Acta Agric. Scand., Sect. A, Animal Sci. 2001: Suppl. 30, 17–20
Printed in Ireland. All rights reserved

ACTA AGRICULTURÆ
SCANDINAVICA
ISSN 0906-4702

Development of a Decision Support System to Assess Farm Animal Welfare

Bracke, M. B. M., Metz, J. H. M. and Spruijt, B. M. (Institute of Agricultural and Environmental Engineering (IMAG), Wageningen University and Research Centre, P.O. Box 43, 6700 AA Wageningen, The Netherlands and Animal Welfare Centre, Faculty of Veterinary Medicine, University of Utrecht, Yalelaan 17, 3584 CL, Utrecht, The Netherlands). Development of a decision support system to assess farm animal welfare. Acta Agric. Scand., Sect. A, Animal Sci. Supplementum 30: 17–20, 2001. © 2001 Taylor & Francis.

The progress of a project aimed at developing a decision support system (DSS) for overall welfare assessment is described. We chose the pregnant sow as a 'case' to develop the assessment method. First, we designed and tested a very simple prototype DSS in order to examine several basic ideas as to how welfare can be assessed on a scientific basis. In this prototype welfare assessment was based on the needs of animals. The second version of the DSS, which extended the approach taken in the first, included a wider range of housing systems and an improved knowledge base. It used a rigid formal procedure to construct the model, moving directly from scientific statements into if-then rules. However, this extended version resulted in counter-intuitive scores for the seven main housing systems for pregnant sows. In the third version of the DSS the complexity of the model was reduced, if-then rules being excluded. It was based on more general biological considerations (needs and sub-needs) and produced scores which accorded better with expert opinion. Weighting was managed in a simplified, but procedural way. For improved welfare assessment we suggest that the method of 'reflective equilibrium' should be used.

Marc B. M. Bracke[1], Jos H. M. Metz[1] and Berry M. Spruijt[2]

[1]Institute of Agricultural and Environmental Engineering (IMAG), Wageningen University and Research Centre, P.O. Box 43, 6700 AA Wageningen and [2]Animal Welfare Centre, Faculty of Veterinary Medicine, University of Utrecht, Yalelaan 17, 3584 CL, Utrecht, The Netherlands

Key words: information technology, needs, pregnant sows, suffering, weighting problem.

Introduction

When asked, most people involved in animal husbandry will readily offer an opinion about the welfare status of farm animals and its relation to housing. This opinion is generally based on beliefs about the animals that may or may not be scientifically valid. Science can and should play a role in making correct, or best possible, assessments of welfare.

Although index systems have been developed (Bartussek 1986; Sundrum et al., 1994), we possess at present no generally accepted method for assessing the overall welfare status of farm animals which systematically takes into account all the positive and negative aspects of housing and management systems. One reason is the so-called 'weighting problem': it has been argued (see, e.g., Fraser et al., 1997) that we cannot assess overall welfare, because we cannot weigh different aspects of welfare together.

In this paper we formulate a way to assess overall welfare and discuss the weighting problem in the context of an attempt to develop a decision support system (DSS) for welfare assessment at system level. Although, in this short paper, it is not possible to explain fully how the DSS works, the various approaches taken in its development illustrate how one could go about making the procedure for welfare assessment more explicit.

DSS development

At the Institute of Agricultural and Environmental Engineering, Wageningen, a project developing a DSS to assess the welfare status of pregnant sows is currently in progress. A DSS is a computer-based system which is designed to assist in solving unstructured problems (Alter, 1996 p. 133). Welfare presents such an unstructured problem, for no standard procedure for assessing it exists.

The sort of DSS we are concerned with takes a description of a housing and management system as input and produces a welfare score as output. It does so on the basis both of scientific statements contained in a 'knowledge base' and one or more models contained in a 'model base'. In line with, for example, Dawkins (1990), we define welfare as quality of life as perceived from the animal's point of view, i.e. the level of satisfaction and frustration of the animal's needs. Welfare may be assessed via an assessment of needs (Bracke et al., 1999a) that is itself derived from the attributes of the housing and management system.

Our DSS assesses welfare at system level. That is, it applies to groups of farms sharing certain welfare-relevant attributes rather than at the level of the individual farm or group. Nevertheless, although this is a more general level than that of the farm or group, the difference between them is a gradual one. It depends on the degree of specification of the system or farm, and proper assessment at farm level may benefit from an understanding of the assessment at system level.

The development of a DSS proceeds according to the so-called Evolutionary Prototyping Method (Turban, 1995). This means that an initial prototype is developed and improved with repeated updating. This increases the likelihood that the final DSS will be adaptable to change (e.g. to changes in our scientific knowledge).

In our research the DSS has gone through four developmental phases: a multifaceted structured entity (MSE) modelling phase, and the subsequent development of three consecutive versions of the DSS.

MSE modelling helps to decompose a complex problem into its elements by arranging them in a hierarchical way (Zeigler, 1984; Rozenblit & Zeigler, 1986). For example, welfare can be decomposed into the various needs which animals have. Branches can be decomposed further and further, and a certain item can be located in more than one place in the tree. Using MSE modelling we attempted to describe the structural components of welfare (or needs) without trying to weight them. Even this turned out to be rather difficult. For example, experts disagree about whether rooting should be classified as a need for food, as exploration, or as a separate need altogether. Such problems indicate that the weighting problem may not be the primary problem in welfare assessment, in that other issues precede it.

In the next phase we took a more goal-directed approach and built a prototype DSS. We did so to find out whether welfare can be assessed on an explicitly scientific basis in principle. We described a housing system for pregnant sows, made several 'scientific' statements, and designed a procedure to calculate a welfare score. This procedure requires welfare-relevant parameters to be ranked. It calculates overall welfare from need scores. Although very limited in scope, the procedure generated promising results. For example, when applied to one individual housing system and three group-housing systems for pregnant sows, it showed clearly that the individual housing system scored less than the three group housing systems.

As a next step we constructed a new version with the aim of integrating the procedure into a more complete DSS. Here we drew on an EU report on the welfare of pigs (Anonymous, 1997), from which we extracted scientific statements. We analysed approximately 700 of these statements into if-then rules, generating 500 attributes describing the housing systems and 600 welfare relevant parameters that made up the welfare model. All parameters counted equally.

The seven principal housing systems for pregnant sows that were included in the DSS as reference systems were as follows: two individual housing systems (tethers and stalls); three intensive group-housing systems indoors without straw (free-access stalls, Biofix or trickle feeding and the electronic sow feeder (ESF) system); and two more extensive systems (outdoor housing with huts and the Family Pen system). Descriptions of these systems can be found in the EU report mentioned above (Anonymous, 1997). The results were in part counter-intuitive: we found only a small difference between the more extensive housing systems and the more intensive ones, but no difference between the two individual housing systems and the three indoor group-housing systems. This was not only contrary to our personal expectations; it was also at variance with the expectations of the 11 international pig-welfare scientists we had asked to give welfare scores for these systems (Bracke et al., 1999b).

This second version of the DSS enabled a strong link between scientific statements and the welfare model to be established. However, because the number of welfare parameters, at 600, was so large, and because a literature review such as the EU report is not well suited to the extraction of if-then rules, it was very difficult to make further adjustments to the DSS. Indeed we failed to resolve the problematic findings in a satisfactory way.

In the third version of the DSS we reduced the number of welfare relevant parameters from 600 to 37. These parameters were based on more general biological considerations about the different sub-needs that can be identified in pregnant sows. As a result the link between the parameters in the welfare model and the scientific statements in the knowledge base was much less rigid. However, we did derive scores that accorded more closely with our (and the pig-welfare scientists') expectations. Although the third version of the DSS requires further improvement, it does allow moderate optimism that welfare assessment will be possible without using complex weightings.

Weighting

From the discussion above it follows that weighting is performed correctly only under certain specific conditions. One criterion of success is that welfare parameters must apply across the domain of housing systems. So, for example, older ESF systems did not have a head-first exit; and because sows had to back out, agonism and vulva biting problems were elevated. The possession of a head-first exit cannot be treated as a welfare parameter, because it does not apply to other feeding systems such as feeding stalls and floor feeding. Having a head-first exit does, however, affect the level of agonism, and the latter is a candidate for welfare assessment, because it does apply across housing systems.

Furthermore, the parameters should have proper 'units' in which weighting can be performed. For example, square meters of space cannot be weighed against kilograms of food. Nor should the amount of rooting substrate be allowed to load directly onto welfare, because its effect depends, for instance, on whether the sows have nose rings. Rather than having metres of space or amounts of rooting substrate, it is better to have the different needs in the welfare model.

Thirdly, it may not be correct to attach one weight to an entire parameter. For example, the statement that food is important because animals die without it seems to make sense, but it is incomplete. Not all increases in the amount of food are equally important. This means that we should not only be careful to select the parameters that must be weighed, but that the weighting itself should involve differential weighting of parameter values rather than entire parameters. This may be a difficult task, but there may be ways of overcoming these diffculties.

There are several ways to assign weighting factors (WFs). They can be assigned either intuitively, or on the basis of empirical data, or on the basis of theoretical considerations. Intuitions may be valid, but they may also be erroneous. Therefore, we would prefer a more rational basis for assigning WFs if it were available. Empirical data, such as preferences, operant conditioning, or elasticity of demand would be ideal, but owing to methodological difficulties, few quantitative empirical data are available to assist with weighting at present (e.g. Fraser, 1993). In the absence of such data – or when such data point in different directions – we may have to resort to theoretical considerations and assign WFs on the basis of concepts such as fitness value, the ability to cope or adapt, and predictability and controllability.

In the second and the third version of the DSS we calculated welfare as a weighted average of need scores. We used the simplest weightings possible and thus set all WFs at 1. Further refinement of the weighting procedure would include setting minimum requirements which have particularly high WFs such that, when they are satisfied, their value determines overall welfare. Furthermore, the various need scales should be calibrated. Needs are expressed on a relative scale from 0 to 10, but some needs cover a wide range (e.g. the need for food). Other needs count mainly negatively (e.g. health or aggression), while still others mainly count positively (e.g. the ability to root). This implies that it may be necessary to transfer need scores to a communal scale before calculating welfare. Finally, we may attempt to aggregate arguments that are relevant to weighting.

Consider the following example: which is more important for individually stalled sows: being able to turn around or social contact? We can list the arguments in favour of each alternative.

Turning is important to allow orientation towards danger. It may be important for preparing the resting area and for exploration. Turning also allows the use of muscles and may improve bone strength. This adds up to four advantages. By contrast, social contact allows sows to establish a dominance hierarchy and settle disputes. It also allows them to huddle. A disadvantage of social contact is that sows which have it are no longer protected from aggression. This adds up to two advantages for social contact and one disadvantage.

Of course, social contact involves the ability to turn around. Therefore, when we look at social contact and turning together, the former is better, even though at the level of parameter values the ability to turn is relatively more important for stalled sows – as indicated by the number of advantages that can be listed in its favour. Since it is possible that not all arguments are equally important, more sophisticated weighting may use a similar procedure to determine the importance of each advantage and disadvantage separately. However, even without this sophistication, this example illustrates the fact that it is possible, in principle, to quantify weightings in an aggregative way.

Such weightings can be implemented in a model in order to calculate welfare scores. The output should be in accordance with our most basic opinions, as was illustrated for the three versions of the DSS. This dialectic, in which a theory is developed from one's most basic intuitions once these are harmonised with each other and with other available knowledge, is known in philosophy as the method of 'reflective equilibrium'. A contemporary philosopher who applies this method (which is also called the coherence model) to the field of animal welfare is DeGrazia (1996). Although DeGrazia uses it primarily for solving moral questions, the method of reflective equilibrium may also be suitable for assessing farm animal welfare, because our most basic opinions (about which consensus exists) play an important role in validating welfare models, and because (as a coherence model) it emphasises the role of making overall (or all-things-taken-together) judgements.

Conclusion

Our discussion of the various development stages of the DSS shows that welfare is complex (Dawkins, 1997). MSE modelling proved difficult, and every new version of the DSS contained both improvements and setbacks. In particular, it proved useful to test the model against our most basic opinions, which is a first step in trying to find a reflective equilibrium.

The weighting problem is challenging, but it should not paralyse us. First, it must be established which parameters are to be incorporated in a welfare model. This requires careful attention to the reasoning steps that are involved in welfare assessment. When necessary, quantitative weighting procedures can be constructed. However, less complex models may already achieve a reflective equilibrium – that is, when they make use of available knowledge and generate output that is in accordance with our most basic opinions about animal welfare.

Acknowledgements

This work was funded by the Technology Foundation (STW) (through a joint grant from the Netherlands Ministry of Agriculture, Nature Management and Fisheries and the Netherlands Organisation for Scientific Research (NWO)), and the Dutch Society for the Protection of Animals (NVBD).

References

Alter, S. 1996. Information Systems: A Management Perspective, 2nd edn. Benjamin/Cummings, Menlo Park, California.

Anonymous 1997. The welfare of intensively kept pigs. Scientific Veterinary Committee, Brussels, 199 pp.

Bartussek, H. 1985. Ergänzung zum Artikel 'Vorschlag für eine Steiermärkische Intensivtierhaltungsverordnung', Irdning. Der Österreichische Freiberufstierartzt 97 (4–15).

Bracke, M. B. M., Metz, J.H.M. & Spruijt, B. M. 1999a. Overall animal welfare reviewed. Part 3: Welfare assessment based on needs and supported by expert opinion. *Netherlands Journal of Agricultural Science* 47.

Bracke, M. B. M., Metz, J. H. M., Spruijt, B. M. & Dijkhuizen, A. A. 1999b. Overall welfare assessment of pregnant sow housing systems based on interviews with experts. Netherlands Journal of Agricultural Science 47, 93–104.

DeGrazia, D. 1996. Taking Animal Seriously: Mental Life and Moral Status. Cambridge University Press, Cambridge, New York, 302 p.

Dawkins, M. S. 1990. From an animal's point of view: motivation, fitness, and animal welfare. Behavioural and Brain Sciences 13, 1–9.

Dawkins, M. S. 1997. D. M. G. Wood-Gush Memorial Lecture: Why has there not been more progress in animal welfare research? Applied Animal Behaviour Science 53, 59–73.

Fraser, D. 1993. Assessing animal well-being: Common sense, uncommon science. In: Food Animal Well-Being. Proceedings. Purdue University Office of Agricultural Research Programms, West Lafayette, USA: 37-54.

Fraser, D., Weary, D. M., Pajor, E. A. & Milligan, B. N. 1997. A scientific conception of animal welfare that reflects ethical concerns. Animal Welfare 6, 187–205.

Rozenblit, J. W. & Zeigler, B. P. 1986. Entity-based structures for model and experimental frame construction. In: Elzas, M. S., Oren, T. I. & Zeigler, B. P. (eds.) Modelling and simulation methodology in the artificial intelligence era. Elsevier Science Publishers B.V. Amsterdam, pp. 79–100.

Sundrum, A., Andersson, R. & Postler, G. (Eds) 1994. Der Tiergerechtheitsindex-200/1994-Ein Leitfaden zur Beurteilung von Haltungssystemen für Rinder, Kälber, Legehennen und Schweine. Verlag Köllen, Bonn, 211 pp.

Turban, E. 1995. Decision support systems and expert systems, 4th edn. Prentice-Hall, London, 887 p.

Zeigler, B. P. 1984. Multifacetted modelling and discrete event simulation. Academic Press, London, 372 p.