

The major welfare problems of dairy cows in French commercial farms: an epidemiological approach

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Abstract

Animal welfare enhancement requires that problems are reliably identified and ranked in order to prioritise corrective actions. Welfare problems vary with the conditions in which animals are maintained. The objectives were to highlight major welfare problems for dairy cows on farms in France, and find out how farm characteristics (housing and milking systems, breed) could impact specific welfare aspects on these farms. We conducted a cross-sectional survey on 131 French dairy farms. We used the Welfare Quality[®] protocol, which addresses all aspects of welfare, and yields scores for principles and criteria that represent how well farms meet welfare requirements (from 0 for a very adverse situation to 100 for an excellent one). We used descriptive statistics to highlight low welfare scores, and variance analyses to compare farms. Most farms were found 'Acceptable' according to the Welfare Quality[®] classification. Principles scores for Health, Feeding and Behaviour ranged from 33 to 39. The median score for eight of the welfare criteria was below 50 ('Pain', 'Integument alterations', 'Diseases', 'Comfort around resting', 'Social behaviours', 'Human-animal relationship', 'Positive emotional state', 'Hunger'), while the median score was above 50 for the four other criteria ('Thirst', 'Lameness', 'Expression of other behaviours', 'Ease of movement'). The scores varied widely between farms, within and between systems. Farms with cubicles obtained lower scores for 'Comfort around resting', 'Injuries'; farms with Holstein cows obtained lower scores for 'Hunger'; farms using an automatic milking system obtained lower scores for 'Expression of other behaviours' and 'Diseases' in Holstein herds. This survey yields information on bottlenecks in dairy cow welfare with all dimensions of welfare considered together. The results can be used by stakeholders to prioritise corrective actions in welfare plans, focusing either on the whole population of farms or on farms with characteristics that are at high risk for specific welfare problems.

Keywords: animal welfare, dairy cows, farm characteristics, risks factors, welfare criteria, welfare plan

Introduction

Animal welfare is covered by legislation in many countries (eg Directive 98/58/EC in Europe, Prevention of Farm Animal Cruelty Act in the US). Nevertheless, some animal populations are still affected by serious welfare problems. The European Food Safety Authority (EFSA 2009) pinpointed lameness, mastitis, metabolic disorders, low fertility and short longevity as major problems affecting welfare in dairy cows. To implement control plans designed to improve the welfare status of cows, it is essential to identify major vs minor risks, based on severity of effects and likelihood of exposure (EFSA 2012).

Animal welfare has many components: good health, expression of normal behaviour, absence of fear, etc (Farm Animal Welfare Council 1992). A protocol allowing the assessment

of all these components is necessary to describe precisely the different risks for welfare. The Welfare Quality[®] project designed such an expert-based protocol: four principles split into 12 independent welfare criteria are listed, covering all aspects of welfare, and measures are proposed to assess how well farms meet them. Scores are calculated, based on the severity of problems and their prevalence (Botreau *et al* 2007; Botreau 2008). Scores are calculated using an evaluation model that reflects the opinion of a group of experts — from different disciplines — consulted during the Welfare Quality[®] project. A common value scale allows the results from different criteria to be compared so that priorities can be more easily set. The results should therefore provide a guide to identifying major welfare risks on a farm and, in turn, at population level.

One important question is how well do farm characteristics inform us of risks to animal welfare. Cows' living conditions are highly variable, depending not only on the housing but also on breed, food, climatic conditions, etc. We conducted a survey on French dairy farms, where the living conditions of cows are diverse, in order to: (i) highlight the most important welfare problems; and (ii) find out to what extent the farm characteristics, defined by housing conditions, cow breed, milking system, herd size and location, can statistically explain variations in cows' welfare.

Materials and methods

Farms surveyed

This study was carried out on private land (ie commercial dairy farms), and each farm owner gave permission to conduct the study on his site. The sample of farms surveyed was chosen to reflect the diversity of dairy systems in France, except tie-stall systems that are becoming scarce in France (French Livestock Institute 2009), and were not included in our study. There is currently no database publicly available including all French dairy farms with their characteristics. Nevertheless, several studies provide information on the number of farms with particular environmental constraints (and their relation to milk specialisation level, intensification of feeding system, and density on land), specific housing and milking systems, and the number of cows of each breed (Agreste 2008; French Livestock Institute 2009). To reflect the diversity of French dairy farms as described in these studies, we chose five characteristics as stratification parameters (referred to as 'farm characteristics' in the next sections): farm location (two French regions: lowland [Brittany and Pays de la Loire, western France] vs highlands [Auvergne, central France and Rhône-Alpes, eastern France]), cow breed (Holstein vs Montbéliarde, ie a specialised vs a less-specialised dairy breed), milking system (parlour vs automatic milking system [AMS]), housing system (straw-yard barns vs cubicles), and herd size (less vs more than 50 lactating cows). We excluded the combination of AMS and straw-yard housing system because we expected to find no farms with such characteristics, as an AMS is most often used in cubicles (de Koning 2011). All farms were enrolled in the national milk recording scheme. The French Animal Health Service ('Groupement de Défense Sanitaire' GDS) provided anonymous lists of farms. Farms were selected at random from these lists using R®2.10.1 software (R Development Core Team 2009). Then the GDS provided the name, address and telephone number of the randomly selected farms. A phone interview with the owner was used to ascertain the characteristics of the farms, with the aim of visiting at least six farms per combination of farm characteristics.

Measurements and scoring

We used the Welfare Quality® assessment protocol for dairy cattle (Welfare Quality® 2009). Only a brief description is provided here. The protocol is based on four welfare principles ('Good Feeding', 'Good Housing', 'Good Health', and 'Appropriate Behaviour') subdivided into 12 welfare criteria (eg the 'Good Feeding' principle

comprises the criteria 'Absence of prolonged hunger' and 'Absence of prolonged thirst'). Each criterion is checked by one to seven measures, resulting in a total of 33 measures yielding raw data, such as percentage of animals with a given problem or frequency of social interactions (Table 1). Most measures are made on animals (clinical and behavioural observations). A few are made on resources (eg number of drinkers) or on management (eg dehorning method). The rationale behind the choice of measures is given in Forkman and Keeling (2009). The animal-based measures made at individual level were performed on a sample of animals chosen at random in the herd, the size of the sample depending on the herd size: if there were 30 or fewer lactating cows on a herd, all the animals were observed; otherwise 75 to 45% of cows were randomly chosen, the proportion decreasing with the size of the herd (eg 30 cows out of 44, 54 cows out of 120).

The data provided by the measures relevant to a given criterion are gathered into a score that reflects how well the farm meets this criterion. The score synthesises information on prevalence and severity of problems and reflects the opinion of experts consulted during the Welfare Quality® project (Botreau 2008). The scores are expressed on a 0–100 scale, with 0 for very poor welfare and 100 for excellent welfare. In the Welfare Quality® protocol, three main types of calculation are made:

- The measures used to check the criteria 'Absence of prolonged hunger', 'Absence of injuries', 'Expression of social behaviours', 'Expression of other behaviours', 'Good human-animal relationship', 'Positive emotional state' yield continuous data on similar scales. The severity of the problem can be considered (eg percentages of not lame, moderately lame and severely lame cows). A weighted sum is then calculated (eg percentage of lame animals weighted for severity of the lameness). Cubic functions are then used to transform the weighted sum into the criterion score. The weightings in weighted sums and the parameters of the cubic functions reflect the experts' views. Two partial scores, one for integument alterations (ie alterations of the skin in the Welfare Quality® protocol: hairless patches and lesions/swellings of a minimum diameter of 2 cm at the largest extent) and one for lameness, are calculated for the criterion 'Absence of injuries' and then combined into the criterion score.
- The measures used to check the criteria 'Comfort around resting' and 'Absence of diseases' yield continuous data expressed on different scales. For each kind of data (proportion of animals affected, average time to lie down, etc), three levels are defined: data gathered on the farm correspond to no problem, a moderate problem, or a serious problem. The number of problems noted on the farm is then turned to a score using cubic functions (as above).
- Measures used to check the criteria 'Absence of prolonged thirst', 'Ease of movement', and 'Absence of pain due to management procedures' yield data expressed in a limited number of categories, and a decision tree is used to calculate discrete scores. For example, for the removal of horns, the procedure used (no horn removal, disbudding by thermo-

Table 1 Welfare Quality® principles, criteria and measures, and type of data produced for dairy cattle.

Principle	Criterion	Measure	Data produced
Good Feeding	Absence of prolonged hunger	Body condition score	% very lean cows (ie 'lean' corresponds to a score of < 2.5 in the grid of Edmondson <i>et al</i> [1989])
	Absence of prolonged thirst	Provision of water	Number of drinkers; length of troughs; cleanliness of drinkers; water flow
Good Housing	Comfort around resting	Behaviour at lying	Mean time to lie down; % cows colliding with housing equipment when lying down or lying outside the lying area
		Cleanliness of cows	% cows with a dirty udder, dirty flank/upper legs, dirty lower legs (ie 'dirty' corresponds to a score of 3 or 4 of Cook's grid: http://www.vetmed.wisc.edu/dms/fapm/fapmtools/hygiene.htm)
	Thermal comfort	No measure available	Criterion not assessed
	Ease of movement	Possibility for cows to walk*	Presence of tethering; if tethered, possibility of daily exercise
Good Health	Absence of injuries	Clinical observations: Lameness	% moderately lame and severely lame (ie 'moderately' and 'severely' correspond, respectively, to score 3 and to scores 4 and 5 in the grid of Winckler & Willen [2001])
		Clinical observations: Integument alterations	Percentage of animals with mild integument alterations (hairless patches) and severe integument alterations (lesions/swellings)
	Absence of disease	Clinical observations	Number of coughs (per cow per h); % cows with nasal discharge, ocular discharge, hampered respiration, diarrhoea, or vulval discharge
		Farm records	% cows with high milk somatic cell count (SCC \geq 400,000 at least once during last 3 months); over last 12 months; % affected by dystocia or downer cows, mortality (% cows dead or euthanised)
Appropriate Behaviour	Absence of pain induced by management procedures	Dehorning practices*	Procedure used for disbudding or de-horning or tail docking; use of anaesthetics or analgesics
	Expression of social behaviours	Interaction between cows	Number of head-butts or other aggressive events (per cow per h)
	Expression of other behaviours	Access to pasture*	Number of days per year and hours per day with access to pasture
	Good-human animal relationship	Avoidance distance of cows when approached at the feeding rack	% cows that can be touched, approached at 50 cm, at 100 cm, or cannot be approached
	Positive emotional state	Qualitative behaviour assessment	Values for the 20 terms (0–125 scale) (Wemelsfelder <i>et al</i> 2009)

* From farmer's interview.

cautery, chemical disbudding, dehorning of adult cows) and the use of medicines (none, anaesthetics, analgesics, both) are taken into account to estimate 'Absence of pain due to management procedures'.

For each principle, a score (0–100 scale) is calculated synthesising the scores obtained by the farm on the various criteria related to this principle, with more importance attributed to the worst criterion score. Finally, the farm is assigned to an overall welfare category according to its principles scores:

- The farm is deemed 'excellent' if it scores more than 55 on all principles and more than 80 on at least two principles;
- The farm is deemed 'enhanced' if it scores more than 20 on all principles and more than 55 on at least two principles;
- The farm is deemed 'acceptable' if it scores more than 10 on all principles and more than 20 on at least three principles; and
- Otherwise, the farm is deemed 'not classified'.

The full protocol can be downloaded from the Welfare Quality® Network website at <http://www.welfarequalitynetwork.net/network/45848/7/0/40>.

Organisation of the visits

The farms were visited during winter, between December 2010 and March 2011, so that the cows were indoors. Farmers were contacted by mail and telephone. After completion of the work, the farmers were given the results obtained by their farm together with anonymous descriptive statistics on the whole 131 farm sample (eg 'your farm obtained score 72.3 for criterion 'Absence of prolonged hunger' whereas the average score for all farms visited was 49.3').

Five observers carried out the visits. They had been trained previously by a partner from the Welfare Quality® project. Training consisted of classroom exercises using photographs and video clips, observations on animals, and 'test

Table 2 Number of farms visited per farm system.

Housing system	Breed	Milking system	Location	Number of lactating cows	Number of farms
Straw yard	Montbéliarde	Parlour	Highland	28–49	10
Straw yard	Montbéliarde	Parlour	Highland	50–120	6
Straw yard	Montbéliarde	Parlour	Lowland	28–49	11
Straw yard	Montbéliarde	Parlour	Lowland	50–120	6
Straw yard	Holstein	Parlour	Highland	28–49	5
Straw yard	Holstein	Parlour	Highland	50–120	5
Straw yard	Holstein	Parlour	Lowland	28–49	7
Straw yard	Holstein	Parlour	Lowland	50–120	5
Cubicles	Montbéliarde	Parlour	Highland	28–49	8
Cubicles	Montbéliarde	Parlour	Highland	50–120	8
Cubicles	Montbéliarde	Parlour	Lowland	28–49	5
Cubicles	Montbéliarde	Parlour	Lowland	50–120	6
Cubicles	Montbéliarde	AMS	Highland	50–120	7
Cubicles	Montbéliarde	AMS	Lowland	50–120	3
Cubicles	Holstein	Parlour	Highland	28–49	8
Cubicles	Holstein	Parlour	Highland	50–120	5
Cubicles	Holstein	Parlour	Lowland	28–49	7
Cubicles	Holstein	Parlour	Lowland	50–120	6
Cubicles	Holstein	AMS	Highland	50–120	5
Cubicles	Holstein	AMS	Lowland	50–120	8

runs' on four farms where the whole assessment protocol was applied. During training, observers' results were compared between them and against reference values to ensure reproducibility between observers and accuracy of their assessment. Observers' agreement with reference values ranged from 0.74 to 0.96.

Data collection started just after the morning milking, and ended in the afternoon. Each observer carried out one visit daily.

Data analysis

First, we calculated descriptive statistics (medians, first and third quartiles for continuous data, percentages of farms for discrete data) for data collected on the 131 farms and for the resulting calculated criterion scores. Second, we tested the effect of each of the five farm characteristics on criterion scores with ANOVA (results not shown). As neither herd size nor location had any effect on welfare scores ($P > 0.05$ in all cases), cow breed, housing system, milking system and their interactions were kept for further analyses. The multivariate models were then simplified, based on the Akaike Information Criterion (AIC) (Akaike 1973). The procedure was stopped when no factor could decrease the AIC value (Burnham *et al* 2011). Then, among models with close AIC values (difference

below 2), we selected the most parsimonious one, ie with the fewest parameters. Models were interpreted using their parameters and SEM. The normal distribution of the residuals was checked graphically and using the Shapiro-Wilk normality test. The adjusted R -squared value (R^2) was used to assess the proportion of variability explained by the model. In addition, within each final model, factors were ranked by the proportion of variability they explained themselves.

All data analyses were performed on R.2.10.1® software (R Development Core Team 2009). The significance threshold was set at $P = 0.05$.

Results

Population studied

A total of 432 farmers were contacted by mail and telephone, of which 30% were visited, corresponding to 131 farms. We visited, on average, 22 farms of each farm system (Table 2). The herd size of the farms ranged from 21 to 120 lactating cows (mean [\pm SEM]: 51.2 [\pm 1.51]). Calvings were not grouped: the average stage of lactation of cows in herds ranged from 109.5 to 261.3 days, with a mean (\pm SEM) of 168.2 (\pm 2.7).

Table 3 Descriptive statistics on principle scores (expressed on a 0–100 scale with 0 for very poor welfare and 100 for excellent welfare)* from the 131 dairy farms.

Principle	Farm score				
	Median	First quartile	Third quartile	Min	Max
Good Feeding	38.8	14.6	62.4	3.5	100
Good Housing	61.3	53.4	67.5	37.0	81.7
Good Health	33.0	28.4	38.3	13.9	54.2
Appropriate Behaviour	38.2	28.4	47.2	10.8	69.3

* Due to missing data, scores were not calculated for 'Appropriate Behaviour' on two farms, and for 'Good Feeding', 'Good Housing', and 'Good Health' on one farm.

Table 4 Descriptive statistics on criterion scores (expressed on a 0–100 scale with 0 for very poor welfare and 100 for excellent welfare)* from the 131 dairy farm.

Criterion	Farm score				
	Median	First quartile	Third quartile	Min	Max
Absence of prolonged hunger	49.3	27.6	100	2.5	100
Absence of prolonged thirst	60.0	11.5	100	3.0	100
Comfort around resting	38.5	26.0	48.4	0.0	70.9
Ease of movement	100	100	100	100	100
Absence of injuries	54.7	40.0	69.6	6.7	100
Lameness [†]	70.9	51.3	86.4	11.2	100
Integument alterations [†]	33.1	11.6	63.7	0.0	100
Absence of disease	33.3	27.4	44.8	11.9	86.0
Absence of pain due to management procedures	28.0	28.0	28.0	2.0	75.0
Expression of social behaviours	42.0	20.5	62.6	0.0	95.9
Expression of other behaviours	82.3	77.9	86.3	0.0	100
Good human-animal relationship	42.0	33.9	51.0	13.5	70.0
Positive emotional state	49.0	34.6	66.1	0	93.3

* Due to missing data, scores were not calculated for 'Good human-animal relationship' on two farms, and for 'Absence of prolonged hunger', 'Comfort around resting', 'Absence of injuries', and 'Absence of disease' on one farm.

[†] Partial scores for lameness and integument alterations are produced before being synthesised into a score for 'Absence of injuries'.

Descriptive statistics

Overall scores

Most farms were classified as 'acceptable' (n = 75; 57.3%) or 'enhanced' (n = 48; 36.6%). Only six farms (4.6%) were 'not classified'. No farm was considered 'excellent'. Some measures could not be recorded in two farms due to practical constraints. Consequently, overall welfare could not be assessed on these farms.

Table 3 gives descriptive statistics for welfare principles' scores on all farms, Table 4 for welfare criteria scores, and Table 5 for data collected on farms. A score of 100 means that targets were met perfectly for a principle or a criterion. On average, the farms scored between 33 and 39 for all

welfare principles, except 'Good Housing' for which they scored 61 on average, always with large variations between farms. The results per criteria are presented below.

Absence of prolonged hunger

There was no lean cow on 25% of the farms, but 25% of the farms had between 23.1 and 87.5% very lean cows, resulting in a score of 27.6 for the first quartile and 100 for the third quartile, with a median of 49.3.

Absence of prolonged thirst

Of the farms, 29.8% provided at least two drinkers available at all times and one clean drinking place (ie one water bowl or 60 cm of trough) for ten cows, and thus scored 100 for 'Absence of prolonged thirst'. Conversely, 25.2% of the farms did not

Table 5 Descriptive statistics on the data collected on the 131 dairy farms.

Data collected on farms	Median	First quartile	Last quartile	Min	Max
<i>Absence of prolonged hunger</i>					
% very lean cows	9.1	0	23.1	0.0	87.5
<i>Comfort around resting</i>					
Mean time to lie down (s)	5.9	5.2	6.7	3.1	10.7
% cows colliding with housing equipment when lying down	14.3	0.0	42.3	0.0	100
% cows lying outside the lying area	0.0	0.0	0.0	0.0	45.8
% cows with a dirty udder	21.8	9.1	35.4	0.0	96.7
% cows with dirty flank/upper legs	52.5	27.6	74.8	0.0	100
% cows with dirty lower legs	88.0	71.5	96.9	2.7	100
<i>Absence of injuries</i>					
% moderately lame cows	9.2	3.4	17.1	0.0	48.6
% severely lame cows	0.0	0.0	3.6	0.0	34.6
% cows with mild integument	15.9	5.9	28.8	0.0	62.5
% cows with severe integument alterations	33.4	10.8	62.2	0.0	100
<i>Absence of diseases</i>					
Number of coughs per hour	0.4	0.0	0.8	0.0	3.6
% cows with nasal discharge	14.5	2.5	28.6	0.0	58.3
% cows with ocular discharge	0.0	0.0	2.9	0.0	45.7
% cows with hampered respiration	0.0	0.0	0.0	0.0	2.8
% cows with diarrhoea	0.0	0.0	15.1	0.0	84.6
% cows with vulvar discharge	0.0	0.0	0.0	0.0	11.4
% cows with high somatic cell counts	19.0	14.5	25	2.0	46.0
% cows affected by dystocia	5.0	2.0	8.0	0.0	25.0
% downer cows	4.0	2.0	7.0	0.0	20.0
Mortality	2.0	1.0	5.0	0.0	17.0
<i>Expression of social behaviours</i>					
Number of butts per cow per hour	0.5	0.2	0.9	0.0	6.9
Number of other aggressive events per cow per hour	1.0	0.6	1.5	0.0	4.8
<i>Expression of other behaviours</i>					
Expression of other behaviours	82.3	2.6	77.9	86.3	100
Number of days at pasture per year	229	204	259	0.0	365
Number of hours at pasture per day	16.0	9.5	19	0.0	24.0
<i>Good-human animal relationship</i>					
% cows that can be touched	42.0	33.9	51.0	13.5	70.0
% cows that can be touched	8.9	3.2	15.4	0.0	36.7
% cows that can be approached by 50 cm	47.1	34.7	58.1	6.1	90.5
% cows that can be approached at 100 cm	33.3	24.1	42.4	0.0	81.1
% cows that cannot be approached	3.2	0.0	13.9	0.0	64.2

provide enough drinkers (more than 15 cows per drinking place) and so scored 3. On the other farms, only one drinker was available at all times, there were between 10 and 15 cows per drinking place, or the drinkers were not clean, resulting in scores between 20 and 60. The median score was 60 (difference between first and third quartiles: $\Delta_{\text{quartiles}} = 88.5$).

Comfort around resting

The median time to lie down was 5.9 s ($\Delta_{\text{quartiles}} = 1.5$ s), the median percentage of cows colliding with equipment while lying down was 27.1% ($\Delta_{\text{quartiles}} = 42.3\%$), and cows lay down outside the lying areas in only 25 farms. On average, 21.8% cows had a dirty udder ($\Delta_{\text{quartiles}} = 26.3\%$), 52.5% had dirty flanks or upper legs ($\Delta_{\text{quartiles}} = 47.2\%$), and 88.1% had dirty lower legs ($\Delta_{\text{quartiles}} = 25.5\%$). Finally, the median score for 'Comfort around resting' of 38.5 ($\Delta_{\text{quartiles}} = 22.4$).

Ease of movement

In all the farms we visited, the cows were loose-housed. Thus, they all scored 100 for 'Ease of movement'.

Absence of injuries

The median percentages of moderately and severely lame cows were, respectively, 9.2 and 0.0%, resulting in a median partial score for 'Lameness' of 70.9 ($\Delta_{\text{quartiles}} = 35.4$). The median percentages of cows with mild and severe integument alterations were 15.9 and 33.4%, respectively, resulting in a median partial score for 'Integument alterations' of 33.1 ($\Delta_{\text{quartiles}} = 52.1$). Lastly, the median score for 'Absence of injuries' was 54.7 ($\Delta_{\text{quartiles}} = 29.6$).

Absence of disease

The clinical observations highlighted a median percentage of cows with nasal discharge of 14.5% per farm, and of 0% for ocular discharge, hampered respiration, diarrhoea, or vulval discharge. The median frequency of coughs was 0.4 per cow per hour. Farm records revealed a median prevalence of 19% cows with high somatic cell counts ($> 400,000$ cells ml^{-1} at least once during the last three months), and 2% mortality, 5% dystocia and 4% downer cows during the previous year. The median score for 'Absence of diseases' was 33.3 ($\Delta_{\text{quartiles}} = 17.4$).

Absence of pain due to management procedures

Horn removal was performed on all the farms visited. Disbudding of the calves was the most common practice (129 farms, of which 113 farms used thermocautery and 15 caustic paste) and this was usually performed without anaesthetics or analgesics, by thermocautery (83 farms) or caustic paste (15 farms), resulting in scores for 'Absence of pain due to management procedures' equal to, respectively, 28 and 20. Anaesthetics or analgesics or both were used, respectively, by only 24, 3 and 3 farmers disbudding calves by thermocautery, resulting in scores of 49, 52 and 70. The 15 farmers disbudding calves with caustic paste never used anaesthetic or analgesics. On a few farms, adult cows were dehorned with anaesthetic (1 farm, score = 14) or without anaesthetic or analgesics (2 farms, score = 2). Because fewer than 25% of the farms obtained scores either below or above 28, the median score, the first and last quartiles equalled 28.

Expression of social behaviours

The median number of butts and other aggressive events were 0.5 ($\Delta_{\text{quartiles}} = 0.7$) and 1 ($\Delta_{\text{quartiles}} = 0.9$) per cow per hour. The median score for 'Expression of social behaviours' was equal to 42 ($\Delta_{\text{quartiles}} = 42.1$).

Expression of other behaviours

Herds spent a median time of 229 days on pasture per year and a median time of 16 h per day (Table 4). The median score was 82.3 ($\Delta_{\text{quartiles}} = 75.3$).

Good human-animal relationship

On average, 8.9% cows could be touched, 47.1% could be approached to 50 cm but not touched, 33.3%, could be approached to between 1 m and 50 cm, and 3.2% could not be approached. The final median score was 42 ($\Delta_{\text{quartiles}} = 17.1$).

Positive emotional state

The median score was 49.0 ($\Delta_{\text{quartiles}} = 31.5$).

Relations between farm characteristics and criterion scores

None of the three farm characteristics kept for analyses affected the score of 'Good human-animal relationship' and 'Absence of pain due to management procedures' ($P > 0.05$).

For the other criteria, the final models explained from 5.38% (ie 'Absence of prolonged thirst') to 42.5% (ie 'Comfort around resting') of the variability between farms (Table 6). Housing system had a significant effect on the scores for four criteria ('Comfort around resting', 'Absence of injuries', 'Absence of diseases' and 'Expression of other behaviours'): in all cases, straw-yard barns scored higher than cubicle barns. Breed had a significant effect on four criteria: herds with Montbéliarde cows obtained higher scores for 'Absence of prolonged hunger', 'Comfort around resting' and 'Absence of diseases', while herds with Holstein cows obtained higher scores for 'Expression of social behaviours'. Milking system affected the scores for three criteria ('Absence of injuries', 'Absence of diseases' and 'Expression of other behaviours'), a milking parlour being associated with higher scores in all cases. Finally, an interaction between housing system and breed was observed for two criteria: 'Absence of prolonged thirst' and 'Positive emotional state'. In straw yards, Montbéliarde herds obtained lower scores than Holstein herds for 'Absence of prolonged thirst' ($F = 4.61$; $P = 0.036$) and for 'Positive emotional state', ($F = 5.68$; $P = 0.021$), while the opposite was observed in cubicles for 'Positive emotional state' ($F = 5.96$, $P = 0.017$). In cubicles, no breed differences were observed for 'Absence of prolonged thirst' ($F = 0.57$, $P = 0.449$).

All subpopulations of farms obtained scores below 50 for 'Comfort around resting', 'Absence of diseases', 'Absence of pain due to management procedures', and 'Good human-animal relationship' (Table 7). The scores for 'Expression of social behaviours' were also below 50, except in Holstein cows housed in cubicle barns and milked with an AMS.

Table 6 Parameters of the final linear models chosen to explain criterion scores: the percentage of total variability (%Total variability) explained, F-values (for differences between classes) and their probability (P).

Criterion	Parameters of final model	% Total Variability explained by farm characteristic	F-value	P-value
Absence of prolonged hunger	Breed	21.50%	35.11	< 0.001
Absence of prolonged thirst	Housing × Breed	3.67%	4.93	< 0.05
	Housing	1.11%	1.49	0.22
	Breed	0.6%	0.82	0.36
Comfort around resting	Housing	37.2%	81.6	< 0.001
	Breed	4.31%	9.44	< 0.01
	Housing × Breed	1.04%	2.27	0.13
Absence of injuries	Housing	17.4%	28.5	< 0.001
	Milking system	2.64%	4.31	< 0.05
	Breed	1.11%	1.89	0.17
	Housing × Breed	2.01%	3.27	0.07
Absence of diseases	Housing	5.86%	8.67	< 0.01
	Breed	4.58%	6.77	< 0.05
	Milking system	3.39%	5.00	< 0.05
	Milking system × Breed	1.52%	2.26	0.14
Expression of social behaviours	Breed	6.36%	8.87	< 0.01
	Milking system	1.95%	2.71	0.1
Expression of other behaviours	Milking system	21.6%	41.1	< 0.001
	Housing system	11.2%	21.2	< 0.001
Positive emotional state	Housing × Breed	8.77%	12.5	< 0.001
	Milking system	1.50%	2.13	0.14
	Housing system	1.05%	1.49	0.22
	Breed	0.10%	0.14	0.7

We do not present results for the criteria 'Absence of pain due to management procedures' and 'Good human-animal relationship' because no model yielded significant effects for any of the farm characteristics studied.

Only one subpopulation obtained scores below 50 for 'Absence of prolonged thirst' (Montbéliarde cows housed in straw yard and milked in a parlour) and two subpopulations for 'Expression of other behaviours' (Montbéliarde or Holstein cows milked with an AMS). Holstein cows housed in cubicles barn obtained the lowest scores for 'Comfort around resting' and 'Absence of diseases' for which they obtained scores below 25.

Discussion

The use of a common (0–100) scoring scale expressing how closely farms met welfare criteria defined in the Welfare Quality® protocol enabled us to rank the risks facing dairy cows, to highlight the relative contribution of farm characteristics on these risks, and to identify specific risks for each farm subpopulation.

Most farms were found acceptable according to the Welfare Quality® classification, which means that improvements are necessary to achieve a good level of dairy cow welfare. This is true for the health, behaviour and feeding of cows for which low principle scores were obtained (between 33 and 39 on the 0–100 scale). The prevalence of the welfare problems noted in our survey was similar to that available in the literature. This held for diseases (eg dystocia, 5% here vs 6.6% in Fourichon *et al* [2001], 2–6% in Mee [2008] and 5% in de Vries *et al* [2013]), cows' difficulties lying down (eg time to lie down: 5.9 s here vs 5.4 s in Brörkens *et al* [2009]), cows' dirtiness (eg on lower legs: 88% here vs 100% in Main *et al* [2003] and Whay *et al* [2003]; on udder: 22% here vs 20% in Main *et al* [2003] and 22% in Whay *et al* [2003]), integument alterations (eg cows with at least one instance of integument alteration, 59% here

Table 7 Risks for dairy cows' welfare according to farm characteristics. Mean scores of each farm sub-population (in rows) were estimated from analyses of variance, except for criteria 'absence of pain due to management procedures' and 'good human-animal relationship' for which the mean scores are calculated on raw data. To ease the reading of the table, a cell is blue when the score is below 50 and red when the score is below 25.

Housing	Breed	Milking Farms system (n)	Criterion										
				1	2	3	4	5	6	7	8	9	10
Straw yard	Montbéliarde	Parlour 33	Mean	72.3	40.0	49.6	64.3	43.3	30.1	35.5	39.7	85.5	44.2
			(± SEM)	(± 3.69)	(± 6.30)	(± 2.24)	(± 4.71)	(± 5.19)	(± 2.13)	(± 5.67)	(± 2.15)	(± 5.14)	(± 5.40)
Straw yard	Holstein	Parlour 22	Mean	40.0	62.9	46.7	67.4	31.2	34.0	47.6	42.4	85.5	58.8
			(± SEM)	(± 5.45)	(± 10.0)	(± 2.41)	(± 5.25)	(± 6.05)	(± 2.36)	(± 5.67)	(± 2.26)	(± 5.15)	(± 5.90)
Cubicles	Montbéliarde	Parlour 27	Mean	72.3	60.1	32.8	55.2	38.8	31.8	35.5	45.9	78.7	51.2
			(± SEM)	(± 3.69)	(± 8.71)	(± 3.08)	(± 4.68)	(± 5.14)	(± 3.11)	(± 5.67)	(± 2.4)	(± 3.93)	(± 5.40)
Cubicles	Montbéliarde	AMS 10	Mean	72.3	60.1	32.8	45.8	36.3	35.2	44.8	47.1	46.1	62.0
			(± SEM)	(± 3.69)	(± 8.71)	(± 3.08)	(± 4.69)	(± 2.79)	(± 3.66)	(± 5.68)	(± 4.39)	(± 5.20)	(± 5.36)
Cubicles	Holstein	Parlour 26	Mean	40.0	54.9	22.9	39.8	24.3	32.9	47.6	42.4	78.7	38.5
			(± SEM)	(± 5.45)	(± 13.0)	(± 4.65)	(± 3.10)	(± 6.67)	(± 2.49)	(± 5.67)	(± 2.42)	(± 3.93)	(± 7.74)
Cubicles	Holstein	AMS 13	Mean	40.0	54.9	22.9	30.4	21.7	34.7	57.0	38.7	46.1	49.3
			(± SEM)	(± 5.45)	(± 13.0)	(± 4.65)	(± 6.80)	(± 6.19)	(± 3.37)	(± 4.33)	(± 2.81)	(± 5.20)	(± 5.36)

Criteria: 1, Absence of hunger; 2, Absence of thirst; 3, Comfort around resting; 4, Absence of injuries; 5, Absence of diseases; 6, Absence of pain due to management procedures; 7, Expression of social behaviours; 8, Good-human animal relationship; 9, Expression of other behaviours; 10, Positive emotional state.

vs more than 50% in Weary and Taszkun [2000], Whay *et al* [2003] and Kielland *et al* [2009]; cows with severe integument alterations, 33.4 here vs 35.3 in de Vries *et al* [2013]), social behaviour (eg frequency of head butts per cow per hour, 0.5 here vs 0.7 in de Vries *et al* [2013]). These similarities suggest that the average level of cows' welfare is rather homogeneous across countries, and that our conclusions may apply to other countries, at least when the cows are kept in similar systems (eg loose-housed in winter and out at pasture in summer).

The lowest median scores were obtained for the criteria 'Absence of pain due to management procedures' (28 on a 0–100 scale), 'Absence of diseases' (33), and 'Comfort around resting' (38.5). Although these problems have already been described in the literature (Main *et al* 2003; Broom & Fraser 2007; Halasa *et al* 2007; European Food Safety Authority 2009), the calculation of welfare scores can help to draw attention to these problems as major ones for dairy cows, calling for control actions to significantly improve their welfare.

The scores for 'Absence of pain due to management procedures' were low in almost all the farms: the scores did not vary according to farm characteristics. The low scores were due to calf disbudding without pain relief. Although the use of anaesthetics and analgesics has been largely recommended (Stafford & Mellor 2005; Stock *et al* 2013), they are still not commonly used in Europe and North America (Fulwider *et al* 2008; SANCO 2009; Vasseur *et al* 2010). Improvements could be made by informing farmers about the negative effects of pain on calves' health and welfare and on ways to reduce it (Stafford & Mellor 2005), thereby encouraging the use of anti-inflammatory drugs and allowing them to use anaesthetics after appropriate training, as done in Switzerland (Article 16 of the federal law on the protection of animals 2005).

There was a large variation in the scores for 'Absence of diseases' and 'Comfort around resting'; the high scores indicating that good managers can be successful at assuring health and comfort of their cows. Also, the variation was linked to the characteristics of farm systems. This suggests that control plans should be adapted to the specific characteristics of the farm (cow breed, housing system and milking system). Regarding 'Absence of diseases', the lowest scores among all farm systems were found for Holstein herds housed in cubicles. Previous work reported that high milk producing cow breeds (eg Holstein) are at higher risk for several health disorders (for a review, see EFSA 2009). Our results suggest that this is particularly the case when cows are housed in cubicles. In addition, farms that used a cubicle housing system had lower scores for 'Comfort around resting', as previously reported (Fregonesi & Leaver 2001; Cook & Nordlund 2009). This resulted in Holstein cows housed in cubicle barns being at high risk of poor welfare regarding 'Absence of disease' and 'Comfort around resting', with scores below 25.

Cubicles can restrain the cows during lying movements, causing injuries (Lidfors 1989; Veissier *et al* 2004; Kielland *et al* 2009). This may not be due to the cubicles *per se*, but to the way they are designed and adjusted (CIGR 1994; Veissier *et al* 2004; Kielland *et al* 2009). On farms where low scores are observed for this criterion, further observations of particular features of the resting area and the combination of their adjustments (eg neck rail, brisket board position, etc) would be necessary to identify exact causes of the problems.

The farms included in our survey obtained moderate to high median scores for 'Expression of social behaviours' (42.0), 'Good human animal relationship' (42.0), 'Positive emotional state' (49.0), 'Absence of prolonged hunger'

(49.3), 'Absence of injuries' (54.7), 'Absence of prolonged thirst' (60) and 'Expression of other behaviours' (82.3).

The scores for 'Absence of prolonged hunger' and 'Absence of injuries' were variable among farms; this variability was partly explained by farm characteristics. For 'Absence of injuries', farms with a cubicle housing system had lower scores, as previously reported (Fregonesi & Leaver 2001; Cook & Nordlund 2009). Again, it may not be the cubicle *per se* that induced injuries, but the way it was designed (see above). The scores for 'Absence of prolonged hunger' were especially low in farms with a specialised dairy breed (Holstein). It might be argued that the lower body condition scores of Holstein cows are due merely to their conformation. However, the scale used for body condition in the Welfare Quality® protocol is adapted to the breed (pure dairy breed vs dual purpose breed). Therefore, the frequent leanness of Holstein cows should rather be ascribed to their higher milk production that puts them at higher risk of nutritional deficit at least at the beginning of lactation, even when they are fed a rich diet *ad libitum* (Roche *et al* 2009). However, whether the high mobilisation of body reserves during lactation in high-producing cows is accompanied by hunger, and thus poor welfare, remains an open question. This could be investigated in experimental conditions using, for example, operant conditioning to measure motivation for feeding, as has been proposed by Cooper *et al* (2010).

The score for 'Good human-animal relationship' varied between farms but, according to our results, these variations were not linked to the farm system in place. This implies that specific attention should be given to this criterion because welfare problems may be pronounced on some farms. For this criterion, for which variations between farms are not explained by farm characteristics, other factors are likely to play a role. The attitude of the stockperson and his/her behaviour towards animals affect animals' responses towards humans (Hemsworth & Coleman 1998; Breuer *et al* 2000; Waiblinger *et al* 2002). These attributes seem not to depend on the housing system, the milking system or the breed stocked on the farm. Again, these findings stress the importance of the farmer for the welfare of animals, through attitude, behaviour, or way of managing the farm.

Animal welfare implications

This study was based on the use of the Welfare Quality® protocol, which aims to provide not only a description of the welfare state of animals, but also an evaluation of this state (Botreau 2008). Scores are calculated to reflect the compliance of farms to a set of welfare criteria. By nature, this exercise cannot be value-free (Fraser 1999; Veissier *et al* 2011) and cannot be validated against any gold standard. The validity of an evaluation exercise lies in the fact that: (i) the values attributed to certain situations correspond to a broad consensus; and (ii) the evaluation is likely to encourage improvements (Roy 1993; Botreau 2008). In Welfare Quality®, the calculation of scores was decided from experts' opinion. Many experts were involved, with ranging background and country of origin (72 animal scientists, social scientists and stakeholders) (Miele *et al* 2001).

The evaluation system was based on a consensus between these persons and thus may be considered to represent the most common value judgment in Europe regarding farm animal welfare. Then, to encourage improvements, the protocol should first be able to highlight variations among farms, and more specifically to highlight major problems. The present study confirms this potential. Moreover, from our survey we can extend the list of 'major welfare problems' proposed by the experts of the EFSA (2009). The EFSA report concludes that mastitis, lameness, and leg disorders are the most important welfare problems in dairy cows, and that reproductive, metabolic, and behavioural problems are relevant indicators of poor welfare. Our results suggest that pain (not mentioned in the EFSA report) is a crucial welfare problem and should therefore be considered in further surveys. The results of the present survey also allow us to rank welfare problems: pain due to dehorning seems the most problematic, then diseases and finally resting discomfort. Interestingly, when communicated to stakeholders, some of these set in place a welfare plan focused on the welfare problems identified in the present survey (pain due to dehorning, leanness of cows, appropriate housing, prevention of diseases) (Danone Animal Welfare Program© 2011). In addition, recent studies in organic farms showed that improvements can be stimulated thanks to the monitoring of the results of farms from the Welfare Quality® protocol (Winckler *et al* 2012).

Conclusion

In conclusion, dairy cows are exposed to various welfare problems, of which the most crucial ones (in terms of severity and prevalence) are — according to the Welfare Quality® protocol: pain, health disorders, including diseases and injuries, and poor resting comfort. Feasible control actions should be prioritised in relation to these major problems. More specifically, our study lends support to the concern that the housing of dairy cows needs improvement to enhance resting comfort and reduce cows' injuries, and that Holstein cows are at high risk of leanness and diseases. It shows that the welfare of cows depends not only on the characteristics of the farm, but also on its management. There is broad scope for the improvement of many welfare aspects. Some farms obtained very high welfare scores and could serve as a model for others, thanks to their system and/or management.

Acknowledgements

This work received financial support from Danone Research and pole ESTIVE. We are grateful to them. We thank the Groupements de Défense Sanitaire (GDS) for providing lists of eligible farms, and all the farmers who willingly co-operated in this survey. We are also particularly grateful to Eric Delval (INRA), Christophe Mallet (INRA) and Remi Debauchez (ISARA) for their help in data collection, Jean-Yves Audiart (ONIRIS) and Didier Billon (ONIRIS) for their help in data entry, and Anne Lamadon (INRA), Yoan Gaudron (INRA) and Pascal Champciaux (INRA) for calculating the welfare scores. The authors also thank Jos Noordhuizen and Claire Agabriel (VetAgro Sup) for their valuable advice on survey design.

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