**The 83rd Annual Conference of the Agricultural Economics Society**

**Dublin**

**30th March to 1st April 2009**

# Trade-offs between conflicting animal welfare concerns and cow replacement strategy in out-wintering Scottish suckler herds

Bouda Vosough Ahmadi[ac], Colin A. Morgan[b] and Alistair W. Stott[a]

[a]Land Economy and Environment Research Group, Scottish Agricultural College, King's Buildings, West Mains Road, Edinburgh, Scotland EH9 3JG.

[b]Sustainable Livestock Systems Group, Scottish Agricultural College, Bush Estate, Penicuik, EH26 0PH, UK

[c]Corresponding author's email address: Bouda.v.ahmadi@sac.ac.uk

**Abstract**

Since decoupling of the CAP, many Scottish suckler cow farms are facing financial difficulties. In response, many farmers are out-wintering extensively managed suckler cows to minimise production costs. These systems are of animal welfare concern. A range of trade-offs between animal welfare indicators and between animal welfare and farm profitability can be identified. A Dynamic Programming (DP) model was developed to study these trade-offs. Two herds were modelled assuming their feeding regimes were either low (LHERD) or high (HHERD). The objective of the DP was to maximise the expected net margin from a current cow and its successors over an infinite time horizon. Preliminary results showed that the rate of voluntary culling was higher in HHERD than in LHERD. Animals in HHERD had shorter life expectancy. The expected net present value was 58% lower in LHERD than HHERD (-£41.5 and -£24.3 respectively). These results suggest a heavier culling rate and shorter longevity for animals in HHERD that compromises animal welfare. Also HHERD had a greater implied stocking density than LHERD. This increase of the cows' population may adversely affect the environment. The presented model provides some of the basic information required to explore some of the trade-offs between farm profit, animal welfare and the environment.

**Keywords and JEL codes (if available)**

**Beef cow, economics, dynamic programming, animal welfare**

## Introduction

In Scotland, 70% of the national herd is comprised of beef suckler cows (Scottish Executive, 2008). Since decoupling of the CAP, many suckler cow farms, which are often situated in disadvantaged areas, are facing financial difficulties (Scottish Executive, 2008). Relatively high fixed costs including hired labour costs, machinery running costs and land are major impediments to these enterprises competing in global markets (Oglethorpe, 2005). In response, many farmers are out-wintering extensively managed suckler cows to reduce costs. However, out-wintering herds may have important effects on the environment and on biodiversity. Nevertheless, reductions in livestock numbers in some regions due to poor farms profits is causing concern (SAC, 2008a). Moreover, extensive out-wintering systems are of animal welfare concern. Management and the physical and social environment of these herds may have a wide range of negative effects on animal welfare. For example animals might suffer cold stress and commonly loose weight (body condition) in potential breech of Farm Animal Welfare Council guidelines (FAWC, 2001). This can be alleviated by supplementary feeding to generate sufficient maintenance energy for the animals to maintain body condition but at significant cost. On the other hand, cows calving in high body condition may experience increased risk of calving difficulties, which reduces animal welfare. Also in extensive out-wintering systems, reproductive performance and animal fertility are the main determinants of production efficiency (Caldow et al. 2005) which are affected by both feeding regime and body condition. Besides the biological and physiological parameters, reproductive performance of the herd is highly influenced by reproduction management decisions such as replacement and re-breeding policy. These issues highlight a range of trade-offs between animal welfare indicators and between animal welfare and farm profitability. Bio-economic models provide useful frameworks to investigate the trade-offs between these

conflicting business and welfare concerns. The purpose of this paper is to study these trade-offs using dynamic programming (DP) and to examine the effects of farm management practises on animal welfare and profitability of out-wintered beef suckler cows.

**Methods**

A DP model (Bellman, 1957) of the out-wintering suckler cow replacement decision problem was developed. The objective of the DP was to maximise the expected net margins (i.e. expected net present value (ENPV) of returns expressed as an annuity) from a current suckler cow and future cows over an infinite time horizon by making appropriate replacement decisions. The possible decision options were either to 'keep' the current cow/heifer or 'replace' her with an in-calf heifer at the start of each stage (annual production cycle). In case of a 'keep' decision involuntary replacement was still possible as a result of failure during the calving interval (death, serious disease, injury etc.). Probability of involuntary replacement increased with parity (Table 1). The stage return for the 'keep' decision therefore included the expected cost of involuntary replacement following failure. Cows were represented by 210 states in the DP, 15 cow parity states (lactation), 6 21-day calving period states, 1 barren cow state and 2 body condition score (BCS) states.

In the most simplistic manner possible, low BCS ('thin') and high BCS ('fat') states represent the distribution of BCS states that cows in any herd might occupy. Any body condition score at calving of <=2.25 was regarded as 'low' and any body condition score of >=3 was considered as a 'high' BCS. These states can represent two groups of cows in any herd according to their overall body condition. The high BCS cows have good fertility (i.e. calving rate) but sometimes calving difficulties as a consequence of excessive condition. In general these groups represent a more animal welfare orientated management i.e. cows are considered free from hunger, one of the five freedoms set out by FAWC (2001) considered important for animal welfare. Cows in low BCS state have the reverse of these parameters set at slightly lower than typical of commercial production systems. Two hypothetical herds were modelled assuming parameters associated with managing a herd for either generally low (LHERD) or generally high (HHERD) BCS. Differences in herd management included feeding regime and hence cow-calf performance and feed costs reflected in the stage returns for each state in the DP. The transition probabilities between stages for BCS state reflected the tendency for high/low BCS cows to remain high/low. For simplicity, it was assumed that the LHERD consist of a homogenous population of low BCS animals and the HHERD consists of a homogenous population of high BCS animals (i.e. transition probabilities were set at 0 and 1). No interactions between states were built into the state transition probabilities. These interactions will exist in practice, for example high parity cows will have poorer fertility and a tendency towards lower BCS affecting their transition between calving and BCS states. However, the data needed to reflect these tendencies were not available so for the current study we required a baseline from which sensitivity analysis could later be conducted to explore possible impact of these effects.

Table 1. Age specific probabilities of involuntary culling.

| Lactation number | Probability of involuntary culling[1] |
|---|---|
| I | 0.0025 |
| II | 0.0230 |
| III | 0.0150 |
| IV | 0.0320 |
| V | 0.0460 |
| VI | 0.0440 |
| VII | 0.0280 |
| VIII | 0.0520 |
| IX | 0.0800 |
| X | 0.0500 |
| XI | 0.1250 |
| XII | 0.2100 |
| XIII | 0.2360 |
| XIV | 1.0000 |
| XV | 1.0000 |

[1] Probability of involuntary culling (i.e. due to death or health problems) adopted from Azzam et al. (1990).

In the LHERD performance of calves will be inferior to HHERD due to lower cow feed intakes, lower milk production and hence smaller calves at birth and lower calf growth rates thereafter. A longer period of in store feeding is required to reach the target weight at sale in the LHERD. Therefore, as in Varo Barbudo et al. (2008) a growth curve was used to estimate the growth of the calves from their date of birth to their sale date in the two modelled herds (Figure 1).

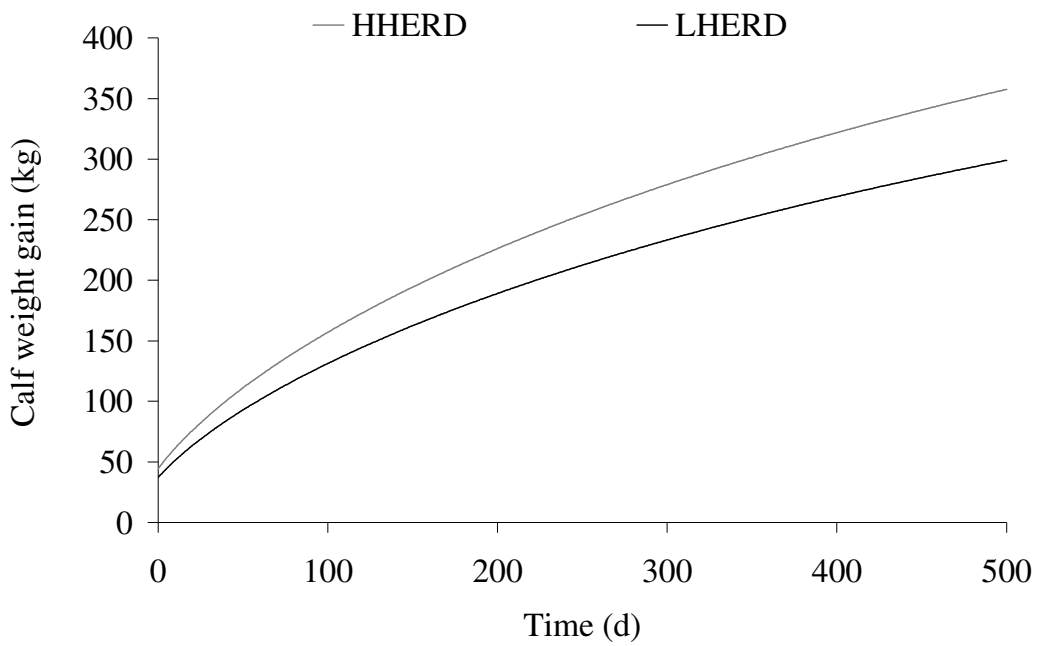


Figure 1. Growth curve used in the DP to estimate the growth of the calves from their date of birth to their sale date.

To establish the stage returns, a margin over feed supplementation and other costs were obtained for all possible states based on least-cost diets formulated using SAC's 'FeedByte' software (Schofield et al., 1999). This was done with a simple budget model in gross margin form using parameter estimates that were obtained either from the literature SAC (2008b) (Table 2) or from a survey of reproductive management in 66 spring calving commercial Scottish suckler herds carried out by Varo (2005) and reported by Stott et al. (2008) (Table 3).

Table 2. Financial and technical assumptions used in the DP model.

| Assumptions | Value | Unit |
|---|---|---|
| Discount rate | 5 | % |
| Calf sale price (live weight) | 1.55 | £/kg |
| Cull cow sale price | 509 | £ |
| In-calf heifer purchase price | 850 | £ |
| Net replacement cost | 341 | £ |
| Vet and medicines | 23 | £/cow |
| Bedding | 23 | £/cow |
| Commission, haulage and tags | 27 | £/cow |
| Feed and forage costs (high energy diet) | 0.88 | £/day |
| Feed and forage costs (low energy diet) | 0.72 | £/day |
| Cost of calving difficulties (BCS>=3) | 4.88 | £/cow |
| Cost of calving difficulties (BCS<=2.25) | 2.72 | £/cow |
| Total variable cost (HHERD) | 245 | £/cow |
| Total variable cost (LHERD) | 212 | £/cow |

The DP model was run separately using general purpose DP software (GPDP, Kennedy, 1986) for the two modelled herds. An optimal culling strategy associated expected net margin and long run (infinite) state probabilities for each herd were thereby generated. By changing key parameters in the DP and re-optimising, the impact of alternative assumptions and management strategies including over wintered body condition could be explored.

Table 3. Basic reproductive parameters[1] used to estimate the transition probabilities in the DP.

| | Post partum/post bull introduced oestrus cycle (21 days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| *Conception prob.* | | | | | | | | |
| Calved Cow | 0.00 | 0.00 | 0.55 | 0.65 | 0.70 | 0.70 | 0.70 | 0.70 |
| Heifer/barren cow | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 |

[1] Varo Barbudo et al 2008 and Varo Barbudo 2005.

**Results**

Preliminary results of the DP showed that the rate of voluntary culling was higher in HHERD than in LHERD (Table 4). Similarly, the HHERD had a shorter average life expectancy than the LHERD. The ENPV expressed as an annuity showed a 58% reduction in LHERD compared to HHERD (Table 4). The annuities of the keep decision in the LHERD showed less variation compared to HHERD. Annuities ranged

from a minimum of -£40.0 to a maximum of -£1.5 for the HHERD and from a minimum of -£55.6 to a maximum of -£20.6 for the LHERD.

Table 4. Effect of feeding regime in HHERD and LHERD on financial performance of beef suckler cows and their longevity.

| | ENPV annuity (£/cow/yr) | Voluntary culling (%) | Average age of herd (number of lactations) |
|---|---|---|---|
| HHERD | -24.3 | 3.3 | 4.5 |
| LHERD | -41.5 | 1.4 | 4.9 |
| Difference | 17.2 | 1.9 | -0.4 |

High BCS cows in the HHERD caused a higher voluntary culling rate in lactation number seven as well as lactations X to XIII than low BCS animals in the LHERD (Figure 2). As a result of this culling and replacement strategy, the age distribution of the animals in these two herds looks different (Figure 3). The HHERD had more cows in earlier lactations (i.e. I, II, III and IV) than the LHERD. The number of animals in the LHERD increased from lactation number V onward.

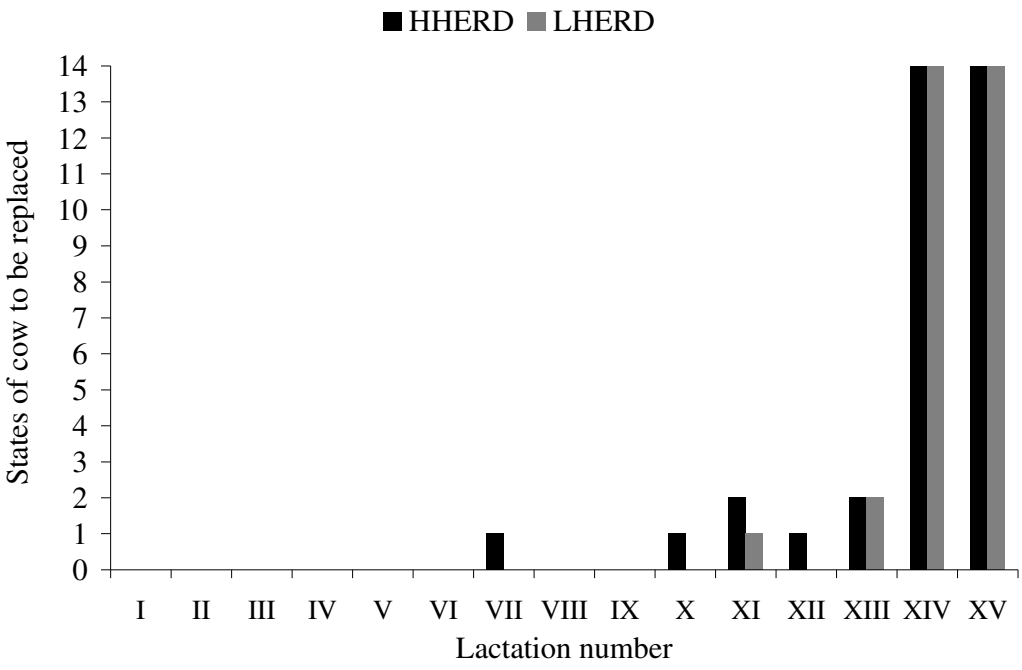


Figure 2. Optimum culling and replacement decisions in each lactation for an infinite time horizon generated by the DP for HHERD and LHERD.

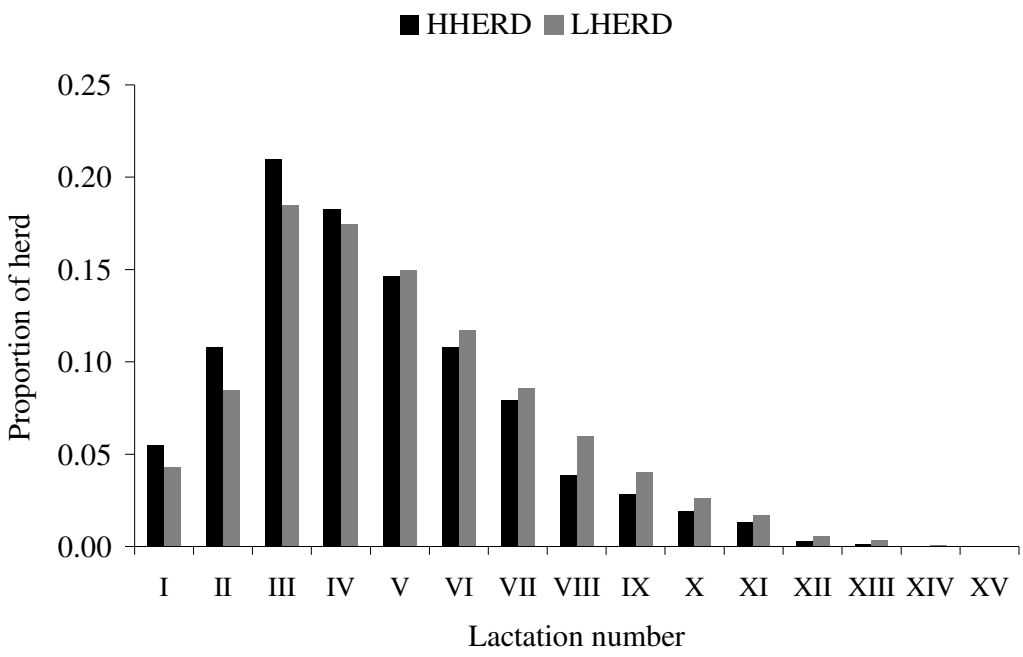


Figure 3. Age distribution of the animals in the long term predicted by the optimum replacement strategies for HHERD and LHERD determined by the DP.

Preliminary results show a poor profitability for both modelled herds (Figure 4). However, the HHERD was more profitable than the LHERD. In both herds, the first three calving periods (i.e. P1-P3) generated better figures suggesting the importance of early calving in typical spring suckler herds. Cows calving in the last calving period P6 had the least profitability in the LHERD. The negative impact of the barreners on profitability of the two modelled herds was close to the negative impact of late calving (P4-P5) but still had less adverse effects than calving in the last calving period (P6).

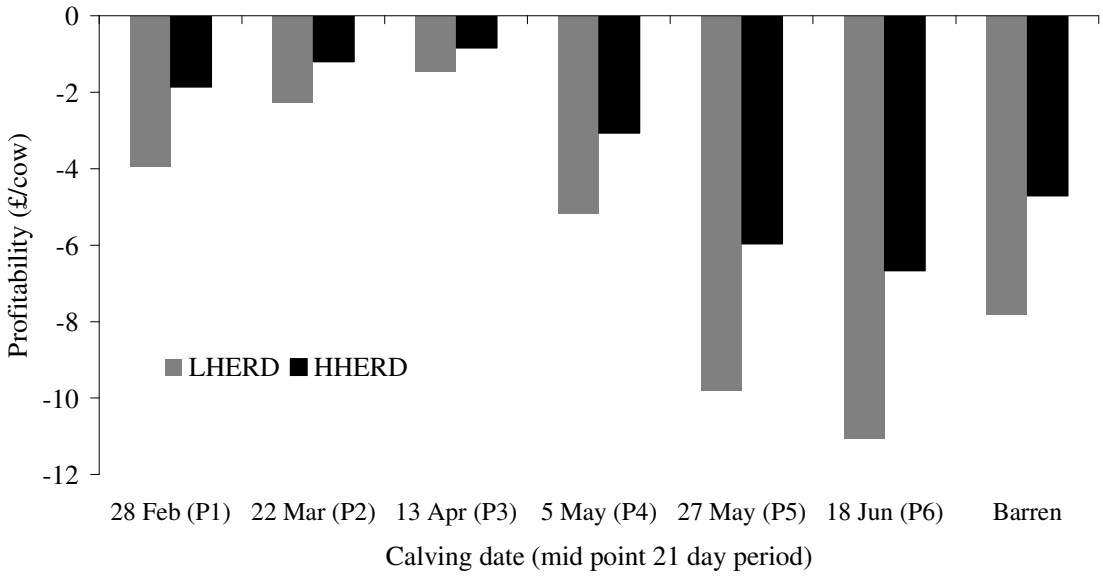


Figure 4. Contribution of alternative calving dates to herd profitability (annuity of cow) in the HHRED and LHERD spring calving beef suckler herds.

## Discussion

The expected trade off between animal welfare (higher feeding level) and profitability was not apparent in our results. Animals from LHERD suffered from lower nutrient intake (lower welfare) but were also less profitable than animals from HHERD. Achieving such improvements in BCS depends on a high energy feed regime in the winter time which adds some extra costs but these were outweighed by improved technical performances such as having a higher calf weight at birth as well as higher calf growth rate and eventually a higher generated revenue at sale. Obviously, our results are dependent upon the assumptions we made. There may well be circumstances in practice where a trade-off occurs. However, such trade-offs are not inevitable and there are probably many opportunities such as this to obtain a win-win for profit and for welfare in current farming practice (Lawrence and Stott, 2009)

We assumed a high BCS herd implies a better animal welfare status. However, the presented results suggest that animals in such herds are more prone to be culled and replaced by heifers and thus their longevity is shorter than the low BCS herds. In so far as longevity is a mark of good welfare there is a potential conflict here i.e. overall welfare may not be adequately captured by one index alone. This issue has been dealt with elsewhere e.g. by Vosough Ahmadi et al. (2009) and Stott et al. (2009). However, as with any model, ours was a simplification of the true situation, for example, we did not build in all interactions that exist in practice. Similarly, the extra cost of greater calving difficulties in the high BCS state might have been under estimated in our model as we have not included the associated labour costs. Calving difficulties are in any case another potential welfare compromise in a state we considered to be of superior welfare. These difficulties highlight the need for further bio-economic research in this aspect of animal welfare.

As well as difficulties with welfare assessment, our work highlights possible conflicts between policy on animal welfare and policy on other important issues such as the environment. Preliminary results presented in this paper suggest that the HHERD required more in-calf heifer replacements as a result of heavier culling rate leading to a higher number of animals on farm, compare to LHERD. Because cattle have been identified as the greatest threat to the climate, forests and wildlife (FAO, 2006), increasing the population of suckler cows as a result of a different feeding regime as well as culling/replacement strategies is detrimental to the environment. HHERD herds require more 'bought-in' roughage and concentrates during the winter time and higher quantities of fertilisers and perhaps pesticides used to grow grazing pastures in summer time. These all adversely affect the environment (e.g. air and water pollution) and therefore the trade-offs between these environmental concerns and financial performance of the out-wintering suckler cows and their welfare concerns needs to be studied further using an integrated framework. Such a research project aiming to explore options for mitigating negative environmental effects of out-wintering suckler cows and its relation to economic impact, animal health and welfare and public safety funded by Defra has been started within SAC (Measuring The Impacts Of Out-wintering Beef And Dairy Cattle, SAC Project Number: 53810150). The presented model provides some of the basic information required in that project.

## Acknowledgements

This work was supported by the Scottish Government Rural and Environment Research Analysis Directorate.

**References**

Azzam, S.M., Kinder, J.E. & Nielsen, M.K. (1990). Modelling reproductive management systems for beef cattle. *Agricultural Systems* 34, 103-122.

Bellman, R. (1975). Dynamic Programming. Princeton University Press, Princeton.

Caldow, G., Lowman, B. and Riddell, I. (2005). Veterinary intervention in the reproductive management of beef cow herds. *In Practice*, 27, 406-411.

FAO (2006). Livestock's Long Shadow: environmental issues and options. Food and Agriculture Organization of the United Nations. Rome, Italy. http://www.fao.org/docrep/010/a0701e/a0701e00.HTM

FAWC (2001). Interim Report on the Animal Welfare Implications of Farm Assurance Schemes. Farm Animal Welfare Council, Publication number 5797.

Kennedy, J.O.S. (1986). Dynamic Programming: application to agriculture and natural resources. Elsevier, Amsterdam.

Lawrence, A.B. and Stott, A.W. (2009). Profiting from animal welfare: an animal-based perspective. The Oxford Farming Conference. http://www.ofc.org.uk/images/stories/File/LAWRENCE%2009.pdf

Oglethorpe, D. (2005). Livestock production post CAP reform: implications for the environment. *Animal Science*, 91, 189-192.

SAC (2008a). Farming's Retreat from the Hills. SAC report on Scottish sheep farming. http://www.sac.ac.uk/mainrep/pdfs/retreatreport.pdf

SAC (2008b). Farm Management Handbook. 29th Edition. SAC, Edinburgh, UK.

Schofield, J., Calder, J., Fraser, I., Lewis, M., Oldham, J.D., Offer, N. and Rooke, J. (1999). FeedByte – ration formulation and evaluation. SAC, Edinburgh.

Scottish Executive (2008). Economic Report on Scottish Agriculture, Scottish Executive, Edinburgh, UK.

Stott, A.W., Gunn, G.J. and Varo, B.A. (2008). Management of reproduction in Scottish suckler herds**.** The 82nd Annual Conference of the Agricultural Economics Society, Royal Agricultural College, London, UK.

Stott, A.W., Lawrence, A.B. (2009). Combining economics with science to design for welfare, Knowing Animals Conference, Florence, Italy.

Varo, B.A. (2005). An Economic Evaluation of the Main Causes of Infertility in the Scottish Beef Suckler Herd. PhD Thesis, Aberdeen University, U.K.

Vosough Ahmadi, B., Baxter, E.M., Stott, A.W., Lawrence, A.B. and Edwards, S.A. (2009). Animal welfare and economic optimisation of farrowing systems. Knowing Animals Conference, Florence, Italy.