A new, practical animal welfare assessment for Dutch dairy farmers.

Frank J.C.M. van Eerdenburg*, Jan Hulsen †, Bert Snel ‡, Jan van den Broek* and Arjan Stegeman*

*Dept Farm animal health, Faculty of Veterinary Medicine, Utrecht University, Yalelaan 7, 3584 CL Utrecht, the Netherlands.
†Vetvice/CowSignals, Moerstraatsebaan 115, 4614 PC Bergen op Zoom, the Netherlands
‡DLV Advies, Postbus 546, 7400 AM Deventer, the Netherlands
Email: F.J.C.M.vanEerdenburg@UU.nl

ABSTRACT

The results of three Dutch animal welfare assessment protocols were compared with a modified Welfare Quality® assessment protocol (WQ) on 60 dairy farms in the Netherlands, representing farms with good, moderate and poor welfare, as determined by their local veterinarians. It was one of our objectives to determine if welfare indicators that were easier and faster to measure would correlate with more time consuming animal-based measurements of the modified WQ. Several of the indicators of the modified WQ correlated well with those of three other welfare assessment protocols, that are used in the Netherlands. For example, the number of collisions with the dividers correlated with the width of the freestall (r^2 = 0.63; $p < 0.03$) and time needed to lie down had a correlation with the diagonal of the freestall (distance of the neck rail to the curb) (r^2 = 0.24; $p < 0.06$). Next, an alternative welfare assessment protocol was designed with components of the three Dutch protocols. The outcomes of this new protocol showed good agreement with the modified WQ, only 10% of the farms had a discordant outcome. Execution of this new welfare monitor takes approximately 1.5 h for a farm with 100 dairy cows. Thus it appeared to be possible to create a protocol that is less time consuming and has a comparable outcome to the modified WQ protocol.

Keywords: Animal welfare, dairy cattle, Welfare Quality®, water supply, integument alterations.

INTRODUCTION

Three modifications of the Welfare Quality® protocol (2009) (WQ) for dairy farms have been introduced in the previous chapter (Van Eerdenburg et al., 2018). This was done because the result of the original WQ on 60 farms with varying welfare levels was for most farms 'acceptable'. It was, therefore, concluded that the discriminative capacity of the WQ protocol was low and this was improved after the three modifications (Van Eerdenburg et al., 2018). However, measuring animal welfare on a dairy farm, using this modified protocol, still is time consuming (almost a full day is needed for its execution), which hampers its implementation as a routine, on farm, welfare check (Andreasen et al., 2014; Heath et al., 2014). Since an increase in animal welfare level is correlated with a higher milk yield (Van Eerdenburg et al., 2013), a faster protocol, that can be implemented in routine management checks, is desired. The modified WQ uses mainly animal based measures. These are parameters that are measured directly on/from the animals, like skin lesions or behaviour, and not in the environment (resource based parameters). Other protocols have been developed that include both animal- and resource based measures and can be executed in 1 – 2 hours for a 100 cow herd. In the Netherlands, examples are Welzijnswijzer Melkvee (= Welfare Indicator Dairy cattle) (WM), KoeKompas (= Cow Compass) (KK) and the Continue Welzijns Monitor (= Continuous Welfare Monitor) (CWM). The latter has been designed to monitor welfare without going to the farm at all (De Vries et al., 2014). It uses indices and data that are routinely collected from various sources and can be compared to the method of Nyman et al. (2011). In table 1 a brief overview is presented of the components of these protocols that evaluate the welfare of a herd. So far, the agreement between these Dutch methods and WQ or the modified WQ is unknown. This is important because WM and KK are designed to improve the management, herd health and welfare on a farm and not as a welfare measuring instrument only. These protocols include, therefore, also information to improve housing and health conditions of the cows (not presented in table 1).

To measure the welfare of dairy cows, animal- and/or resource based parameters can be used. The animal-based measures used by WQ and the modified WQ take a substantial amount of time to obtain, whereas the other protocols, mentioned above, include, easily measurable, environment related

Welzijnswijzer Melkvee (Welfare Indicator Dairy Cattle)	**KoeKompas (Cow Compass)**	**CWM**
Number of animals	BCS	% Culled cows
Body Condition Score	Rumen score	Bulk tank SCC
Animals lying in walkways	Space & hygiene at the feed bunk	% of high SCC cows
Thick hocks/injured legs	Schoving the feed	Expected Calving interval
Thick front knees	Evaluation of the feed, ration, concentrate	Non Return % at 56 days
Inflamated joints	Number of drinking places	Economic year result
Thickness on Neck/Shoulder	Quality and flow of the water	
Dirtyness of hind quarters	Dimensions and hygiene of free stalls	
Fungi infections	Lunge space	
Scabies	Swelling of hocks	
Wounds	Hygiene score	
Clinical mastitis	Wounds & swellings, incl hocks & knees	
Teat score	Locomotion score	
Foot score	Manure score	
Locomotion score	Disease status	
Avoidance test	Mastitis	
Number of feeding places	Lameness	
Width of the feeding places	Metabolic diseases	
Heigth of the feeding fence	Retentio Secundinarum	
Cleanliness of the water	Metritis	
Access to water	Culling	
Bedding quality and quantity	Other diseases	
Number & dimensions of free stalls	Avoidance test	
	Is there a health plan?	
	Are there no animals introduced?	

Table 1: Overview of the components of the 3 Dutch welfare monitors used in this study.

parameters as well. If the end score of one of the other protocols would be in some way comparable to the modified WQ, one could save a substantial amount of time and incorporate welfare scoring in routine management assistance programs. Therefore, the first aim of the present study was to compare the methods at end score level. If there is no correlation at the level of the end score, another aim of the present study was, to determine if there are correlations between resource-based measures of the three Dutch protocols and the animal-based measures used in the modified WQ. If there are correlations between resource-based measures and animal-based measures used in the modified WQ, we might be able to construct a welfare monitor that is more practical in use, the ultimate objective of the present study.

MATERIALS & METHODS

In this study, 3 Dutch welfare measuring protocols, i.e. WM, KK and the CWM, have been compared with WQ on 60 dairy farms in the Netherlands. During the study, it became evident that the WQ protocol had a low discriminative capacity because most farms were rated as acceptable. This was confirmed by De Vries et al. (2013) and data of De Graaf et al. (unpublished results) who did a survey in Belgium and 94 farms were rated as acceptable versus 17 enhanced (none not classified or excellent). Therefore, we made 3 modifications to the original WQ protocol (2009) in order to increase the discriminative capacity. In this study, this modified WQ is used. Because the calculations of the modified WQ are, in general, the same as in the original WQ (2009), references are given to the original WQ protocol (2009) when applicable.

The (modified) WQ protocol consists of several steps, which will be described here briefly. For an extensive description of the original WQ protocol (2009) and the modifications is referred to the publication of the WQ protocol (2009) and Van Eerdenburg et al. (2018). It starts with measuring 30 parameters (indicators) that are converted into 12 criteria. These 12 criteria form the basis for the calculation of a score for 4 main principles: Feeding, Health, Housing and Behaviour. Finally, an end score is computed that can be: Not classified, Acceptable, Enhanced or Excellent.

The WM protocol was applied with a scoring that is explained in table 2. For KK the original scoring was applied. This consists of a score for several items that are important in the management of a dairy farm from 1 (bad) to 5 (good). The scores are combined into chapters (e.g. health, milking routines and welfare) and for each chapter an end score of 1-5 is computed. There is no overall end score.

A new welfare monitor was designed, which is based on the modified WQ protocol (Van Eerdenburg et al., 2018). It, therefore, has also the four principles: good feeding, good housing, good health, and good behaviour.

Principle 1: Good feeding is identical to the modified WQ protocol (Van Eerdenburg et al., 2018).

Principle 2: Good Housing. The width (distance between the dividers) and the diagonal of the freestall (distance of the neck rail to the curb) are used in the new protocol. The 'barn environment' as measured in the KK protocol as well as the softness of the bedding as measured in the WM protocol are also included in the new protocol. Furthermore, the way the cleanliness of the cows is measured in the WQ protocol (2009) is also rather time consuming and complex and this is, therefore, done in a different way. The weight of the parameters and calculations are the same as in the WQ protocol (2009). This resulted in the following measurements and calculations:

Dimensions of the cubicles:
- If Diagonal < 185cm = 9 points; else if 185cm < Diagonal < 195cm = 4 points; else = 0 points
- If Width < 110cm = 9 points ; else if 110cm < Width < 120cm = 4 points; else = 0 points
(both measured as space between the tubing)
- If % Lying outside the stall > 2% = 9 points; else if 2% > % Lying outside the stall > 0% = 4 points; else = 0 points

These 3 scores need to be multiplied with 3and summed to calculate **A**

Cleanliness of the animals (Hygiene):The size of the dirty parts of the skin of the cows is measured during the clinical inspection. The number of points belonging to the percentage of cows is presented in table 3. The sum of the points, divided by 3, is the score for hygiene H. If 2.5 > H $\geq$ 1 then **B** = 9 points; if 4 > H $\geq$ 2.5 then **B** = 4 points; else **B** = 0 points.

For the hygiene of the cows the weight is 1/3 of the rest of the factors in this calculation. This is similar to the WQ protocol (2009).

Softness of the bedding is measured with the knee test (Bewley 2010) and can be classified as Good (soft), Moderately good or Insufficient (hard)

	Points				
	1	**2**	**3**	**4**	**5**
% BCS < 1.5	>15	13-15	10-12	5-9	<5
% Cows sleeping in aisles	>5	3-5	1-2	0-1	0
% Thick hocks < a fist	>15	11-15	6-10	0-5	0
% Thick hocks > a fist	>5	3-5	1-2	0-1	0
% Thick carpi < a fist	>15	11-15	6-10	0-5	0
% Thick carpi > a fist	>5	3-5	1-2	0-1	0
% Arthritis	>3	2-3	1-2	0-1	0
% Withers humps	>15	11-15	6-10	0-5	0
Dry manure on skin (% cows)					
• 25x25 – 50x50cm	>30	21-30	11-20	5-10	<5
• 50x50 – ½ rear part	>15	11-15	6-10	3-5	<3
• > ½ rear part	>7	6-7	4-5	1-3	<1
Sum and divide by 3					
% Fungal skin infection	>15	11-15	6-10	0-5	0
% Scabies	>15	11-15	6-10	0-5	0
% Lesions	>15	11-15	6-10	0-5	0
% Clinical mastitis	>7	3-7	2-3	0-2	0
Teat health	>15	11-15	6-10	0-5	0
% Foor score 3	>30	21-30	11-20	0-10	0
% Severely lame cows	>5	3-5	1-2	0-1	0
Locomotion score					
• *% Normal*	<20	20-30	31-50	51-70	>70
• *% Moderately lame*	>30	21-30	11-20	5-10	<5
• *% Severely lame*	>5	3-5	1-2	0-1	0
Sum and divide by 3					
Avoidance test					
- *% Score 1*	>5	3-5	1-2	0-1	0
- *% Score 2*	>30	21-30	11-20	5-10	<5
- *% Score 3*	<25	25-35	36-50	51-60	>60
- *% Score 4*	<20	20-30	31-50	51-70	>70
Sum and divide by 4					
Number of feeding places (%)	<80	80-85	86-95	96-100	>100
Width feeding space	<65	65-70	71-75	76-80	>80
Height feed rack	<150	150-155	156-160	161-165	>165
Water is clear (Y/P/N)	N		P		Y
Unlimited access to water (Y/N)	N				Y
Bedding is soft (Y/N)	N				Y
Litter present (Y/N)	N				Y
Number of cubicles (%)	<80	80-85	86-95	96-100	>100
Length of cubicles (front open)	<210	210-215	216-220	221-235	>235
Length of cubicles (front closed)	<220	220-235	236-250	251-265	>265
Width of cubicles	<100	100-105	106-110	111-115	>115
Diagonal	<195	195-200	201-205	206-210	>210

Table 2: Points allocated to the various parameters of the Welzijnswijzer protocol

Size of the dirty patch	1	2	3	4	5	points
25x25 – 50x50cm	>3	>2	>1	>0.5	≤ 0.5	
50x50cm – ½ Hind Quarter	>1.0	>0.5	>0.25	>0.15	≤0.15	
> ½ Hind Quarter	>0.5	>0.25	>0.15	>0.1	≤0.1	
Sum						

Table 3: clinical scoring for dirtiness of the skin. The percentage of cows having each category of dirty patch size is calculated and marked with 1 – 5 points. These are summed. Example: 1.5% of the cows had a dirty patch size 25x25 – 50 x 50 cm; 0.4% had a dirty patch 50 x 50 cm – ½ hind quarter and 0.2% was dirty > ½ hind quarter. This will result in 3 + 1 + 2 = 6 points. This sum is divided by 3 in order to calculate the score for hygiene **H**: H = 2.

When it is Good: **C** = 0; Moderately good: **C** = 4; Insufficient: **C** = 9

The barn environment is measured in three parameters: light, ventilation and the presence of a mechanical brush. Each parameter can be good, partly good or insufficient.

Ventilation:
- Good – air in the barn smells fresh and ample options for ventilation
- Partly – air smells not so fresh and there are not many ventilation options
- Insufficient – air is dirty and few options for ventilation

Light:
- Good – everywhere in the barn it is easy to read a newspaper
- Partly – only at the feeding fence and some other places
- Insufficient – (almost) nowhere in the barn

Mechanical brush: Present or not

The flow chart for calculation of the score for barn environment (D) is presented in figure 1.

Finally, the index for comfort around resting (P) becomes then:

P=100-(**A**+**B**+**C**+**D**)/108

This is divided by 108 because of the theoretical maximum of the sum. The score is computed according to the WQ protocol (2009).

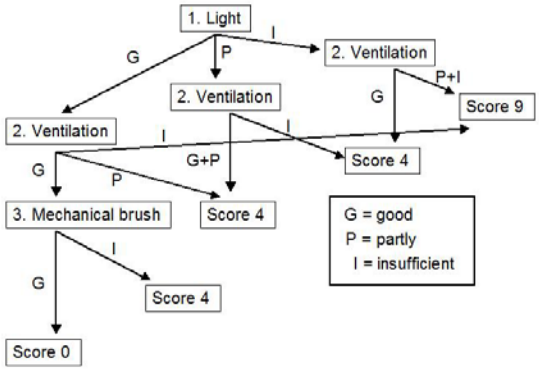

Figure 1: Flowchart for the scoring of the barn environment.

Principle 3: Good health:
This is identical to the modified WQ protocol.

Principle 4: Good behaviour:
The avoidance distance at the feeding fence (ADF) is measured according to the WQ protocol (2009). In the result of this test, the cows are grouped into 4 groups: 0 cm (can be touched); 0-50 cm; 50-100cm; >100cm. The correlation (r^2) between social behaviour of the WQ protocol (2009) with the ADF group 3 was 0.833 (p = 0.11). Therefore, this result is used in the new

protocol to replace the time consuming watching and sometimes difficult interpretation for social behaviours. The formula is 100 - % cows in ADF group 3 (50-100 cm).

This results in the calculation for the principle of Good Behaviour:

B_1 = Expression of social behaviours: 100 - % cows in ADF group 3.
B_2 = Expression of other behaviours as in WQ protocol (2009) (access to area outdoors)
B_3 = Index for good human animal relationship: ADF + calculations as in WQ protocol (2009)

$$\text{Principle for Good Behaviour} = \begin{cases} B_1 + (B_2-B_1)\mu_{23} + (B_3-B_2)\mu_3 & \text{if } B_1 \leq B_2 \leq B_3 \\ B_1 + (B_3-B_1)\mu_{23} + (B_2-B_3)\mu_2 & \text{if } B_1 \leq B_3 \leq B_2 \\ B_2 + (B_1-B_2)\mu_{13} + (B_3-B_1)\mu_3 & \text{if } B_2 \leq B_1 \leq B_3 \\ B_2 + (B_3-B_2)\mu_{13} + (B_1-B_3)\mu_1 & \text{if } B_2 \leq B_3 \leq B_1 \\ B_3 + (B_1-B_3)\mu_{12} + (B_2-B_1)\mu_2 & \text{if } B_3 \leq B_1 \leq B_2 \\ B_3 + (B_2-B_3)\mu_{12} + (B_1-B_2)\mu_1 & \text{if } B_3 \leq B_2 \leq B_1 \end{cases}$$

$\mu_1 = 0.20$ $\mu_{12} = 0.24$
$\mu_2 = 0.14$ $\mu_{13} = 0.24$
$\mu_3 = 0.24$ $\mu_{23} = 0.30$

Number of animals for clinical scoring:
After the initial scoring according to the WQ protocol (2009), animals were removed from the dataset in a systematical way. First, every fourth animal was removed (25%). This procedure was repeated with every third animal (33%) and finally with every second animal (50%). The outcome of the clinical scoring was compared with the scoring of the 100%.

Animals & farms:
The same 60 farms as used by Van Eerdenburg et al. (2018) were visited in this study.

Observers:
Of each practice at least one veterinarian was trained during a three day course, provided by the Welfare Quality consortium, to execute WQ and the WM. Other veterinarians were trained to execute KK. In the KK protocol there are a few comparable tests, but the execution is different. In order to avoid confusion and errors, other persons executed the protocols. The farms were visited within 2 weeks for all protocols in order to avoid changes in welfare status. The results of the (modified) WQ protocol and the other protocols were correlated with each other (Pearson correlation in SPSS, version 20). Not only at the level of the end score, but also at principle, criteria and indicator level.

RESULTS & DISCUSSION

For the modified WQ the 60 farms resulted in 23 farms with score Not Classified, 30 Acceptable and 7 Enhanced, no farms were scored Excellent. The correlations of the modified WQ (Van Eerdenburg et al., 2018) with the other three protocols were very low and not statistically significant at end result level.

Because also the modified WQ protocol still takes almost one day to assess a farm, a shorter protocol was constructed out of the components of the four protocols tested (table 4). Out of the 60 farms, 54 had the same score as in the modified WQ protocol, 3 farms that had a score Not Classified in the modified WQ protocol scored Acceptable in our new protocol, 1 farm that had a score Acceptable in the modified WQ protocol scored Not Classified in our new protocol, 1 farm that had a score Acceptable in the modified WQ protocol scored Enhanced in our new protocol and 1 farm that had a score Enhanced in the modified WQ protocol scored Acceptable in our new protocol. So in total 6 farms (10%) had a different score, of which 4 scored higher and 2 lower. Furthermore, the number of animals that need to be assessed on an individual basis could be reduced substantially as well (table 5). Even with a reduction of 50% of the animals, the result was within 10% of the level as measured with 100% of the cows for all parameters measured. Thus reducing the time

required for the execution of the protocol (ADF & clinical scoring).

Principle	Parameters measured
Feed & water	Body condition
	Water supply
Housing	Freestall dimensions
	Softness of bedding
	Cleanliness of the cows
	Access to pasture
	Cows lying outside freestall
Health	Locomotion score
	Skin lesions
	Mastitis
	Other diseases (respiratory/metabolic/fertility)
Behaviour	Avoidance distance at the feeding fence
	Possibilities for expression of normal behaviour

Table 4. Parameters measured in the new welfare monitor

	75%	66%	50%
Lameness	5,5	6,8	9,9
Skin Lesions	5,2	6,1	9,3
Diseases	5,9	3,9	8,8
Health (principle)	4,9	4,5	7,9

Table 5: Average deviation in % of the original score for parameters in the WQ protocol when 75%, 66% or 50% of the animals was scored individually during the clinical inspection.

Replacing animal based measures by environment based measures provides better and more reliable outcomes. Furthermore, these are usually parameters that a farmer can do something about (Roe et al., 2011)

In addition to the changes, already incorporated in the modified WQ protocol (Van Eerdenburg et al., 2018), several measures for principle 2 and 4 were changed as well, as will be explained below.

Principle 2: Good Housing. In the WQ protocol (2009) the number of collisions with the dividers of the freestalls is counted and the average time to lie down is measured during lengthy observation periods. The results of the present study revealed that there was a correlation with several dimensions of the freestall. The number of collisions with the dividers correlated with the width of the freestall ($r^2 = 0.63$; $p < 0.03$) and time needed to lie down had a correlation with the diagonal of the freestall (distance of the neck rail to the curb) ($r^2 = 0.24$; $p < 0.06$). These freestall dimensions are, therefore, used in the new protocol. The 'barn environment' as measured in the KK protocol had a correlation with the principle of good housing ($r=0.43$; $p<0.01$), as well as the softness of the bedding as measured in the WM protocol ($r=0.23$; $p<0.08$). Both are also included in the new protocol. Furthermore, the way the cleanliness of the cows is measured in the WQ protocol (2009) is also rather time consuming and complex. The way the WM protocol handles this, is much more simple and this is thus used in the new protocol (see Table 2). The correlation for this item between the WQ protocol and the WM was 1 ($p < 0.000$).

Principle 4: Behaviour. The correlation (r^2) between social behaviour of the WQ protocol (2009) with the ADF group 3 was 0.83 ($p = 0.11$). Therefore, this result is used in the new protocol to replace the time consuming watching, and sometimes difficult interpretation, for social behaviours.

So, in short, the new Welfare Monitor is based on the modified WQ protocol (Van Eerdenburg et al., 2018) with substitutions of environment based measurements for lengthy observations of the herd.

The question is of course: Why create another protocol? To answer this question, the first argument is that the (modified) WQ protocol (Van Eerrdenburg et al., 2018) takes too much time to be used as a practical tool (Andreasen *et al*., 2014). Therefore, the Danish Cattle Federation has developed a protocol that correlates well with the original Welfare Quality® protocol (2009), and takes 2 hours to execute (Andreasen *et al*., 2014). But, as explained before, this has a low discriminative power. In Sweden, a protocol has been developed that uses the outcome of measures of all Swedish farms to determine the welfare level of a particular farm (Sandgren *et al*., 2009). It uses the recorded data of all farms and if a farm does not score in the 10% worst cases for a measure, it is classified as a farm with good welfare (Nyman *et al*., 2011). So if most farms have a bad score for one measure (e.g. % of lame cows), this will be the standard. WQ (2009) is not taking into account what most farms score, but what a farm should score, based

on what is considered acceptable from expert opinions. On the basis of all protocols in use lies, however, the wish to improve the welfare status of the dairy cows. Whether a protocol will be successful in achieving this, is largely depending on the attitude of the farmers (Kielland et al., 2010). They prefer a quick and straight forward approach. The assessment protocol described here fulfils these requirements and can be implemented in a routine farm-management check.

CONCLUSIONS / ANIMAL WELFARE IMPLICATIONS

The newly developed welfare monitor is a practical instrument that takes about 1.5 h to execute on a farm with 100 cows. It consists of most measures of the WQ protocol (2009) after modifications to make this more discriminative. It also uses the same calculations and weights when applicable and the end result is comparable to the modified WQ. However, the lengthy observation periods for the behavioural components are replaced by measures of the direct environment of the cows, that were correlated with the behaviours measured in the WQ protocol (2009). The result is a protocol that can be executed simply and quick, leaving the complex calculations to the computer (An Excel file with the calculations can be obtained from the authors via email). Further studies with the newly developed protocol are ongoing and the farmers receive advice to improve the welfare of their cattle over a period of 2 years.

ACKNOWLEDGEMENTS

The study was financed by the Dutch Ministery of Economic affairs, Agriculture and Innovation.

REFERENCES

Andreasen SN, Sandøe P and Forkman B 2014 Can animal-based welfare assessment be simplified? A comparison of the Welfare Quality® protocol for dairy cattle and the simpler and less time consuming protocol developed by the Danish Cattle Federation. *Animal Welfare:* 23 81-94

De Vries M, Bokkers EA, van Schaik G, Botreau R, Engel B, Dijkstra T and de Boer IJ 2013 Evaluating results of the Welfare Quality multi-criteria evaluation model for classification of dairy cattle welfare at the herd level. *Journal of Dairy Science:* 96 6264-6273

De Vries M, Bokkers EA, van Schaik G, Engel B, Dijkstra T and de Boer IJ 2014 Exploring the value of routinely collected herd data for estimating dairy cattle welfare. *Journal of Dairy Science* 97: 715-730

Kielland C, Skjerve E, Osterås O, and Zanella AJ 2010 Dairy farmer attitudes and empathy toward animals are associated with animal welfare indicators. *Journal of Dairy Science:* 93 2998-3006

Koe kompas https://www.zuivelplatform.nl/over-koe-kompas (in Dutch)

Nyman AK, Lindberg A and Sandgren CH 2011 Can pre-collected register data be used to identify dairy herds with good cattle welfare? *Acta Veterinaria Scandinavica:* 53 Suppl 1:S8

Roe E, Buller H and Bull J 2011. The performance of farm animal assessment. *Animal Welfare*: 20, 69-78.

Sandgren CH, Lindberg A and Keeling LJ 2009 Using a national dairy database to identify herds with poor welfare. *Animal Welfare:* 18 523-532

Van Eerdenburg FJCM, Vázquez-Flores S, Saltijeral-Oaxaca J, and Sossidou EN 2013 A cow comfort monitoring scheme to increase the milk yield of a dairy farm. In: Aland A and Banhazi T (Eds.), *Livestock Housing*, Wageningen Academic Publishers, Wageningen, the Netherlands pp 55-74

Van Eerdenburg, FJCM, Hulsen, J, Snel, B, Van den Broek, J and Stegeman, JA 2018 A proposal for three modifications for the Welfare Quality© protocol for dairy cattle. In: Van Eerdenburg, FJCM (Ed.) Bienestar animal en la práctica, en producciones lecheras, desde la perspectiva europea. pp 55-62. (this book) https://www.dropbox.com/s/q9jdztauo43io26/Bienestar%20animal%20en%20la%20practica.pdf?dl=0

Welfare Quality® 2009 Welfare Quality® assessment protocol for cattle. Welfare Quality® consortium, Lelystad, the Netherlands.

Welzijnswijzer Melkvee Published by GD Deventer, Deventer, the Netherlands. Can be obtained at http://www.wageningenur.nl/nl/show/Welzijnswijzer-Melkvee.htm (in Dutch)