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Measuring foot-pad lesions in commercial broiler houses. Some aspects of methodology

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Abstract

For monitoring purposes there is a need for a protocol to measure foot-pad dermatitis (FPD) on-farm. Therefore, we studied the effect of number of birds sampled, number of locations sampled and sampling location in a broiler house on the accuracy of measurement, in order to construct a protocol that can be applied in practice. Samples were taken from eight commercial flocks (Ross 308) at up to ten locations with up to 25 birds sampled per location. Foot-pad lesions were scored in all birds for both feet using the Swedish scoring method. No significant differences in FPD score were found between the first five birds and all birds sampled at a particular location. Although locations near the walls did not differ in FPD score from locations in the central area of a house, the severity of foot-pad lesions was unevenly distributed over the house. A model was constructed showing the inaccuracy related to the number of locations sampled in the house and the number of birds sampled per location. The model shows that in situations with at least five locations differences in inaccuracy are relatively small when a total of 100 birds or more is sampled. Inaccuracy is largest in a flock with variation in foot-pad scores, as compared to flocks with little variation. The results of this experiment can be used to determine the optimal sample size in a commercial broiler house.

Keywords: *animal welfare, broiler, foot-pad dermatitis, inaccuracy, on-farm monitoring, sampling method*

Introduction

Foot-pad dermatitis (FPD) in broilers, also called pododermatitis or foot-pad lesions, is a contact dermatitis of the plantar surface of the birds' feet (Greene *et al* 1985). Foot-pad dermatitis is usually associated with wet litter (Shepherd & Fairchild 2010) in combination with high concentrations of ammonia (Greene *et al* 1985). FPD is characterised by inflammation and necrotic lesions, ranging from superficial to deep in the plantar surface of the feet and toes. Deep ulcers may lead to abscesses and thickening of the underlying tissues (Greene *et al* 1985; Shepherd & Fairchild 2010). It is likely that FPD causes pain and therefore has a negative effect on bird welfare, but because of its association with litter quality it also reflects other welfare aspects (Haslam *et al* 2007).

The welfare of broilers is receiving increasing attention in Europe, which is illustrated by the European Council Directive laying down minimum rules for the protection of chickens kept for meat production (Council Directive 2007/43/EC 2007). Besides requirements on administration, light intensity and duration, air quality and training of the farmer, for example, the Council Directive restricts the maximum stocking density for broiler chickens. If all requirements are fulfilled and the mortality is kept below the maximum level stated in the Directive, farmers are allowed to keep their birds at a stocking density of 42 kg m^{-2} if national legislation so permits (Council Directive 2007/42/EC 2007). Individual countries may choose to include additional welfare measures to the Broiler Directive in their national legislation. For example, in The Netherlands, foot-pad dermatitis will be included as an additional welfare indicator for broilers from 2012 onwards (Anonymous 2009). Denmark and Sweden already included foot-pad dermatitis as welfare indicator in their own broiler welfare legislation (Berg & Algers 2004; Pedersen, VFL, Denmark, personal communication 2011). In Denmark and Sweden, FPD is assessed at the slaughter plant by trained veterinarians or by assistants under veterinary supervision. A sample of 100 feet per flock is assessed according to a three-point scale, discriminating between no or very small lesions (score 0), mild and superficial lesions (score 1) and severe, deep lesions (score 2) (Ekstrand *et al* 1998; Pedersen, VFL, Denmark, personal communication 2011).

Assessing FPD at the slaughter plant has several advantages as compared to assessing FPD at broilers on-farm. The assessment does not cause stress to the birds as FPD is assessed at the plant after killing. As the feet have passed the scalding tank most of the litter and manure is removed, in contrast to rather dirty feet in commercial broiler houses. In addition, light conditions are often better and can easily

Table 1 Examples of sampling inaccuracy for (a) a flock with a relatively low FPD score, (b) a flock with an average FPD score and (c) a flock with high FPD score.

a) Low FPD score, ie 90.12, 7.96 and 1.91% for score 0, 1 and 2, respectively								
	Model		**Lower limit (μ–2 s)**			**Upper limit (μ + 2 s)**		
N	**M**	**LE**	**% score 0**	**% score 1**	**% score 2**	**% score 0**	**% score 1**	**% score 2**
100	–	No	91.77	6.66	1.57	88.19	9.48	2.33
100	1	Yes	93.66	5.15	1.19	84.94	12.01	3.06
100	4	Yes	92.47	6.10	1.43	87.15	10.29	2.56
100	8	Yes	92.16	6.35	1.49	87.63	9.92	2.45
100	10	Yes	92.09	6.41	1.51	87.74	9.84	2.43
200	–	No	91.31	7.02	1.67	88.79	9.01	2.20
200	1	Yes	93.53	5.25	1.22	85.20	11.80	3.00
200	4	Yes	92.21	6.31	1.48	87.55	9.98	2.47
200	8	Yes	91.84	6.60	1.56	88.09	9.56	2.35
200	10	Yes	91.75	6.67	1.58	88.22	9.46	2.32
b) Average FPD score, ie 29.69, 40.66 and 29.65% for score 0, 1 and 2, respectively								
	Model		**Lower limit (μ–2 s)**			**Upper limit (μ + 2 s)**		
N	**M**	**LE**	**% score 0**	**% score 1**	**% score 2**	**% score 0**	**% score 1**	**% score 2**
100	–	No	34.03	40.32	25.65	25.69	40.32	33.98
100	1	Yes	40.60	38.74	20.66	20.69	38.75	40.56
100	4	Yes	36.23	39.91	23.85	23.89	39.92	36.18
100	8	Yes	35.23	40.11	24.66	24.69	40.12	35.18
100	10	Yes	35.01	40.15	24.84	24.87	40.16	34.96
200	–	No	32.73	40.49	26.79	26.83	40.49	32.68
200	1	Yes	40.09	38.90	21.01	21.04	38.94	40.05
200	4	Yes	35.41	40.08	24.51	24.55	40.09	35.36
200	8	Yes	34.25	40.28	25.47	25.51	40.29	34.20
200	10	Yes	33.98	40.32	25.69	25.73	40.33	33.94
c) High FPD score, ie 1.89, 7.88 and 90.23% for score 0, 1 and 2, respectively								
	Model		**Lower limit (μ–2 s)**			**Upper limit (μ + 2 s)**		
N	**M**	**LE**	**% score 0**	**% score 1**	**% score 2**	**% score 0**	**% score 1**	**% score 2**
100	–	No	2.30	9.38	88.32	1.55	6.59	91.86
100		Yes	3.03	11.89	85.09	1.18	5.09	93.73
100	4	Yes	2.53	10.19	87.28	1.41	6.04	92.55
100	8	Yes	2.42	9.82	87.76	1.47	6.28	92.24
100	10	Yes	2.40	9.74	87.86	1.49	6.34	92.17
200	–	No	2.17	8.92	88.91	1.65	6.95	91.41
200	1	Yes	2.96	11.68	85.35	1.20	5.19	93.60
200	4	Yes	2.44	9.88	87.68	1.46	6.24	92.30
200	8	Yes	2.32	9.46	88.22	1.54	6.53	91.93
200	10	Yes	2.30	9.36	88.34	1.56	6.60	91.84

N = total number of chickens; M = total number of sampling locations; LE = location effects taken into account (yes/no); μ-2 s = average – 2 × SED; μ + 2 s = average plus 2 × SED.

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be standardised at a slaughter plant (at least if feet are assessed in a separate room) as compared to broiler houses (although, if the farmer permits, light intensity can be increased gradually). Scoring at the slaughter line is more time efficient as compared to scoring on-farm. And, finally, samples can easily be stored if necessary. However, there is still a need for a protocol to measure FPD in commercial broiler houses. A certain proportion of the Dutch broilers are commonly slaughtered in slaughter plants in neighbouring countries that do not have to comply to the Dutch broiler welfare legislation. This means that if farmers would like to keep their birds at the highest stocking density allowed (42 kg m^{-2}) and slaughter their birds abroad, FPD of these broilers should be assessed on-farm before transportation to the slaughter plant. But, also for monitoring and research purposes, it may be valuable to have a standardised protocol for measuring FPD on-farm.

The Welfare Quality® assessment protocol for broiler welfare (Welfare Quality® 2009) describes a sampling method for foot-pad lesions on-farm. However, no scientific background for this method, sampling ten birds at ten randomly chosen locations in the house of which three are locations near the walls, is given. As it may save time and prevent stress in birds if fewer birds can be sampled, or sampling can be done at less locations, it is useful to study the effect of number of birds sampled, number of locations sampled and sampling location in a broiler house on the accuracy of the measurement. Therefore, we sampled FPD at eight Dutch commercial broiler farms. These data were used to construct a simple model that estimates the inaccuracy in relation to the sample size per location and the number of locations. In practice, as well as in research, different scoring systems for FPD are used varying from five classes (eg Bristol Foot Burn scale, Welfare Quality® 2009) to three classes (the so-called 'Swedish' scoring method [Algers & Berg 2001]). In this study we used the 'Swedish' method as this method will be used in future monitoring of commercial flocks in The Netherlands.

Materials and methods

Data collection

Data were collected by sampling broilers from eight commercial flocks of broilers (Ross 308 birds as hatched). The commercial flocks were selected from a large number of farms that were willing to co-operate in research concerning foot-pad lesions in broilers and had birds of suitable age at the time of the experiment. Flocks were sampled between 5–1 days prior to slaughter. For each flock, birds were assessed using three sampling methods.

Method 1

Four locations in the house, ie 4 × 25 birds. One location near the wall at the left side of the house, approximately three metres from the corner of the house closest to the entrance, one location on the opposite side approximately three metres from the corner at the back of the house, two locations between feeding and drinking lines on an imaginary diagonal line between the two locations near the walls. Per location 25 birds were sampled.

Method 2

Ten locations in the house, ie 10 × 20 birds. Three locations near the walls and seven locations near drinking and feeding lines evenly distributed over the house, according to the Welfare Quality® sampling protocol (Welfare Quality® 2009). Per location 20 birds were sampled.

Method 3

Ten locations in the house according to the Welfare Quality® sampling protocol (Welfare Quality® 2009), ie 10 × 10 birds. Per location 10 birds were sampled.

Each location (for all methods) was separately coded in the data file. In addition, information was recorded regarding the proximity of the location near a wall or being in the central area of the house, and the sequence of the birds per location was noted.

Per location, a random sample of birds was penned using a catching pen that consisted of four wire mesh panels of approximately 1 × 1 m each. One person took a broiler out of the catching pen and the feet were scored by a trained assessor according to the Swedish classification of foot-pad lesions (Ekstrand *et al* 1998, see below for description). Because of low light levels in some broiler houses the assessor used a head lamp to increase the light intensity at the location of scoring. If feet were covered with manure or litter the observer tried to remove this by gently rubbing over the feet with his fingers. After scoring the feet the bird was placed outside the catching pen and another bird was scored. Birds were taken out of the catching pen in random order (irrespective of whether they were able to walk or not) until the desired number of birds per location was scored.

Foot-pad lesions were scored according to the Swedish scoring method (Ekstrand *et al* 1998): score 0 — no discoloration or only very small discoloration, healed lesions; score 1 — mild lesion, ie hyperkeratosis and/or substantial discoloration but only superficial; and score 2 — severe lesion, lesion into the deeper skin layers, ulcers or scabs, signs of haemorrhages or severely swollen foot pads. Only the central foot pad was evaluated. Observers were trained by Danish and Swedish scorers and experienced in classifying foot pads according to the Swedish method. From each bird, both feet were scored and the highest score was further used in the analysis.

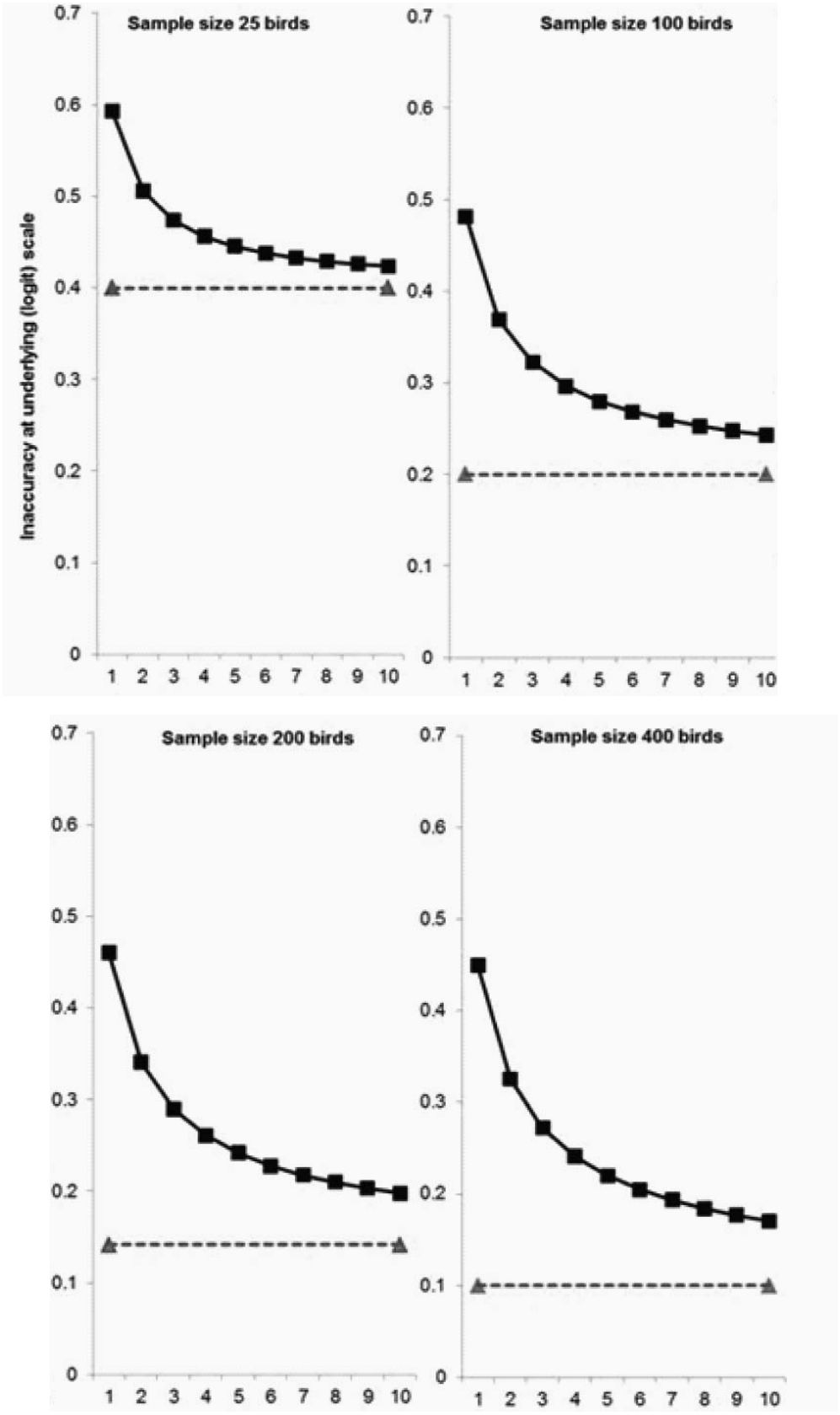
Data analysis

All calculations were performed with the statistical package Genstat (Genstat Committee 2002). Fixed effect of flock and random effects of location within flock were included in the mixed model. The scores of individual animals within a location were considered as independent with the exception of location effects. In a pre-model the fixed effects of the first five animals within each location and the area near the wall versus central area were tested, but were not significant and removed from the model. The final model was:

$$Y_{ij} = \mu_i + \varepsilon_{ij}$$

where Y_{ij} = the total score of the location with number of animals for each of the possible three classes, μ_i = the estimated mean (fixed) effect of flock and $\varepsilon_{ij} \sim N(0,\sigma^2)$; the random effects of location (on logit scale).

Figure 1



Inaccuracy of sampling (2 s = 2 × SED) (vertical axis) as a function of the number of locations in the house sampled (horizontal axis), represented for a sample size of 25 birds in total (top left panel) to 400 birds in total (bottom right panel). The dashed line represents the asymptote, a situation where an infinite number of locations is sampled in the house. In that case, effects of location are absent and the situation without any location effects is approached.

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The data were recognised as ordinal response data and analysed with a Generalised linear mixed model for ordinal data. The ordinal response model estimates the K–1 intercept terms or cut-off points (α_n), where K (number of classes) is 3, in the equation Logit(γn[x]) = $\alpha_n + \beta^T x$ ($\beta^T x$ is a short notation of the model terms in the final model). Cut-off points, means for the underlying variable Z and variance component σ^2 for variation between locations were estimated by the method described in Keen and Engel (1997), utilising procedure IRCLASS (Keen 2001), which is written in Genstat.

With an estimated variance-component for location and a known (as we knew the distribution of the ordinal response) variance between animals, we were able to estimate the variance of the mean value of flock (on the logit scale): Variance (μ_i) = $\sigma^2_{location}$ /a + σ^2_{animal} /b, with a locations in the flock and b animals for each location. From there, 2 s intervals (2 × square root of variance) were calculated on logit scale. Since this generalised linear model was fitted with a logit link function, the antilogs of the 2 s intervals summarise their multiplicative effects on the odds scale. With an underlying logistic distribution, and without random location effects, the threshold model is also known as the proportional odds model; some details are in McCullagh and Nelder (1989).

Results

Number of birds sampled per location

Analysis of the data showed that there was no significant difference in average foot-pad lesion score of the first five birds per location as compared to the average score of all birds per location. Average (back-transformed) scores for the first five birds were 39.2% score 0, 39.1% score 1, 21.7% score 2 as compared to 37.6% score 0, 39.6% score 1 and 22.8% score 2 for all birds scored at a particular location.

Location of sampled birds in the house

It turned out that birds sampled at locations near the walls did not differ in foot-pad lesion score as compared to birds in the central area of the house. Average (back-transformed) scores for birds at locations near the walls were 38.4% score 0, 39.4% score 1, 22.2% score 2 as compared to 38.5% score 0, 39.4% score 1, 22.1% score 2 for birds sampled in the central area. However, the inclusion of the random effects of location in the model ($_{ij}$ in the final model) significantly improved the model ($P < 0.05$). This means that FPD scores within one location were more similar than scores on different locations, indicating that FPD scores were not homogeneously distributed over the house.

Inaccuracy of measurement in relation to the number of locations and sample size per location

Based on the data a model was constructed that shows the inaccuracy of measurement in relation to the number of locations sampled in a house, and the number of birds sampled per location. Figure 1 shows the inaccuracy of measurement for different sample sizes (25 to 400 birds sampled) and a different number of locations in the house. The figure shows that the inaccuracy of measurement sharply decreases between 1 and 5 locations sampled in a house. In addition, the inaccuracy largely decreases when the total number of birds sampled increases from 25 to 100, but that differences between 200 and 400 birds sampled are relatively small. Table 1 further illustrates the consequences of sampling inaccuracy for three imaginary flocks, with either a small percentage, an average percentage and a high percentage of severe FPD. The flock with average FPD scores has the largest inaccuracy which is caused by the ordinal scale (0, 1 and 2) of sampling. Figure 1 and Table 1 provide guidelines for defining a sampling protocol.

Discussion

The results of this experiment indicate that several aspects should be taken into account when measuring FPD in (commercial) broiler houses. First, as FPD scores are not homogenously distributed over the house, it is best to sample as many locations as possible. Five birds per location may be sufficient. Figure 1 and Table 1 can be used to determine the desired sampling method to measure FPD in commercial broiler houses, taking into account the acceptable inaccuracy of measurement and practical implications such as the workload for the assessor, the time needed for assessment and the stress for the birds. The method as advised in the Welfare Quality® assessment protocol for broilers, ie ten locations with ten birds sampled per location (Welfare Quality® 2009), provides an acceptable level of inaccuracy.

The results of the experiment showed that there was no difference in FPD score between locations near the wall and the central area, but that FPD scores were not homogenously distributed over the house. During the sampling procedure we got the impression that litter quality differed between different locations in the house. As wet litter is the most important factor causing FPD in broilers (Shepherd & Fairchild 2010), this may explain the heterogeneity in FPD scores in a broiler house. Probably broilers prefer to stay in more or less the same area of the house, especially at an older age when stocking density reaches maximum level and the possibility to move through the house is reduced and broilers are less active (eg Hall 2001; Arnould & Faure 2003).

As illustrated by Table 1, the level of inaccuracy is least in flocks with very low or very high levels of FPD. In these flocks, sampling fewer locations may be sufficient to be as accurate as compared to flocks with intermediate FPD levels. However, in practice, it might be preferred to provide assessors with a fixed protocol.

Animal welfare implications

The results of the current experiment provide guidelines to determine a protocol for measuring FPD in commercial broiler houses, balancing accurate sampling, minimal disturbance of the birds and minimal workload. For accurate sampling, it is advised to sample at least five locations in a house (inaccuracy sharply decreases between one and five sampling locations) with a total sample size of at least 100 birds, and sampling more locations in a house is preferred over sampling more than five birds per location.

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References

Anonymous 2009 *Afsprakenkader Vleeskuikenrichtlijn*. http://www.minlnv.nl/txmpub/files/?p_file_id=43482. [Title translation: Agreement within the framework of the Broiler Directive]

Algers B and Berg C 2001 Monitoring animal welfare on commercial broiler farms in Sweden. *Acta Agriculturae Scandinavica Section A-Animal Science Supplement 30*: 88-92. http://dx.doi.org/10.1080/09064700131692313 5

Arnould C and Faure JM 2003 Use of pen space and activity of broiler chickens reared at two different densities. *Applied animal Behaviour Science 84*: 281-296. http://dx.doi.org/10.1016/j.applanim.2003.07.003

Berg C and Algers B 2004 Using welfare outcomes to control intensification: the Swedish model. In: Weeks CA and Butterworth A (eds) *Measuring and Auditing Broiler Welfare* pp 223-229. CABI: Oxford, UK. http://dx.doi.org/10.1079/9780851998053.0223

Council Directive 2007/43/EC 2007 *Council Directive 2007/42/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production*. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:182:0019:0028:EN:PDF

Ekstrand C, Carpenter T, Andersson I and Algers B 1998 Prevalence and control of foot pad dermatitis in broilers in Sweden. *British Poultry Science 39*: 318-324. http://dx.doi.org/10.1080/00071669888845

Genstat 2002 *Reference Manual, Release 6.1*. VSN International: Oxford, UK

Greene JA, McCracken RM and Evans RT 1985 A contact-dermatitis of broilers: clinical and pathological findings. *Avian Pathology 14*: 23-38. http://dx.doi.org/10.1080/03079458508436205

Hall AL 2001 The effect of stocking density on the welfare and behaviour of broiler chickens reared commercially. *Animal Welfare 10*: 23-40

Haslam SM, Knowles TG, Brown SM, Wilkins LJ, Kestin SC, Warriss PD and Nicol CJ 2007 Factors affecting the prevalence of foot pad dermatitis, hock burn and breast burn in broiler chicken. *British Poultry Science 48*: 264-275. http://dx.doi.org/10.1080/00071660701371341

Keen A 2001 Procedure IRCLASS. In: Goedhard PW and Thissen JTNM (eds) *Biometris GenStat Procedure Library Manual*. http://www.biometris.nl/genstat

Keen A and Engel B 1997 Analysis of a mixed model for ordinal data by iterative re-weighted REML. *Statistica Neerlandica 51*: 129-144. http://dx.doi.org/10.1111/1467-9574.00044

McCullagh P and Nelder JA 1989 *Generalized Linear Models, 2nd Edition*. Chapman and Hall: London,UK

Shepherd EM and Fairchild BD 2010 Footpad dermatitis in poultry. *Poultry Science 89*: 2043-2051. http://dx.doi.org/10.3382/ps.2010-00770

Welfare Quality® 2009 *Welfare Quality® assessment protocol for poultry (broilers, laying hens)*. Welfare Quality® Consortium: Lelystad, The Netherlands

https://doi.org/10.7120/09627286.21.3.325 Published online by Cambridge University Press