Productivity, Management and Disease in Dairy Cattle

D. N. Logue
SAC Veterinary Services
Dairy Health Unit, SAC AYR KA6 5AE
Scotland

Abstract

There is a widely held view that increased productivity and intensification of dairy cow management is necessarily associated with reduced welfare and conversely extensive systems are good. This is a gross over simplification and in some cases plainly wrong. However the main problem besetting the industry is that we still have no reliable measure of how well the cow is coping with the stresses imposed by this search for greater efficiency. The three main reasons for involuntary culling are infertility, mastitis (including SCC) and lameness. Together with weight and condition score and some simple behavioral parameters these offer a practical yardstick to measure herd welfare. However we still need to develop our understanding of the fundamental etiology of these conditions and the cost benefits of any management intervention since we may well need to weigh them differently under different circumstances.

Introduction

It is well recognised that the pressure of improved productivity or perhaps more appropriately, efficiency, is one of the major reasons for changes in management and that these alterations can then influence the incidence and prevalence of a number of diseases in dairy cattle. It is daunting that although this paper is being given in a session on Cattle Welfare there is no mention of welfare in the title. Yet this is the very word which every young vet in the UK uses as part of the admission statement to the Royal College of Veterinary Surgeons ". . . . *my constant endeavour will be to ensure the welfare of animals committed to my care.*" Furthermore, it has always been recognised that welfare was more than just freedom from disease. One has just to look at the curriculum of the veterinary course 50 years ago to recognise this. However in the last few years the definition of welfare has been more critically evaluated than hitherto. This need for the more scientific appraisal and consideration of animal welfare was recognised in the UK in the rather simplistic five freedoms (freedom from hunger and thirst, discomfort, pain injury and disease, to express normal behaviour, and finally freedom from fear and distress) which Webster (1995) refines with the rider that the animal should be able to resolve potential problems raised by the limitation of these freedoms by conscious action. In fact even this is not all encompassing as in some cases, especially disease, the cow cannot do this and stockmanship and treatment is required. The prevention control and treatment of mastitis serves as an example.

Animal Welfare and the National Interest

One over-riding criterion in the development of a strategy for animal welfare has been the cost benefits of interference. This need to consider cost-benefit of interference. This need to consider cost-benefit has been something which in the last century a number of governments including the UK government have seen fit to undertake. One area which saw considerable endeavour was the understanding and control of large scale epidemic disease. In a number of cases starting with Rinderpest in 1865, it has considered that in the national interest there is a cost-benefit in financing (or more usually these days underpinning) an eradication programme of a number of epizootic or zoonotic diseases - the so-called "Notifiable Diseases" (Anon 1995). Such a freedom has its price in terms of susceptibility (vaccination may be banned to allow recognition of such entry) and of course there needs to be a system of surveillance and an ability to trace and regulate animal movement.

For many diseases government rightly or wrongly has judged that there is no cost-benefit advantage to society as a whole to control. However it has been prepared to do two things. Firstly, it has been prepared to fund research into understanding some of the issues involved. Secondly, in addition to research and development government legislates in order to prevent the more extreme cases of inadequate welfare. In the UK it uses a number of regulations governing welfare in intensive units, transport, marketing and slaughter of animals which are supervised by the State Veterinary Service.

Leaving aside the issues of fairly clearly defined lack of welfare or cruelty, government has preferred not to be involved in the more contentious areas of welfare. However there is increasing politicisation of the welfare issue and this has ramifications for us all. Recently in the UK we have seen the effect of politics in terms of calf export and BSE. These show that when such issues reach into large scale politics with major coverage in the popular daily press, suddenly money is found which in cost benefit terms would have been much better invested 10 to 20 years ago. While such cost-benefit analyses have been recognised for a long time it has

Presented at the XIX World Buiatrics Congress, Edinburgh, Scotland, July 8-12, 1996.

only been relatively recently that complex methods of analysis commonly referred to in the jargon as modelling have been applied to allow the cost benefit appraisal of management strategies broadly considered to be related to welfare (McInerney 1991). An exploratory study of the willingness of people to pay for welfare essentially found that the greater the perceived problem of welfare the greater the preparedness to pay. However this was influenced by the level of information (presupposing it to be accurate) and there was a strong expectation for the common good or tax man to pay some of this price (Bennet 1996). Furthermore the furore in the UK over the past 2 months over the BSE illustrates that the perception of human safety has a much greater importance in public and political perception than animal welfare. While at the time of writing the public generally has not been aware of the real difficulties in animal welfare terms associated with this crisis for the industry one suspects that if there was a direct choice between food safety and animal welfare then the former would be paramount. With even stronger justification one could say the same about starvation.

Ignoring the effects of BSE in overall terms the three most important reasons for reduced production in the UK dairy cattle industry are infertility, mastitis and lameness (Benyon 1976, Esselmont and Peeler 1993). These feature strongly in every farmer survey of constraints on efficiency or production and of reasons for culling. In view of what is happening at present it may seem obtuse but nevertheless if involuntary culling (ignoring BSE) could be totally eliminated, then the UK industry would conservatively save around £100 / cow in production /year. While it is unlikely all such culls could be stopped, a one percent per annum improvement in culling would give a benefit of £4 to £11/cow / year (Stott 1992). Thus if research and development funding for the reduction of these problems would yield such a return (i.e. a one percent reduction in involuntary culling) at a ratio to the investment of 10:1 then for these areas of study and development alone the UK investment would need to be at a level of £3 million per year. While we cannot claim to have been funded at this level, nevertheless there have been a number of UK studies which might be useful as a means of discussing this theme and relating it to the broader issue of animal welfare. This concentration predominantly on our own research is not done in any jingoistic sense, (since there are many other excellent studies elsewhere) but because there are studies close to home and thus easier discussed.

Welfare, Efficiency and Intensification

It is a widely held assumption that welfare is compromised at the level of intensification in animal production seen in some parts of Europe and elsewhere in the world. For generations dairy cattle have been bred and selected for a number of characteristics all with the aim of increasing productivity. The most direct means was to select for milk yield and, with a few exceptions, this has been the major selection criterion for the past 50 years. Such breeding aims have now been generally recognised as simplistic and more complex measures conferring efficiency of production are now being generally sought and used (Veerkamp *et al* 1995). Nevertheless the present dairy cow in the UK is such that given adequate nutrition she can vastly out yield her primeval ancestor. It is impossible for us to ignore the influence of nutrition in any discussion of the welfare of the dairy cow. All mammals experience a period of negative energy balance following parturition when feed intake, even if in plentiful supply, does not meet requirements. Modern dairy cows have an ability to yield very large amounts of milk at considerable expense to themselves (Webster 1995). In order to limit the effects of this, research has developed a means of analysis of foodstuffs, dietary formulation and predictors of response which, if applied correctly, have considerably aided in ensuring that the metabolic knife edge of balancing input, internal catabolism (so-called "milking off the back") and output is met within the normal coping mechanisms of the cow. However some believe that there are potential problems with the high levels of wet grass silage fed in certain areas such as our own in south-west Scotland (Webster 1995).

Study at the SAC Crichton Royal Farm comparing a lower and higher input system comparison (Bax & Thomas 1992) illustrates the way in which the cow uses her body condition to balance input and output and that this mechanism is more utilised in the low input system. This agrees with the data from a similar but less extreme comparison at Langhill (Veerkamp *et al.*, 1994). One must agree with Webster (1995) that there is a limit to the extent that one can ask the cow to do this. Management should balance these opposing needs for efficiency and forcing the cow towards the edge of her capability to cope. While this is clearly desirable it needs some bench marks which recognise the extent of coping of the cow and whether the stresses she is under are unacceptable. Unfortunately we have no simple parameter to determine this and generally all involved in such studies are tending to an evaluation of a number of parameters of well being. This includes the use of health targets (Esslemont and Peeler 1993) productivity such as protein percent (Dewhirst *et al.,* 1995) and aspects of behaviour (Manson & Appleby, 1995). As part of the drive for increased efficiency or even in some cases the opposite, such as an uninformed desire to increase welfare by refusing, say, antibiotic treatment, these various interactions between the animal, management and her environment can further influence the development of reduced welfare. For example, unless there is some man-

agement intervention, herds in Scotland on low input systems are at risk of hypomagnesaemia when first introduced to grass in the spring. In other words the insult (in this case a deficiency) has been enlarged by management. Other mechanisms which may be effected are an increase in the level of infection, allowing enhanced transference of infection, and perhaps even reducing the resistance of the host. Cases can be made for both extensive and intensive management systems leading to these changes.

Reproduction

Failure to be put back in calf at the correct time is the most common cause of culling. The average UK dairy herd, and Scotland is no exception, has a relatively low overall heat detection and conception rate (Esslemont and Peeler 1993). While the former could be legitimately argued to be a problem of technology transfer (and indeed some units are very much more successful than average) the latter is much more difficult to influence. Although there are detractors it is considered by many that reproductive failure is becoming more common and in some way it is related to the increased productivity (Grohn *et al.*, 1994; Kossaibati & Esslemont 1995). At a practical level Ryan & Mee (1994) showed an association between grass height and fertility in spring calving cows mated at grass under low input conditions in southwest Ireland.

Recent developments in understanding the physiology of the ovary and the development of the embryo and their possible relationship to production and management suggests that these associations with nutrition and output may be real. For example, studies at the Roslin Research Institute have shown that giving exogenous rBST to heifers, alters the dynamics of the follicular wave disrupting the selection of the ovulatory follicle and leading to an increase in the number of multiple ovulation (Webb *et al.,* 1994). This may at least in part explain the substantial rate of prolonged progesterone phase profiles seen in a SAC study of post calving and breeding Scottish cows in a number of herds. This extended period could occur either through impaired luteal function or loss of the late embryo which is more likely with a multiple pregnancy (Ball *et al.,* 1995). We believe that there is a relationship between production, management and these phenomena and that study of these factors will allow us to develop a measure of the extent that the cow is coping with her environment rather than luxuriating in it.

Lameness and Associated Behaviour

Lameness in dairy cows is found in all the major dairying countries and is a major cause of poor welfare and economic loss. In intensive surveys (Clarkson *et al.*, 1993) the incidence has been shown to be as high as mastitis running at approximately one third of cattle being treated per year. A simple break-down of the various lesions causing lameness shows that the claw is the seat of lameness in approximately 75% of almost 20,000 observations. Furthermore there is an irregular distribution of these claw lesions with over 75% being found on the outer claw of the hind foot. For this reason in our studies in Scotland we have concentrated on trying to understand the development of these conditions affecting the claw.

A common finding from early SAC reductionist studies of the influence of nutrition was that a considerable proportion of the young first calving Friesian-Holstein heifers showed severe lesions of the claw and were more likely to exhibit lameness than older, similarly affected cows (Logue *et al.,* 1994). Work in Scotland involving SAC, Edinburgh University and the Hannah Research Institute has therefore concentrated upon obtaining information on lameness and lesion development in first calving heifers. The majority of this work has been carried out at the SAC Acrehead unit which, as already mentioned, allows a comparison of the effects of two very different management systems (Bax & Thomas 1992). The development of image analysis techniques for the study of the development of lesions of the bearing surface of the claw (Leach *et al.,* 1994) and histological techniques including EM have all been of importance in further defining these lesions and characterizing their development (Kempson & Logue 1993; Offer *et al.*, 1996). Other specific studies have been carried out at the main unit Crichton Royal Farm and the Hannah Research Institute. The latter have also been developing a biopsy and tissue culture method to enable study of the exact format of this disruption leading to impaired hoof horn formation (Hendry *et al.,* 1995). Recently we have been able to apply behavioural observations across study groups when they are housed after a period at grass with clear evidence for an interaction between housing and calving (Chaplin *et al.,* 1996; Berry R. 1996 PhD thesis in preparation).

As far as the development of lameness is concerned our preliminary data comparing intensive with extensive systems suggests that intensification of the milking herd at the level seen in most farms in the UK is not of itself a major cause of lesions of hoof horn. It seems that heifer rearing is more important; the lower the baseline lesion score prior to calving the better. All the evidence is that this should be obtained by steady growth rates and training the animals to the various management regimes they are likely to encounter in later life. However, care is needed with the introduction of newly calved cows. This is especially the case for the autumn calving heifer which in Scotland is generally calved at grass and then housed soon afterwards in a cubicle house. Good

cubicle comfort and adequate access to forage is essential. In summary, care of the young cow will mean fewer lesions in older ones! It can be seen that much of this advice could be interpreted as reducing "stress". It is for this reason that study of behaviour is important as it may serve to identify the trigger to the severe outbreaks of lameness seen in some farms. Finally, at the risk of being controversial, it may well be worthwhile considering the use of crossbred dairy cows which have other advantages in terms of efficiency and disease resistance.

Mastitis and SCC Control

Webster (1995) raised the possibility that the immune system might be impaired by increasing stress and as a consequence there might be an increase in the incidence and prevalence of mastitis. As with lameness our preliminary observations have failed to show any evidence of this as yet. However, work involving colleagues at Glasgow and Strathclyde Universities has shown the need for in-depth study of the interaction of the agent causing mastitis and the animal. Firstly, we consider that mastitis even in the subclinical state causes pain since one of the group has found evidence for a number of mediators of pain in milk from mastitic animals (Eshraghi *et al.,* 1995). Secondly we have shown that there are a wide variety of DNA types of *S. aureus* involved in causing mastitis particularly subclinical mastitis and these can be quite specific to the herd (Platt *et al.,* 1995). Alongside this we have preliminary evidence that these strains have different abilities in terms of stimulating a proliferative T-cell response. Furthermore not only does the agent modify the response but it would appear so does the genotype of the host (Logan *et al.,* 1996). Thus there are a whole series of issues regarding the host-pathogen interaction which need to be better investigated before we can begin to address Webster's hypothesis.

However, perhaps more relevant to the title are some aspects of the interrelationship between subclinical mastitis and production and management which return to initial theme of cost-benefits. In 1992 the EC required that all milk for intracommunity trade should meet certain hygiene standards (EC 92/46). Thanks to a derogation these standards will not be fully applied until the end of the next year. Nevertheless in 1990 these standards presented considerable difficulties with approximately 20% of Scottish producers regularly exceeding this figure. As a result a joint project was undertaken with the three Scottish Milk Marketing Boards (now deregulated) to develop technology transfer for the control of subclinical mastitis. Subsequently for the last two and a half years, thanks to EC funding, we have been able to apply this technology transfer to help producers meet these new standards. Part of the study involved convincing the producers of the cost benefit such action might bring. This was essential because at that time the penalties for failing to meet returns were rather small due to the desire for milk buyers to recruit producers at the start of a deregulated market. This coincidence of deregulation with a drive to control SCC was, to be polite, unfortunate! More recent studies on the Isle of Man have shown just how successful a properly coordinated campaign can be (Chaplin *et al.,* 1996).

Cost Benefit Analysis

However by using linear and general regression models based on these Scottish data it has been calculated that milk yield loss due to SCC varied from 0.64 l/day in low SCC herds (SCC < 148,000) to 3.43 l/cow/day in high SCC herds (SCC > 400,000) with the loss for each 100,000 increase in SCC varying between 0.6-1.7 litre/cow/day (Yalcin C. 1996 PhD thesis in preparation). Thus a reduction in SCC and so an increase in cow welfare will bring direct benefit to the producer. Using this estimate of milk reduction, which was the most important component of financial loss due to high SCC in the data available (culling was not included) it was now possible to calculate the likely cost benefit of a number of management strategies for controlling subclinical mastitis. In summary there seems to be a sizeable interaction of management practices with the type of milking system (parlour or byre) and thus these figures are for parlour only. There are two ways this cost-benefit can be described, either as a marginal return i.e. total saving or if funds are limited due to a restriction of access to a capital market then one should prioritise the mastitis control procedures by ranking them according to their return from £1 investment. In parlour based systems both highest marginal return and £1 investment return were greatest for dry cow therapy while post milking teat dip (PMTD), as long as it was not preceded by washing with water in a premilking routine, gave a higher return for both parameters than the employment of a regular machine test. (Yalcin C. 1996 PhD in preparation). It is interesting to note that the milking machine test was one of the most commonly introduced management strategy over the period of the project. Cynically one could suggest that it was a simple thing for the herd to undertake and did not involve them in any extra effort. Nevertheless, despite this cynicism, it was clearly of some benefit.

Recently this same group has been involved with other veterinary colleagues in a study of the cost-benefit of preventing and treating outbreaks of calf scour and pneumonia (Gunn & Stott 1995). In this study large numbers of cases were of low cost but these were balanced by a lesser number of severe and costly outbreaks. This has led to a decision matrix aimed at reducing the

risk of the more serious outbreak. Thus in these days of rapidly reducing resources it is essential that the application of effort is concentrated at the best point.

Conclusion

This influence of cost-benefit has been operating for as long as man has been trading in animal products. The "market" has been subtly evaluating a cost benefit between the means of production, the product and its image. The increasing need to appear to have a high welfare image can be seen by the spawning of a plethora of Assurance schemes. Virtually all of these are built around the five freedoms and some have a very high standard of specification. Yet one is well aware of cows being kept in buildings which do not reach these standards but which house cattle which are apparently more content than others in more salubrious surroundings. The need for an accurate measure of "cow contentment" is obvious and would save a lot of wasted effort in trying to write and rewrite farm assurance guides! One has to wonder whether in cost-benefit terms such effort could be more usefully applied in other methods of technology transfer. Finally it has been suggested that only in a market with surpluses and a prosperous customer can the apparent luxury of considering the needs of the animal be made. However it is hoped that the principles of these analyses could be applied to other areas and if our experience is a guide, then in every situation there is an optimum which will not only increase the welfare of the cows but should also help the farmer relieve his stress by making a profit.

Acknowledgments

The author gratefully acknowledges all his colleagues who allowed him to use their preliminary data and also the various funding bodies who have supported all these studies; the EC, the three MMBs in Scotland, the Animal Health Trust, MAFF, the Wellcome Trust, the Nuffield Foundation and of course the Scottish Office Agriculture, Environment and Fisheries Department.

References

Anon (1995) Introduction. *State Veterinary Journal (Special Issue Notifiable Diseases)* 5 3. Ball P.J.H., Logue D.N., Crawshaw M., & McEwan E.E.A. (1995) The use of real time ultrasound scanning to confirm embryo and early foetal losses in dairy cows as deduced from milk progesterone profiles. *Society for the Study of Fertility Annual Conference Dublin 1995 Journal of Reproduction and Fertility Abstract Series* 15 73-75 (Abst). Bax J.A. & Thomas C. (1992) Developments in legume use for milk production. *British Grassland Society Occasional Symposium No. 26*, pp 40-53. Bennet R.M., (1996) People's willingness to pay for farm animal welfare. *Animal Welfare* 5 3-11. Benyon V.H., (1976) The disposal of dairy cows in England and Wales. *Veterinary Annual (Edit Grunsell C.S.G. and Hill F.W.G.)* 16 1-6. Chaplin S.J., Ternent H.E., Offer J.E., Logue D.N., Knight C.H., (1996) Behavioural aspects of sub-clinical laminitis in dairy heifers. *Association of Veterinary Teachers and Research Workers Jubilee Scientific Meeting 2nd - 4th April 1996,* p56 (abst). Chaplin S.J., Wilson B., Campbell L., Offer J.E., Gunn J., Ternent H.E., Allen C.F., Logue D.N., (1996) Somatic cell count control by the Isle of Man Milk Marketing Association. *Association of Veterinary Teachers and Research Workers Jubilee Scientific Meeting 2nd-4th April 1996,* p24 (abst). Clarkson, M.J., Downham D.Y., Faull, W.B., *et al.,* (1993). An epidemiological study of the risk factors of lameness in dairy cows. *Final report June 1993 The University of Liverpool (ref CSA 1379)* pp190. Dewhirst R.J., Moorby J.M., & Aston K., (1995) Definitions of quality and factors affecting it: milk composition in *Quality milk from grass. Proceedings of the British Grassland Society Winter Meeting 5th and 6th December 1994,* pp11-22. Eshraghi H.R., Zeitlin I.J., Ternent H.E., Logue D.N., Fitzpatrick J., (1995) Kinnins in bovine mastitis. *British Journal of Pharmacology* 116, 369p. Esslemont R.J. and Peeler E.J., (1993). The scope for raising margins in dairy herds by improving fertility and health. *British Veterinary Journal* 149 537-547. Grohn Y.T. Hertl J.A. Harman J.L., (1994). Effect of early lactation milk yield on reproductive disorders in dairy cows. *American Journal Of Veterinary Research* 55 1521-1528. Gunn G. & Stott A., (1995). Combining economic arguments and active surveillance to promote better management of endemic cattle disease. Hendry K.A.K., Lancelott M.J., Knight C.H., Kempson S.A., & Wilde C.J., (1994) Bovine lameness - a cell culture approach. *Proceedings of the VIIIth International Symposium on Disorders of the Ruminant Digit and International Conference on Bovine Lameness at Banff Canada 26th June to 30th June 1994.* Kempson S.A., Logue D.N., (1993). Ultrastructural observations of hoof horn from dairy cows, changes in the white line during the first lactation. *Veterinary Record,* 132, 524-527. Kossaibati M.A., & Esslemont R.J., (1995) *Wastage in dairy herds. Report no. 4, DAISY - the dairy information system, University of Reading* pp167. Leach K.A. Kempson S.A., Logue D.N. and Randall J.M. (1994a) Use of image analysis in studies of lesions of the sole & white line in cattle. *Proceedings of the VIIIth International Symposium on Disorders of the Ruminant Digit and International Conference on Bovine Lameness at Banff Canada 26th June to 30th June 1994,* p 32. Logan K.E., Platt D., Logue D.N., & Fitzpatrick J.L., (1996) Proliferation of bovine peripheral blood mononuclear cells to *Staphylococcus aureus in vitro* varies with *S. aureus* strain. *Association of Veterinary Teachers and Research Workers Jubilee Scientific Meeting 2nd-4th April 1996* p59 (abst). Logue D.N., Offer J.E. & Hyslop J.J. (1994). Relationship of diet hoof type and locomotion score with lesions of the sole and white line in dairy cattle. *Animal Production* 59: 173-181. Manson P.J., & Appleby M.C., (1990) Spacing of dairy cows at a food trough. *Applied Animal Behavior Science* 26, 69-81. Platt D.J., Candish D., Pyett H.E., Smith I.W., Sommerville, Gunn J., and Logue D.N., (1994) Genetic fingerprinting of *S. aureus* from mastitic milk samples. *Proceedings of the 45th Annual Meeting of the European Association for Animal Production, Edinburgh, 5-8th September 1994,* pp.200 (abst). McInerney J. (1991) Assessing the benefits of animal welfare. *In Farm animals it pays to be Humane ed Carruthers S A University of Exeter* pp 15-31. Offer J.E., Logue D.N., Fisher G.E.F., & Kempson S.A. (1996) Observations of sole lesions, hoof measurements and lameness during first lactation of heifers fed different diets in early pregnancy. *The 9th International Symposium on Disorders of the Ruminant Digit and The International Conference on Lameness in Cattle Mitzpeh Rachel Jerusalem April 14-19th 1996,* p38 (abst). Stott A. (1992) The cost of involuntary culling in the dairy herd. *A report commissioned by the MMB of England & Wales and the HFS, SAC Aberdeen* pp1-23. Veerkamp R.F., Hill W.G., Stott A.W., Brotherstone S., Simm G. (1995) Selection for longevity and yield in dairy cows using transmitting abilities for type and yield. *Animal Science,* 61, 189-197. Veerkamp R.F., Simm G., Oldham J.D., (1994) Effects of interaction between genotype and feeding system on milk production feed intake efficiency and body tissue mobilisation in dairy cows. *Livestock Production Science,* 39, 229-241. Webster A.J.F., (1995) Welfare strategies in future selection and management strategies. In *Breeding and feeding the high genetic merit dairy cow. Occasional publication No 19 British Society of Animal Science 1995 edit T.J.L. Lawrence Gordon F.J. & Carson A.* p87-93.