cubicle, 100mm.	

Standing Times	Y/N
Passage ways in dry cow house are 10' (3m) wide	

Hygiene	Y/N
Dry cow house is scraped daily (unless very low stocking density)	

Heifer cow house

Floor Quality	Y/N
There is pooling in the heifer house	
The heifer house floor is grooved	

Cow comfort	Y/N

Heifer bedding depth is adequate	
Loose straw, 10kg/cow; Straw on cubicle, 60mm; Straw on cubicle with mat, 15mm; Sawdust on cubicle with(out) matt, 10mm; Sand on cubicle, 100mm.	

Footbathing and lameness control	**Y/N**
Footbathing of milkers is adequate (5x week 4% form)	
Position of footbath is adequate (more than one parlour side away from parlour exit, level etc)	
Footbathing of dry cows is adequate (1/week)	
Footbathing of heifers is adequate (1/week)	
Footbath is permanent/ concrete	
Footbath has ridges	

	Y/N
If DD lesions are treated and covered.	
Foot trimming reactive only	
Foot trimming is preventative and reactive	
Frequency of preventative trimming	
Blocks used on cows with lesions	
Hospitalise/Isolate severely lame cows in straw yard	

Transition/Integration into milking herd	**Y/N**
Heifers are trained in cubicles for 2 or more weeks in summer when cows out	
Heifers are reared in cubicles	
Heifers are exposed to concrete before enter herd	
Heifers are mixed with dry cows before enter herd	
Heifers are introduced to milkers and milking routine for 2-3 weeks before calve	
Concentrate intake is less than 12kg/cow/day in HY cows	
Max amount of concs fed to HYnot reached till 3+ weeks post calving	
Fresh calves cows are housed in a separate maternity group	
A transition diet is fed: to dry cows / heifers / both **circle*	
for how long before calving is it fed	
Heifers are housed with: dry cows / milking cows / heifers only **circle*	

Other

Biosecurity	**Y/N**
Is farm a closed herd	
Are bought in sheep footbathed when arrive on farm	
Is 4 weeks left between sheep and cows grazing the same pasture	

Biotin	**Y/N**
Biotin is included in the ration at 20mg/cow/day	

Summer risk factors

Farm Name

Date of Visit

Milking routine

Cow flow	Y/N
Parlour exit width is adequate for number of cows leaving parlour	
Exit width:	
Number of cows leaving parlour at once:	
Cows flow into collecting yard from the back and entrance is wide enough	
Enterance width:	
Cows exit parlour in a straight line	

Floor Quality	Y/N
There is no pooling in the collecting/dispersal yard	
There is no rough concrete in collecting yard	
There is no rough concrete in parlour	
Collecting yard floor is grooved	
Parlour floor is grooved	
Parlour exit is grooved	
There is rubber in the collecting yard	
There is rubber at the parlour exit	
There is rubber in the parlour	

Standing times	Minutes
How long are the cows shut in the collecting yard before milking	
How long are the cows shut in the dispersal yard after milking	
How long does milking take	
	Y/N
Are the cows milked in groups	
Maximum size of group:	

Tracks/Walkways

	Y/N
Track/walking surface is free from pooling/ muddy areas	
Track is not on a steep slope	
There is rubber on the tracks	