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REVIEW ARTICLE

Model to evaluate welfare in dairy cow farms

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ABSTRACT

The assessment of herd welfare is a scientific discipline that is rapidly developing. The scientific community plays an important role in delivering appropriate, repeatable, valid and feasible models for this assessment. Unfortunately, there are different feelings regarding the welfare of animals and it is imperative for its assessment that certain agreement on the meaning of animal welfare is accepted. Then it is necessary to look at the goals of the models of welfare assessment because different goals require a different combination of welfare indicators.

The different models for welfare assessment can be categorized broadly into research, legislative requirements, certification systems, and advisory/management tools. These models may have various goals: quantification of welfare, provision of welfare assurance or welfare management. However, it is widely accepted that welfare is best assessed with multiple different measures; therefore, a welfare assessment model for a livestock herd can include two types of measure: a description of the housing system and management (indirect indicators) and data recording on how the animals react to the system (direct indicators). The first type provides information on risk factors for welfare problems. Direct measures on the animals provide information on their response to the environment and are more direct measures of welfare than their counterparts, but direct welfare indicators alone do not point out the causes of impaired welfare. Because welfare is a complex construct, different approaches for the aggregation of the different aspects of welfare have been proposed, although the aggregation in an overall welfare value is not sufficient. The thresholds between acceptable and unacceptable welfare levels have to be included in the model of welfare assessment but it seems useful to set certain minimum standards for each single welfare aspect. Afterward, judging the validity of a common welfare assessment model is important. In addition to considering its aim and the fact that a gold standard for animal welfare does not exist, it aids in identifying some widely accepted reference parameters which cannot be utilized in the field (i.e. ACTH challenge, immune system parameters, etc.), but which can be utilized to validate the field models. A new model has been recently set up in our Institute, which is based on many environmental factors included into two clusters: life conditions and feeding. A further cluster considers the animal responses in general and to the previous factors; specific indicators of behavioural, physiological, performance and health type have been included in this last cluster.

Key words: Animal welfare, Welfare evaluation, Dairy cows, Welfare assessment model.

RIASSUNTO

MODELLO PER LA VALUTAZIONE DEL BENESSERE NEGLI ALLEVAMENTI DI BOVINE DA LATTE

La valutazione del benessere degli animali allevati è una disciplina scientifica in rapida crescita. La comunità scientifica svolge un ruolo importante nello sviluppo di sistemi di valutazione appropriati, ripetibili, validi ed applicabili. Tuttavia il termine benessere viene definito ed affrontato in modi diversi ed è imperativo, per la sua valutazione, che si giunga ad una minima condivisione sul significato di benessere animale. È quindi necessario prendere in considerazione gli obiettivi del sistema di valutazione, dal momento che obiettivi diversi vengono raggiunti con differenti combinazioni di indicatori di benessere.
I diversi metodi per la valutazione del benessere si possono classificare come strumenti per la ricerca, per esigenze normative, per la certificazione e per l'assistenza tecnica. Questi metodi possono avere diversi obiettivi: quantificazione del benessere, miglioramento del benessere e sua gestione. È ampiamente accettato che una più accurata valutazione del benessere si ottiene con una combinazione di differenti tipi di rilievo. In un modello di valutazione del benessere a livello di allevamento si possono includere due tipologie di rilievo: descrizione del sistema di allevamento e del suo management (indicatori indiretti); risposta degli animali alle condizioni in cui vengono allevati (indicatori diretti). Gli indicatori indiretti forniscono informazioni sui fattori di rischio per i problemi del benessere. I rilievi sugli animali rappresentano una misura più diretta del benessere rispetto a quella ottenuta con gli indicatori indiretti, tuttavia l'impiego dei soli indicatori diretti non consente di evidenziare le cause di riduzione del benessere. Dal momento che il benessere è una variabile multidimensionale, sono stati proposti differenti approcci per l'aggregazione dei diversi aspetti del benessere in un valore complessivo, tuttavia l'aggregazione in un valore complessivo non è sufficiente. Occorre includere nel modello livelli soglia in termini di benessere accettabile e non accettabile, fissando anche standard minimi per i singoli aspetti del benessere. Per giudicare infine la validità di un comune modello di valutazione del benessere, tenendo presente gli obiettivi del modello e consci che non esiste un "gold standard" per il benessere, occorre identificare alcuni parametri di riferimento che non possono essere utilizzati nel modello comune di campo a causa dei costi (es. risposta a stimolazione con ACTH, parametri del sistema immunitario, ecc.), da usare per la fase di validazione. Un nuovo modello è stato recentemente proposto nel nostro Istituto, basato su indicatori indiretti inclusi in due cluster: allevamento ed alimentazione. Un terzo cluster prende in considerazione la risposta degli animali, utilizzando specifici indicatori comportamentali, fisiologici, produttivi e sanitari.

Parole chiave: *Benessere animale, Valutazione del benessere, Bovine da latte, Modello per misurare il benessere.*

Introduction

Animal welfare is of considerable and growing importance from the social, political, ethical and scientific viewpoint. Nevertheless, the possible ways to define animal welfare are not always and universally accepted (Fraser and Broom, 1990; Broom and Johnson, 1993; Webster, 1994; Appleby and Hughes, 1997; Bertoni and Calamari, 2001). Indeed the word "welfare" includes many aspects and it is very difficult, or even inappropriate, to draw a unique definition for it. Nevertheless, it is imperative for its assessment that certain agreement on the meaning of animal welfare be accepted. Of the "dozens" of definitions (Bono, 2001) that have appeared in the last 30-40 years, some outline the "feelings" aspect: e.g., Dawkins's remark (1980): "Absence of suffering. Suffering understood to be an unpleasant emotional state induced by fear, pain, frustration, exhaustion, loss of social companions." Others are more empirical and incorporate the farmers' interests: "as long as the animal is growing normally, performing well, is properly nourished and free from diseases, and suffers no physical mistreatment, there is no cause of concern" (Blosser, 1987). For a fairer definition of welfare, Carenzi and Verga (2009) suggest that "the broadest definition of animal welfare should include the whole state of the organisms, considering together body and mind and their links." Namely, "the welfare of an animal is determined by its capacity to avoid suffering and sustain fitness" in a given natural or "artificial" environment. This is very similar to Fraser and Broom's (1990) suggestion that welfare depends upon the "…degree of success achieved in coping with difficult conditions."

We consider fair (e.g. acceptable both by philosophers and scientists) these kind of definitions because they confirm that a good level of welfare is not achieved merely by the absence of difficulties - as an oversimplified interpretation of the five freedoms might suggest - but by the herdsman's capacity to overcome them through genetics, management, feeding, hygiene, social environment, etc. (Bertoni and Calamari, 2006). Therefore, measurement of potential stressor stimuli cannot be utilized alone to define welfare because the situation itself may be stressful or contrary to genetics, experience, physiology, etc. of the animals (Mormède and Dantzer, 1988), in other words to their capacity to fight negative conditions. Therefore, the definitive consequences are also affected by this capacity and can only be monitored through more or less specific indicators of the animal response. This approach is more complex, but it can ensure a more objective evaluation of the welfare status: namely, if accepted, it would avoid the risk of misinterpreting the effects of breeding systems by consumers, who quite often are influenced by their subjective and anthropomorphic feelings and tend to overemphasize the natural conditions as a factor in optimal welfare.

The models to assess welfare in dairy farms

Many models to assess animal welfare in dairy farms were developed in Europe in the last few years (Sandøe *et al*., 1997; Bartussek, 1999; Capdeville and Veissier, 2001; Sørensen *et al*., 2001; Calamari *et al*., 2003; Rossi and Gastaldo, 2006; Main *et al*., 2007). To develop reliable on-farm monitoring systems and practical species-specific strategies to improve animal welfare, a European Union project (Welfare Quality®) is underway. In our Institute a model to assess welfare in dairy farms has already been developed and denominated Integrated Diagnostic System Welfare (IDSW), as an update of the Integrated Diagnostic System (Bertoni *et al.*, 1999), with a progressive adaptation to welfare assessment. The new model has been briefly described by Calamari *et al.* (2003) and Bertoni and Calamari (2005) and partially validated (Calamari *et al.*, 2004). In this paper a brief description of the model will be given with special emphasis on the inspirer principles, the criteria used for the indicator selection and weighting, and to the aggregation of the different welfare aspects in an overall value.

The goals

The proposed models in literature are very different and these differences may be due, in part, to the fact that they have different goals. Johnsen *et al* (2001) have suggested that descriptions, comparisons and indeed validations of models of welfare assessment are inevitably relative to the features the models are designed to measure. Furthermore, they suggest that the differences among models for welfare assessment may be to a great extent explained in light of this hypothesis. Main *et al.* (2003) have provided a brief overview of the different models proposed to assess welfare and categorized these models into research, legislative requirements (non-voluntary), certification systems (voluntary) and advisory/management tools according to their various goals: quantification of welfare, provision of welfare assurance or welfare management.

The major objective of our IDSW model is to obtain a reliable scoring system of the dairy cow farms that can express the overall welfare value of bred animals. At the same time the model highlights the judgments of the different welfare aspects, suggesting those that have to be improved. This has been obtained through a multidisciplinary approach and with the inclusion of many indicators of welfare to better fulfil all the requirements reported by Waiblinger *et al*. (2001) and Sørensen *et al.* (2001) and to better assess the real welfare. This approach, which began with the Integrated Diagnostic System (Bertoni *et al*., 1999), also aimed to obtain as much information as possible in order to reveal the causes of impaired welfare and thus to improve the husbandry and management systems. In other words, the major aim of the model is to identify the causes of low levels of welfare and to provide proper advice from technicians as to how it can be improved.

The indicators of welfare

In principle the indicators for welfare assessment can be divided into two categories.

One category, the environmental parameters, indirect indicators, influencing factors or resource indicators, describes features of the production and management system, such as length of stalls, feeding and drinking facilities, space allowance, quality of litter, access to pasture, etc. Assessment is fairly uncomplicated because most of the environmental parameters are relatively easy, quick and reliable to record. It is also true that records of welfare problems based on environmental parameters can often be utilized to diagnose the causes of low levels of welfare and then to remove them. On the other hand these indirect indicators lead to a 'risk assessment' of welfare status, but not to an evaluation of their real effect on welfare status. There is, in fact, a great deal of proof suggesting that a breeding system can be applied in many ways affecting animal welfare quite differently (Fregonesi and Leaver, 2001; Sørensen *et al,* 2001) and animals can respond in a different way to the same uncomfortable situation (Mormède and Dantzer, 1988).

A second category of indicators records animals' reactions to specific environments; the parameters of this category are defined as animal based parameters or direct indicators. These animal based parameters fall within the categories of behaviour, health, and physiology. Level of stress hormones, aggression, fear and abnormal behaviour, symptoms of disease, and mortality are examples of such parameters. In this list some authors include the productive response as well (Bertoni *et al*., 1999; Veissier *et al*., 2000; Verga *et al*., 2000). Animal based parameters, such as behaviour and health, can be taken as indicators of the animal's feelings and as direct measures of the bodily state.

Models for assessing animal welfare at farm level are in general based on a range of welfare parameters or indicators. It is, first of all, necessary to define two desirable properties of these indicators, namely validity and reliability. Validity considers the degree to which a measure actually measures what it is supposed to. There are a number of different forms of validity, some of which are described by Scott *et al*. (2001). Reliability reflects how close the measurements come to each other. There are different reliability measures: inter-observer reliability, which measures the agreement between different observers, the intra-observer reliability which measures agreement between the same observer on different occasions and finally, test-retest reliability which measures the agreement between observations made on the same individual on at least two different occasions (Scott *et al.*, 2001). Another important property of the indicators is the feasibility: to be easily operated by trained people, to require limited time to be measured and to be cheap.

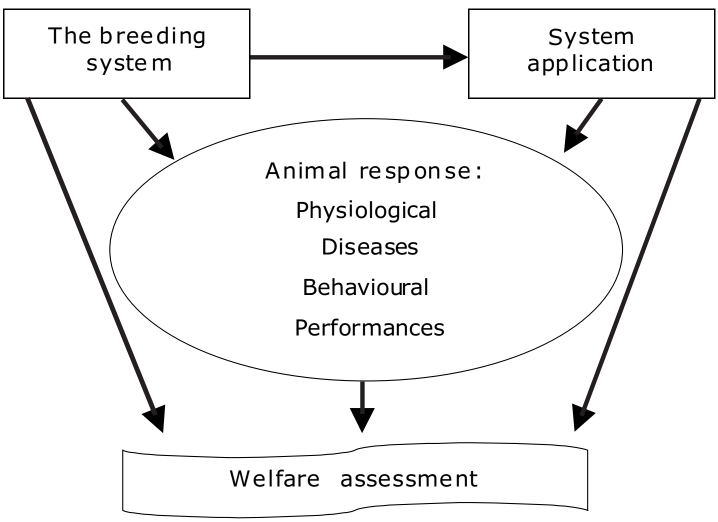
The selection of the indicators

It seems necessary to include both types of indicators, indirect and direct, in an assessment tool that best fulfils all the requirements mentioned above. It is generally accepted that both sets of indicators are important indices of animal welfare, and that the most valid assessment of animal welfare is obtained when parameters of both kinds are used in combination, as suggested by Bertoni *et al.* (1999) and Sørensen *et al.* (2001) (Figure 1).

In the development of the IDSW model the selection of the indicators has been mainly based on the previously described criteria: reliability, validity and practicability; in addition consideration has been given to the need to reduce the effects of the mediation or interpretation of stockmen, with possible biasing of the data and judgements. The collection of data gleaned from filling out questionnaires has been reduced to a minimum, giving greater weight to the collection of the information from the recorded data, measuring and controlling the systems and equipment, observing the animals, etc.

The IDSW model has been developed including both indirect and direct indicators, despite the fact that the direct indicators give a better evaluation of their actual welfare than indirect measures of rearing conditions (Capdeville and Veissier, 2001). In fact, in accordance with Bracke *et al.* (1999), we have also considered essential the major factors of the living environment that can

Figure 1. Sources of information for assessing animal welfare at herd level (Sørensen *et al.*, 2001, modified).



potentially affect animal welfare (housing, equipment, man and animal interaction, grouping, feeding etc.).

The IDSW model has not been published yet and it is quite complex because it evaluates a large number of indicators, both indirect and direct. Among the indirect indicators in the IDSW, together with the indicators commonly used and concerning housing, systems and equipments, as well as many other parameters concerning feeds, feeding systems and diets have also been included. These last indicators in general are not included (or very simplified) in the models proposed in literature to assess welfare. Tosi *et al*. (2001) have included some feeding aspects in a descriptive analysis of welfare and Waiblinger *et al*. (2001) have included, as welfare indicators, feeding management and feeding behaviour. Feed intake was included in the seven major functional domains of behaviour (Bartusseck, 2001), but parameters relevant to feeding were not included in ANI 35L (Animal needs Index) because it was assumed that there was no economic incentive in not feeding animals properly (Johnsen *et al*., 2001). In IDSW many indicators of feeds, feeding system and diets were included because the feed quality, mainly the feed safety, together with the correct balance of the diets, according to the different physiological phases, are considered important factors affecting metabolic and health conditions of cows and, therefore, their welfare as well as performance (milk yield, fertility, etc.).

The indirect indicators used in the IDSW model have been divided in two clusters:

1) the environment cluster where the animals live: namely housing, equipment and general organization within housing;

2) the feeding cluster with regard to feed safety and quality, feed delivery and daily intake, water availability, diet composition and satisfaction of specific nutrient needs in dry period and in early- mid and late-lactation.

The direct indicators have been included in a third cluster (Animal cluster) that consider the consequences of the previous indicators and that can be evaluated according to some indices of behavioural, physiological, performance and health type.

Data collection and welfare scores

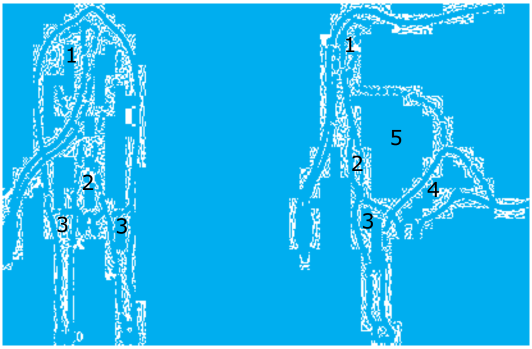
The IDSW model schedules that the data of each direct and indirect indicator, for the most part, have to be directly collected by the observer. Then the quantification and categorization of the welfare state of the animal can be obtained with the model using different methods of measurement (Scott *et al*., 2001), according to the type of data collected with each indicator. Ordinal measurement has been used for the indicators where the responses are ordered and categorical in nature, such as good, better, best or mild, moderate, severe. Three or five different levels, including a neutral mid-point, have been used in relation to the type of data collected with this type of indicator. Interval level measurement has been generally applied to the indicators characterized by continuous variability because they are more appropriate when the measurement is continuous rather than categorical in nature.

The data collected for each indicator are expressed in percentage of their optimal values, comparing the actual farm situation of each indicator with well-established standards. The value of 100% is assigned when the actual farm situation is considered optimal; the value of 60% when the situation is considered just sufficient. So the score values express the data as percentage of optimum welfare and improve the readability of the results. For example Figure 2 shows the procedure used to express the score on standardized scale for the cleanliness score, evaluated according to the method proposed by Faye and Barnouin (1985).

Figure 2. Anatomical areas considered for the evaluation of cleanliness score (Faye and Barnouin, 1985) and procedure to calculate the absolute (weighted) and relative (percentage) IDSW score.

Anatomical areas considered in the cleanliness evaluation:

1 anus-genital
2 rear udder
3 hock-foot
4 lateral udder
5 thigh



Score	Description
0	The viewed area is dirt-free
0.5	Some smaller smudges, little spread
1	Dirt covering less than 50% of viewed area
1.5	Dirt covering more than 50% of viewed area
2	Viewed area fully dirt with encrusting

Evaluation and score assignment to each anatomical considered area using the left design.

Adding up the scores of each anatomical area in a total score (0-10) and conversion in the IDSW score (as absolute value and as percentage value) assigning the maximum pre-defined weighted value for cleanliness in the IDSW model (1.5 as absolute value and 100 as percentage value) to the situation considered optimal (very clean).

Total score	Herd cleanliness judgement	IDSW score	
		Absolute	%
0-2	Very clean	1.5	80-100
2-4	Clean	1.2	60-80
4-6	Slightly dirty	0.9	40-60
6-8	Dirty	0.6	20-40
8-10	Very dirty	0.3	0-20

One of the main problems is the criterion to aggregate the scores obtained and concerning the different aspects of welfare. It is, in fact, of major importance to give them a proper "weight" according to the more probable relationship with welfare. In other words, common to any model of welfare assessment at farm level, there are two needs: first, to collect considerable data during brief farm visits; and second, to integrate these data into a balanced welfare judgment (Wemelsfelder and Lawrence, 2001). Nevertheless, as stressed by Fraser (1995), welfare is a multidimensional concept and the fulfilment of the five freedoms (FAWC, 1993) can be quantitatively described on a common scale with some difficulty. Namely, it has been argued (see, e.g., Fraser *et al.*, 1997) that we cannot assess overall welfare, because we cannot weigh together different aspects of welfare. However, difficult does not mean impossible; in fact, the various on-farm monitoring methodologies have proposed different protocols for weighing health and welfare measurements (e.g. Bracke, 1999; Rousing *et al.*, 2001). These protocols tend to be based on a mixture of research findings, expert knowledge, ethical considerations and common sense, and provide criteria for adding up acquired measurements into a final welfare score. Because we agree with the suggestion of Bracke *et al.* (2002) regarding the overall welfare assessment models: "possibly could be compiled to assess farm animal welfare overall, even if it would not be a scientifically proven fact," an attempt to introduce some scientific data has been established. Therefore, in IDSW, the aggregation of the scores obtained for each aspect of welfare has been obtained by applying a weighting factor to each welfare indicator score to calculate an overall score. The weighting factors have been defined using direct or subjective estimation techniques as suggested by Scott *et al.* (2001), based on our best subjective estimate of the "weights" that would be attributed to the indicators, according to their accuracy, validity and to the supposed relationships with welfare. Nevertheless, according to Bracke *et al.* (1999), considerations of weighting across indicators and concerning the calculation of overall scores have been formulated as separate assumptions and not mixed with assignment of indicators scores. This is because the ranking of level of indicators has a rather firm basis, whereas the weighting indicators against one another is much more hypothetical. In the IDSW model a total score of 100 has been divided in 3 parts: 30 for the environment cluster, 30 for the feeding cluster and 40 for the animal cluster. The further division of each cluster in the specific components, aspects and indicators, with their relative weighted score, is shown in Tables 1, 2 and 3. The report produced by the IDSW model shows, together with the overall score, the scores of each cluster and their specific components, aspects and indicators. These results, to improve the readability, are expressed both as weighted values and as percentage of their optimal value.

The indirect indicators: environment

The list of the indicators included in the environmental cluster are shown in Table 1. In this table, for each component, aspect and indicator, the weighted score is reported, in order to highlight their relative relevance with respect to the overall welfare score. The thirty scores of the environment cluster have been divided in two components: housing and equipment (score of 18) and management (score of 12). In the former component four aspects have been included: building (score of 6), space availability (score of 4), microclimatic conditions (score of 4) and equipment (score of 4). In the building aspect indicators barn characteris-

Table 1. Weighted score of each component, aspect and indicator included in the environment cluster of the Integrated Diagnostic System Welfare (IDSW).

Cluster	Components	Aspects	Indicators
Environment (30)	Housing and equipment (18)	Building (6)	General characteristics (0.60)
			Opening for ventilation/illumination (0.66)
			Floor slippering (0.78)
			Passage-way (availability) (0.78)
			Feeding area (accessibility to feed) (0.78)
			Resting area (type and dimensions) (1.80)
			External areas (0.60)
		Space availability (4)	Cubature (0.80)
			Area (1.60)
			Resting area (1.20)
			Bunk space (0.40)
		Microclimatic conditions (4)	Minimum volume ventilation (0.50)
			Winter thermal balance (0.50)
			Summer thermal balance (1.50)
			Cooling systems (1.50)
		Equipment (4)	Milking parlour (dimension) (0.60)
			Milking parlour (adequacy) (1.20)
			Water availability (0.40)
			Lighting (0.30)
			Cooling system in milking parlour and waiting area (0.80)
			Foot bath (0.30)
			Enrichment (0.40)
	Management (12)	Building and equipment (6)	Hygiene feeding area (0.60)
			Hygiene resting area (2.10)
			Hygiene watering system (2.10)
			Maintenance milking system (0.72)
			Maintenance feeding systems (0.48)
		Animal management (6)	Dry cows (1.10)
			Steaming up (1.10)
			Calving cows (1.10)
			Lactating cows (1.10)
			Primiparous cows (0.25)
			Infirmary area (0.25)
			Calves (0.85)
			Dehorning (0.25)

tics have been considered, and the indicator with the greater weighted score concerns the adequacy of the resting area, considering that the cows require approximately 10 h/d lying or resting time (Grant and Albright, 2001). The judgment of the adequacy of resting area has been obtained comparing the actual cubicle dimensions, considering the estimated live weight of lactating cows, with the standards proposed by McFarland (2003) and the indications of Veissier *et al*. (2004). However, further indicators of the space availability aspect are the total area available per each animal and the area available for resting (number of cubicles per animal or area available per animal). Overcrowding and therefore the competition for the available area, for cubicles and feeding spaces can affect social interactions (Grant and Albright, 2000), dry matter intake, rumination activity and milk yield; furthermore, cows with a previous history of mastitis have shown a higher susceptibility to high stocking density (Grant and Albright, 2001). The effects of high stocking density on feeding space are considered less critical when the feeds are continuously available, as when the TMR technique is used (Grant and Albright, 2001).

Among the indicators of the microclimatic conditions, greater weighted scores have been assigned to the indicators concerning the adequacy of the barn in order to maintain adequate microclimatic conditions, in particular evaluating the risk of heat stress. In fact, dairy cows frequently suffer heat stress during summer in many areas, with many negative effects (Bertoni, 1998; Bernabucci and Calamari, 1998; Calamari and Mariani, 1998). The presence and adequacy of cooling systems (type of cooling system, number of fans per animal, allocation of the fans, number of sprinklers or misters per fan) are considered, together to the calculation of summer thermal balance. For this last calculation, the IDSW uses the procedure proposed by Frazzi and Calamari (1988). This procedure utilizes many measures collected by the observer during the visit to the farm (building dimensions, opening for ventilation, type of material used to build the barn, number of animals housed in the barn for each physiological phase) together to the climatic conditions of the area. This procedure also calculates the winter thermal balance and the minimum volume of ventilation, to evaluate whether the natural ventilation is adequate to eliminate the noxious gases and water vapour.

Among the equipment aspects, greater weighted scores have been assigned to the indicators concerning the milking parlour dimension and adequacy. Besides the common characteristics generally checked, the IDSW model considers the adequacy of waiting area and the adequacy of clusters in the milking parlour in relation to the number of animals per group. This evaluation has been included in the model because a higher ratio animal per pen/clusters in the milking parlour increases the time spent by the animal in the waiting area, causing higher stress. This ratio has to be lower than 4.5 (Smith *et al.*, 2001).

Because houses and equipment can be applied in many ways, animal welfare can be affected quite differently. Their management has a weight of 12 and is divided in two aspects: buildings and equipment (score of 6) and animal management (score of 6). Particular attention has been assigned to the animal management in the different physiological phases, considering the criteria used for the subdivision of the animals (physiological phase, age and parity, live weight, calving). The dimensions of each group have been also considered together to the moving of the animals between the groups. Because animal regrouping affects agonistic behaviour (Bouissou *et al*., 2001), the collection of these data, included in the IDSW, could be an indirect measurement of social behaviour. Improperly grouping of dairy cows may disturb their normal behavioural routines and time budgets (Grant and Albright, 2001).

The indirect indicators: feeding

Generally the feeds and feeding are considered to a very small extent in the models of welfare assessment in dairy farms, despite the fact that one of the five freedoms is related to the freedom from hunger, thirst and malnutrition. In general the checks are limited to the feed availability, feed accessibility and to some aspects of feeding behaviour. In IDSW the feeding factors have been evaluated in detail and the list of the used indicators is shown in Table 2. The score of 30 for the feeding cluster has been divided in two components: feeds (score of 18) and feeding (score of 12). In the former component three aspects are included: storage (score of 4), quality (score of 10) and their supply management (score of 4).

The greatest weight has been assigned to the quality of forages and it has been assessed by sensory evaluation according to some method proposed in literature. Hay judgment has been formulated according to the method proposed by Caddel and Allen (1993) evaluating and scoring the leafiness, maturity at harvest, odour, colour, softness, purity, condition of bale and penalties in relation to the presence of moulds, weeds, dirty or other foreign material and excessive moistness or dryness. The maximum incidence of penalties for forages with poor

Table 2. Weighted scores of each component, aspect and indicator included in the feeding cluster of the IDSW.

<table>
<tr><th>Cluster</th><th>Components</th><th>Aspects</th><th>Indicators</th></tr>
<tr><td rowspan="15">Feeding (30)</td><td rowspan="10">Feeds (18)</td><td rowspan="3">Storage (4)</td><td>Building and system to store silage (2.0)</td></tr>
<tr><td>Buiding and system to store hay (1.0)</td></tr>
<tr><td>Building and system to store concentrate (1.0)</td></tr>
<tr><td rowspan="4">Quality (10)</td><td>Silage evaluation (4.0)</td></tr>
<tr><td>Hay evaluation (4.0)</td></tr>
<tr><td>Concentrate evaluation (1.0)</td></tr>
<tr><td>Feed analysis (1.0)</td></tr>
<tr><td rowspan="3">Supply Management (4)</td><td>Systems for feed distribution (2.0)</td></tr>
<tr><td>TMR characteristics (physical characteristics)* (2.0)</td></tr>
<tr><td>Sequence feed distribution* (2.0)</td></tr>
<tr><td rowspan="5">Feeding (12)</td><td rowspan="2">Before calving (5)</td><td>Dry cows (DMI, energy, crude protein, vitaminic integration) (3.0)</td></tr>
<tr><td>Steaming up cows (DMI, energy, crude protein, viatminic integration) (2.0)</td></tr>
<tr><td rowspan="3">After calving (7)</td><td>Early lactation (DMI, energy, crude protein, NDF, starch) (3.0)</td></tr>
<tr><td>Mid lactation (DMI, energy, crude protein, NDF, starch) (2.0)</td></tr>
<tr><td>Late lactation (DMI, energy, crude protein, NDF, starch) (2.0)</td></tr>
</table>

**: alternative scores according to the feed distribution method used in the farm (TMR or traditional method).*

safety characteristics is 35% of the total score calculated according to Caddel and Allen (1993). The final evaluation of the feeds is largely affected by their feed safety, considered a pre-requisite of the diet and influencing health and welfare.

Corn silage has been judged according to the method proposed by Bates (1998) evaluating and scoring grain content, colour, odour, moisture and chop (precision and length). The fermentative characteristics of silages, describing the feed safety and mainly evaluated through the observation of the colour and odour, have a great influence on the final score.

In the IDSW model, a procedure to evaluate the ration in dry and lactating cows has been also included. This procedure, utilizes the data obtained with the analysis or the data estimated on the basis of the forages evaluation previously described. Moreover, it considers the data collected by the observer on the ration composition, and calculates the dry matter intake, the energy and protein ingested daily by the dry cows, the early lactating cows, and the mid- and late-lactating cows. This procedure also calculates, on the basis of the data concerning live weight, milk yield and composition, the nutritional requirements according to INRA (1988) and NRC (2001). The calculation of the scores has been carried out by comparing the requirement with the actual supply.

The animal response: the physiological indicators

The physiological indicators are considered of great validity in the assessment of acute stress. Nevertheless, it must be emphasised that for welfare we are not interested in the short-lived changes that occur in acute stress situations (Broom, 2003). On the contrary, our interest is for indicators of chronic stress. However, some physiological indicators can be modified by both conditions; therefore, it is essential to discriminate between short-term and long-term variations. The most widely used physiological indicators are heart rate, breathing rate, body temperature (rectal), some metabolic indicators, immune function tests and few endocrine parameters. The meaning of these indicators and the link with the welfare is reported by Bertoni *et al.* (2007). Nevertheless, these physiological indicators are not useful for on farm welfare assessment because they are too expensive and time consuming; they can, however, be useful in research applications. For these reasons, they have not been included in the IDSW model; however, some indirect indicators of physiological changes (i.e. health status and production and reproduction response) have been included. These last indicators have been partly included in the "Physiology, health and reproduction" component, with a weighted score of 24 and partly in the "Production" component, with a weighted score of 8 (Table 3). The aspects and indicators included in the latter component will be discussed in the next chapter.

The animal response: physiology, health and reproduction

The negative relationship between health status and welfare is obvious, especially for the third freedom: "…from pain, injury and disease." Everybody knows that low health status is a cause of physical pain and psychological depression (see the effects of pro-inflammatory cytokines, by Johnson and Finck, 2001). Furthermore, health impairment is a consequence of chronic stress (Elsasser *et al.*, 2000). Therefore, a vicious cycle can occur: low level of welfare, immune depression, disease, low level of welfare … (Broom, 2006).

Any kind of pathology involves some degree of poor welfare (Broom, 2006). Pathological conditions can be caused by genet-

Table 3. Weighted score of each component, aspect and indicator included in the animal cluster of the IDSW.

Cluster	Components	Aspects	Indicators
Animal (40)	Physiology, health and reproduction (24)	External aspect (5)	BCS* (2.00)
			Coat and coughing and/or nose mucus* (0.50)
			Cleanliness score* (1.50)
			Injuries (neck, shoulders, spinal column, pelvis, ribs)* (0.60)
			External parasites* (0.40)
		Gut functionality (4)	Rumination score** (2.00)
			Faeces score* (2.00)
		Udder (4)	Teat score** (2.00)
			Injuries to teats, udder and blind quarters** (0.80)
			SCC of bulk milk (1.20)
		Limbs and feet (4)	Foot score* (1.50)
			Trimming score* (1.50)
			Injuries to the knee, hock lesion and swollen* (1.00)
		Reproduction (3)	Fertility status index*** (2.40)
			Abortion and mortality at birth (0.60)
		Diseases (4)	Placental retention, milk fever and abomasum displacement (4.00)
	Production (8)	Milk yield (4)	Milk yield per lactation (4.00)
		Milk composition (4)	Fat content of bulk milk (3.00)
			Protein content of bulk milk (1.00)
	Behaviour (8)	Social interactions and contact with humans (3)	Withdrawal when observer approaches the manger (0.50)
			Voluntary animal approach test (0.50)
			Avoidance test (0.50)
			Animal reactions to the observer inspection* (0.50)
			Social interactions (0.50)
			Stereotypies (0.50)
		Interaction animal-environment (5)	Lying down and standing up movement (1.00)
			Cow comfort index(1.20)
			Stall use index (0.60)
			Stall perching index (0.60)
			Abnormal position of animals lying in cubicle (0.80)
			Distribution of the animals in the resting area (0.80)

**Evaluated on a representative number of dry cows, early lactating cows and late lactating cows.*
***Evaluated on a representative number of early lactating cows and late lactating cows.*
****Calculated considering culling rate, conception rate, conception rate at 1st insemination and calving interval.*

ics; physical, thermal and chemical injuries; infections and infestations; metabolic abnormalities and nutritional disorders. The indicators of health can be estimated on the basis of frequency and type of health problems, case histories of culled animals, and other information collected by the observer analysing the recorded data and the veterinary record. According to Sørensen *et al.* (2001), the recorded animal health data are rarely straightforward to use. Veterinary treatment records do not give a precise measure for diseases, and diagnoses do not normally describe animal welfare implications. This information has to be used in conjunction with systematic clinical examinations, using a protocol for measuring any clinical symptoms that are relevant to animal welfare. Examples of such symptoms are also reported by Waiblinger *et al*. (2001) and Rousing *et al*. (2000) and include skin lesions, lameness, body condition, ectoparasites, clinical diseases, leg disorders and body condition scores.

In the IDSW, a clinical examination on a representative number of animals in dry period, in early (from 15 to 120 DIM) and in mid-late lactation (over 200 DIM) has been proposed. The clinical examination on a minimum of 6 cows per physiological phase have been proposed, including selection made according to the parity (15% of primiparous and 85% of pluriparous with different number of lactation). The evaluation on cows in different physiological phases is related to the consideration that some of these indicators must be "adjusted" in their interpretation according to specific physiological and production stages of the cows; e.g., time from calving can be very important. Cows in their dry period, in early or late lactation, can, in fact, be judged equally normal even if they show completely different BCS, faeces score, udder aspect, and some other appearances.

These indicators collected with clinical examination and using recorded animal data have been included in the following aspects:

external aspects (score of 5). Body condition score (ADAS, 1986) has been considered the most important indicator of external aspect (score of 2 of the 5 available). In fact, many studies have pointed out the relationship between BCS before calving and disease incidence in early lactation. Furthermore, diseases in early lactation, then poor welfare, cause a greater reduction of BCS in early lactation (Trevisi *et al.*, 2007). Cleanliness score according to Faye and Barnouin (1985) has been considered the second most important indicator of external aspect (score of 1.5), and this evaluation mainly reflects the hygienic conditions. Skin injuries in different body areas (neck, shoulders, spinal column, pelvis, and ribs), infections and external parasites have been also considered. The different level of skin alteration was defined according to Weary and Taszkun (2000). Alteration of the skin is indicative of welfare; the extent of lesions on the skin reflects the quality of the animal's physical and social environment and poor health and injury are accepted as two important and non-controversial indicators of a low level of welfare (Dawkins, 1980). Coat conditions and eye brightness as well as coughing and nose discharges have also been included within the external aspects;

limbs and feet (score of 4). Foot score or locomotion score (Sprecher, 1997) has been used to evaluate the grade and prevalence of lameness, and a score of 1.5 scores has been assigned. Equal importance (score of 1.5) has been assigned to the evaluation of the hoof care (trimming score), considering the length, angle and heel height of rear claws. Injuries to the knee, hock lesions and swellings have been also included;

udder (score of 4). Clinical mastitis, teat score (Neijenhuis *et al*, 2000; Mein *et al*., 2001), injuries to teat and udder blind quarters have been considered. The SCC content of bulk milk has been also considered in order to evaluate udder health. The teat score evaluates the teat-end hyperkeratosis and could be influenced by many factors (teat-end shape, production level and stage of lactation, and interactions between milking management and machine factors, especially slow milking and over-milking). Then, classification of bovine teat condition can be used to assess the effects of milking management, milking equipment or environment on teat tissue and the risk of new intramammary infections (Mein *et al*., 2001);

gut functionality. This judgement has been obtained with the evaluation of the faeces score (Skidmore *et al*., 1996) and the rumination score on early and mid-late lactating cows, observed at defined time after feed distribution;

diseases (score of 4). Other diseases, besides previously showed mastitis, digestive troubles and lameness, have been considered and the information has been obtained using the recorded data. Only placental retention, milk fever and abomasum displacement have been considered, because objectively observed and generally recorded by the farmers;

reproduction (score of 3). As reproductive parameters the conception rate at first insemination, the number of inseminations per pregnancy, the calving interval and the culling rate have been considered. These parameters have been aggregated in a global score (fertility status index) according to Esselmont and Eddy (1977).

The animal response: production

Productive indicators are not included by many authors in the models developed to assess welfare at farm level. It is much less obvious with respect to health to consider good performance as an index of welfare. On the one hand, it seems obvious because a proper covering of needs included in the five freedoms means a better chance for good growth, milk yield, reproduction, etc. (Broom, 1997; Rushen and de Passillé, 1998). On the other hand, intensive milk, eggs, flesh, etc., production is considered a welfare reducing factor (Rollin, 2004). Unfortunately, the level of productivity that can be considered as critical cannot be easily defined; nevertheless, it is not difficult to observe some negative relationships between milk yield and both health (Rauw *et al*., 1998) and fertility problems (Butler, 2000). Furthermore, high genetic merit dairy cows seem more susceptible to metabolic disorders, particularly mastitis and lameness (Knight, 2001), although it seems reasonable to exclude the possibility that high milk yield could modify the HPA axis with a reduction of adaptive capacity (and consequently an impairment of welfare) (Beerda *et al*., 2004).

This apparent contradiction is not surprising. In fact, McInerney (1991), and more recently by Appleby (2005), suggests that the relationship between productivity and welfare is complex. In the first step both are raised; in the second step the productivity increases and welfare decreases; while in the third step, both are reduced. We think it is obvious, and we have in fact demonstrated - in some commercial farms - that high genetic merit cows, if properly managed, which means without excessive exploitation, show an improvement in welfare and "consequently" they show an increase in milk yield and fertility (Trevisi *et al*., 2001; Calamari *et al*., 2003; Trevisi *et al*., 2006)

What is the point? In our view, good performance is a true indicator of good dairy cattle welfare (and this holds true for other species as well). However, it cannot be limited to milk yield. Other aspects of performance, such as fertility and longevity, must be utilized to confirm that the good level of production has been obtained in sustainable conditions for the cows (Appleby, 2005). In the IDSW they have been considered in the reproduction aspect. Of course, it is important to emphasise that high genetic merit animals can yield optimal answers if selection is not restricted to milk yield, and if non productive traits such as disease resistance, fertility, and longevity are also included (Essl, 1998; Darwash *et al*., 1999; Heringstad *et al*., 2000). Furthermore, their superior needs have to be properly satisfied to maintain their optimal welfare (Ingvartsen *et al.*, 2003).

Therefore, a proper evaluation of animal performance, that estimates actual milk yield and composition (in relationship to both the supposed genetic potential and the lactation stage), but also includes the susceptibility to diseases, to reproductive problems and, in one word, to culling rate, can be a useful indicator of welfare. In the IDSW model the scores of the production component (score of 8) have been divided in two aspects: milk yield (score of 4) and milk composition (score of 4). In the milk composition aspect, the greatest importance has been attributed to the fat content (score of 3) because its variability can be a consequence of some digestive and metabolic alterations and poor welfare (Bertoni *et al.*, 2003).

The animal response: the behavioural indicators

In general, the behavioural indicators are considered the most sensible (early developed) among the indices of the animal response (Veissier *et al*., 1999). Nevertheless, there are some difficulties to include the behavioural indicators in a model of welfare assessment at farm level. In practice, only a small number of behavioural measurements can be obtained and these must be made over relatively short observation periods (Waiblinger *et al*., 2001). The interpretation of the normal behaviour can be also complicated in domestic animals with respect to wild animals because selection has caused changes in their behaviour (Price, 1984).

However, some behavioural indicators can be useful. Sørensen *et al*. (2001) have suggested the standardized fear tests to measure the human-animal relationship, comfort behaviour, such as getting-up behaviour, and some degree of observation of social behaviour. In the IDSW the behaviour components (score of 8) has been subdivided in two aspects: the social interactions and contact with humans (score of 3) and the interaction animal-environment (score of 5). In the former, particular attention has been paid to the human-animal interaction which is influenced by many factors such as genetic predisposition, housing conditions, the experience, quality and quantity of human contact, and handling procedures (Hemsworth *et al*., 1990, 1996). Animals displaying fear of humans are often exposed to adverse handling because they react inappropriately to the handling procedures. The result might be a prolonged complicated human-animal relationship. The choice of the appropriate test and test person should be considered very carefully, as the response to an unfamiliar person tends to differ from the response to the regular stock person (Rousing *et al*., 2001). Rousing and Waiblinger (2004) proposed the voluntary/animal approach test and the avoidance test. In the IDSW model as well, these evaluations have been included, together with the observation of the withdrawal of the animals when the observer approaches the manger and observing the reaction of the animals at the clinical examination operated by the observer.

The observation of social interactions is time consuming and only some social behaviours have been included in the IDSW. Social behaviour refers to movements as well as to contact between congeners. Aggression is a normal part of the behavioural repertoire of social species, and aggressive actions that cause injury poses a welfare problem. The agonistic (e.g. displacement, butting, threatening) and the cohesive interactions (e.g. licking, head resting) are performed between the morning and evening milking, but continuous observations for some periods during the day are necessary. The periods better suited to observing the agonistic behaviour are after feed distribution, as used in the IDSW model.

The occurrence of abnormal behaviours is another aspect of behaviour suggested to assess animal welfare (e.g. Veissier *et al.*, 1999). Abnormal behaviour includes stereotypies (repetitive behaviour patterns with no obvious function) but also excessive licking and even eating the hair. The stereotypies are the most studied group of abnormal behaviour patterns. In food-deprived cows, considered a frustrating situation, Sandem *et al.*, (2002) observed at least one of the following behaviours: aggressiveness (the most frequent), tongue-rolling, vocalization, and head shaking. These behaviour patterns have never been observed in well fed cows. The observation of these stereotypies (tongue rolling, licking of equipment or urine, and head shaking and nose-pressing) has been included in the IDSW model.

In the aspect of animal-environment interaction, particular attention has been focused on resting behaviour. It has been shown, for instance, that surface quality in cubicles affects lying behaviour and the number of skin lesions at carpal and tarsal joints (Oertli *et al.*, 1995). Inadequate cubicle size and neck rail positions cause disturbed lying down and standing up behaviour and injury (Veissier *et al.*, 2004).

The indicators of comfort behaviour include resting behaviour and some indices of cow comfort have been proposed. Fregonesi and Leaver (2001) underline the synchronisation of lying behaviour (time when all animals were contemporarily lying). Nelson (1996) has proposed a cow comfort index (CCI) or cow comfort quotient, defined as the proportion of cows touching a stall while they are lying down. The use of an alternative index known as the stall use index (SUI), which is defined as the proportion of cows that are in the pen, not feeding, and that are lying down in the stall has been proposed by Overton *et al.* (2003). Cook *et al.* (2005) have also proposed the stall perching index (SPI), defined as the proportion of cows touching a stall while standing with only the front two feet in the stall and the rear feet in the alley. In the IDSW model the CCI (score of 1.2), SUI (score of 0.6) and SPI (score of 0.6) have been included.

The resting positions of cows are different and this data could be used to evaluate the comfort of the resting area, in particular of the cubicle. The normal positions are long, short, wide and narrow and many abnormal positions are reported with the meaning of each different position (Anderson, 2003). The inadequate dimensions of the cubicles are the main causes of abnormal positions (Veissier *et al.*, 2004). In the IDSW model the abnormal positions described by Anderson (2003) have been included, with a maximum score of 0.8 when any abnormal position has been observed.

The movement to get up and to lie down in the stall are other suggested indicators (Capdeville and Veissier, 2001; Sørensen *et al.*, 2001). These observations have been included in the IDSW model in order to evaluate the adequacy of the space available for the cows to lie down and particularly to stand up, in relation to the mechanism of rising in the cow (Nordlund and Cook., 2003). Veissier *et al.* (2004) have suggested observing the getting-up movements preferably before milking and the lying movements preferably after milking. These authors have also suggested recording the number of intentions, whether the movement has been interrupted or abnormal (not correct sequence of the movements).

Data presentation and interpretation

The output obtained with the IDSW model shows, together to the overall score, the scores of each cluster, component and aspect. All the scores are expressed both in percentage of optimal welfare and also as weighted value. The expression of the results as percentage of the optimum welfare for the different aspects of welfare could provide information in order to diagnose the critical points that impair the welfare, and also the strength points that improve the welfare. This information could be used in order to suggest solutions to improve welfare in dairy farms. Moreover, it is important to emphasise that in a complex model of welfare assessment there are two main opposite risks:

severe fault on some welfare aspect could be masked by few good values or by many other acceptable aspects;

a level of satisfaction with the minimum values of the overall welfare, considering mediocrity to be acceptable.

For these reasons some level of cut off, including waiting for a better calibration of the judgments after a more complete validation of the model, have been defined on the basis of the preliminary results obtained with the IDSW used in some dairy herds, in order to evaluate the results:

a component is acceptable if the score is higher than 60% of the optimum;

a cluster is acceptable if the score is higher than 70% of the optimum;

the overall score is acceptable if the score is higher than 75% of the optimum.

Validation

To validate a model for assessing animal welfare at herd level it is important to specify the goal and the required degree of practicability. It does not make sense to ask simply whether a model is valid. A model which is based on a limited number of measurements may, for example, serve to give a good estimate of the average welfare level in one kind of production system, but it may be quite unsuitable when a farmer needs to find ways of improving the welfare of the animals on his particular farm.

Welfare involves a number of aspects, for many of which the actual measurement is subjective or, at best, made at an ordinal level. It is not integrated over species or management practices, nor is there a 'gold standard' against which to test any scales (Scott *et al*., 2001).

Well aware that a gold standard does not exist, our first attempt to validate the model has been based on the comparisons with biochemical plasma parameters and haematological parameters, together to sanitary conditions collected from all animals (Calamari *et al*., 2003, 2004). In a recent contribution of ours (Bertoni *et al*., 2007), we proposed using as reference methods to validate the simpler models for welfare assessment in dairy farms, a more accurate model for individual welfare assessment mainly based on direct indicators (principally metabolic, immune function and endocrine parameters). However, along with the previously described indicators they should be applied to the majority of the animals living on the farm. In this case, the cost and time are not the most important factors as validation is done at one time.

Conclusions

An objective evaluation of welfare is essential because it can be utilized for research purposes, as well as to guarantee the consumers and to allow the farmers to improve it and then to increase the herd efficiency. To obtain these goals, both indirect and direct indicators of welfare must be utilized, but they should be valid and reliable, as well as practicable.

The model set up by our Institute utilizes three clusters of indicators; two of them (a score of 30 for each one) are indirect indicators regarding life conditions and feeding of the animals. The third (score of 40) includes the animal responses (direct indicators) which can be divided according to physiologic, performance, health and behaviour type. Within each cluster, some different aspects have been evaluated according to specific indices, and the results obtained for each aspect have been aggregated using weighting factors that have been defined considering the more or less narrow relationship with welfare.

The final judgement considers the overall welfare score obtained with the whole model, but also the individual aspects and the three clusters. This gives the possibility to know the general welfare status as well as the good or bad aspects (the latter requiring some form of improvement).

Finally the model utilizes only the practicable indicators, which are not always the best; furthermore, their weight has been defined according to our experience (and knowledge of the relevant literature). This means that it needs to be validated comparing the results of some farms with more objective methods of welfare evaluation.

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