Reducing stress during welfare inspection - Validation of a non-intrusive version of the laywel plumage scoring system for laying hens

Joergen Kjaer, Henrike Glawatz, Britta Scholz, Sophie Rettenbacher, Ragnar Tauson

► To cite this version:

Joergen Kjaer, Henrike Glawatz, Britta Scholz, Sophie Rettenbacher, Ragnar Tauson. Reducing stress during welfare inspection - Validation of a non-intrusive version of the laywel plumage scoring system for laying hens. British Poultry Science, 2011, 52 (02), pp.149-154. 10.1080/00071668.2011.554799 . hal-00686679

HAL Id: hal-00686679

<https://hal.science/hal-00686679>

Submitted on 11 Apr 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**Reducing stress during welfare inspection -
Validation of a non-intrusive version of the laywel plumage
scoring system for laying hens**

Journal:	<i>British Poultry Science</i>
Manuscript ID:	CBPS-2010-041.R3
Manuscript Type:	Original Manuscript
Date Submitted by the Author:	16-Aug-2010
Complete List of Authors:	Kjaer, Joergen; Friedrich-Loeffler-Institut, Institute for Animal Welfare and Animal Husbandry Glawatz, Henrike; FBN Dummerstorf, Fachbereich Genetik und Biometrie Scholz, Britta; Friedrich-Loeffler-Institut, Institute for Animal Welfare and Animal Husbandry Rettenbacher, Sophie; University of Veterinary Medicine, Biochemistry, Department of Biomedical Sciences Tauson, Ragnar; Swedish University of Agricultural Sciences, Animal Nutrition and Management
Keywords:	Behaviour, Welfare, Feather pecking, Laying hens, Physiology, Stress

SCHOLARONE™
Manuscripts

Reducing stress during welfare inspection: validation of a non-intrusive version of the LayWel plumage scoring system for laying hens

KJAER, J. B., GLAWATZ, H., SCHOLZ, B., RETTENBACHER, S. AND TAUSON, R.

*Friedrich-Loeffler-Institut, Institute for Animal Welfare and Animal Husbandry,
Dörnbergstrasse 25-27, D-29223 Celle, Germany*

Running title: Reducing stress during welfare inspection

Accepted for publication: 24th Aug 2010

Correspondence to: Dr Joergen B. Kjaer, Friedrich-Loeffler-Institut, Institute for Animal Welfare and Animal Husbandry, Dörnbergstrasse 25-27, D-29223 Celle, Germany.
Telephone +49 5141 384612; Fax +49 5141 3846117
E-mail: joergen.kjaer@fli.bund.de

Abstract. 1. The objectives of the present study were to validate a reduced, non-intrusive version (RLS) of the LayWel plumage scoring system in domestic laying hens with reference to complete, intrusive scoring (CLS) and to investigate the effect of these two scoring methods on corticosterone metabolite concentrations.

2. A total of 312 medium-heavy laying hens from 4 commercial hybrids kept in 24 floor pens were scored by two experienced teams. Another 150 hens from two hybrids kept in 6 pens were used for estimating scoring treatment effects on corticosterone metabolites in droppings.

3. Plumage scores were in general higher using the RLS method compared to the CLS method. The agreement between teams for plumage scores (CLS) were on a high (total score) to an excellent (single body part except breast and cloaca) level.

4. Birds subjected to CLS tended to have higher concentrations of corticosterone metabolites in droppings 2 h after scoring compared with birds in the control treatment (not scored). Birds subjected to RLS had intermediate concentrations.

5. It was concluded that a reduced version of the LayWel scoring system is a valid and reliable scoring method which tends to induce less stress to the subjects than the original procedure.

INTRODUCTION

Animal welfare inspection of laying hen flocks often includes the evaluation of plumage condition which is considered to be an indirect measure of the amount of feather pecking in the flock (Hughes, 1982). Such scoring systems are important since recording the incidence of feather pecking in a flock by direct observation is difficult and very time consuming. Several methods of plumage scoring have been used, however, for practical reasons, subjective scoring is by far the most common method. The methods are classified as (i) application of a general score for the plumage of the whole body (Hughes and Duncan, 1972; Hill, 1980) and (2) application of a specific score for individual parts of the body (Tauson *et al.*, 1984; Gunnarsson *et al.*, 1995; Abrahamsson, 1996; Kjaer, 2000; Gunnarsson, 2000; Tauson and Holm, 2003). In the LayWel EU-project (LayWel, 2005) it was concluded that meta-analysis of plumage data was difficult due to the use of several different scoring systems. Hence a new practical system based on the scoring of several body parts was proposed as a standard to use in future research (Tauson *et al.*, 2005; 2007).

This new system involves the capture and handling of individual birds, which are scored for plumage condition on 6 parts of the body (neck, breast, back, wings, cloaca/vent and tail) along with scores for pecking damage to the rear of the body and comb, keel bone deviations and hock foot lesions. Scores of 1-4 are awarded with higher scores indicating better condition of the integument. The system can be used to compare the incidence of scores 1-4 for individual body parts, or the scores can be pooled to give a whole body score ranging from 6-24. In the present study, we considered only the plumage condition element of the scoring system, which we refer to as the 'complete Laywel plumage scoring system' or CLS.

Scoring systems should be (1) simple to apply and allow for good repeatability (Tauson *et al.*, 1984), (2) impose as little disturbance to the birds as possible, and (3) be time-effective, enabling the user to score a large number of birds under commercial conditions in a

short period of time, and without stressing the birds. Capture and handling are stressful procedures which can raise plasma corticosterone concentrations within minutes (Kannan and Mench, 1996). In addition, capturing a representative sample in floor or free range systems can be difficult and there are potential risks of sampling errors. CLS fulfils the requirements of the first criterion, but not the second and third. We therefore developed a reduced version of the LayWel scoring system (RLS) by introducing two major changes: (1) scoring only 4 body parts (neck, back, wings and tail) and (2) scoring birds on the ground without catching and handling birds at any point. To our knowledge, no results from objective recording of physiological stress variables after a combination of catching, handling and plumage scoring have yet been published. We therefore assessed adrenocortical activity non-invasively (by quantifying corticosterone metabolites in the droppings) after scoring, comparing values obtained with these two scoring methods with concentrations of un-scored controls.

Thus, the objectives of the present study were to (1) validate the reduced, non-intrusive version of the LayWel plumage scoring system in domestic laying hens (*Gallus gallus domesticus*) with reference to the complete, intrusive scoring, and (2) to investigate the effect of these two scoring methods on corticosterone metabolite concentrations.

MATERIALS AND METHODS

Animals, housing and management

A total of 1100 non-beak-trimmed chickens of 4 hybrid strains (ISA Warren (IW), Lohmann Brown (LB), Lohmann Tradition (LT) and Tetra SL (TS)) were reared on litter floor and housed at 16 weeks in 44 (11 per breed) partly (2/3) slatted floor pens (1.15 m wide x 4.10 m long) at a stocking density of 6 hens per m² (25 hens per pen) and with a communal nest at the rear of the pen. Layer mash (200 g CP/kg, 11.2 MJ ME/kg feed) and water were supplied *ad libitum*. A 14L:10D light programme was applied with an approximate light intensity of 15

1
2 87 lux. The hens were part of an experiment investigating the design of ‘on farm’ performance
3
4 88 tests of laying hen hybrids for organic egg production.
5
6 89

7
8 90 **Data collection**

9
10 91 ***Plumage scoring***

11
12 92 Plumage condition of 312 hens was scored at the age of 73 weeks by two teams, each
13
14 93 consisting of two scorers and one assistant. Both teams scored the same 13 hens from each of
15
16 94 22 randomly chosen pens (6 per breed of LB and LT, 5 pens per breed of ISA and TB). The
17
18 95 practical scoring procedure consisted of the following steps:

19
20 96 (1) All hens were shepherded gently to one half of the pen and kept there by dividing it with a
21
22 97 catching frame made of steel and wire netting.

23
24 98 (2) Hens were separated by an assistant and individually guided through an opening to the
25
26 99 other half of the pen, while the scorers were standing nearby (2-3 m) scoring (blind to the
27
28 100 other scoring team) and recording the scores on paper (RLS method, see below).

29
30 101 (3) The assistant then caught, marked and crated the hen that had just been scored. Blue dye
31
32 102 marks on the legs enabled the second team to identify and score the same birds previously
33
34 103 scored by the first team, in order to produce independent scores by both methods on each bird.
35
36 104 The second team thus produced a CLS score blind to the RLS score given by the first team.

37
38 105 (4) After scoring, birds were immediately released back into the pen, thus avoiding the risk of
39
40 106 recapture.

41
42 107 The Complete LayWel Plumage Scoring System (CLS) is described in the
43
44 108 Introduction. Supplementary material with colour illustrations is available at the LayWel
45
46 109 homepage (LayWel, 2005) and also in Tauson *et al.* (2007). In the present experiment, only
47
48 110 that part of the integument representing plumage quality was used and validated and this
49
50 111 system will be called the ‘complete LayWel plumage scoring system’ (CLS).

51
52
53
54
55
56
57
58
59
60

The Reduced LayWel Plumage Scoring System (RLS) introduced two major changes: (1) scoring only 4 body parts, neck, back, wings and tail, and (2) scoring birds on the ground without catching and handling birds at all. The scorer stood outside the pen during the scoring, thus minimising disturbance.

No scoring was carried out in the control treatment (CON) and no humans stood in front of the pen. Only normal animal care, as practised in the other pens in the house, was permitted.

Measurement of corticosterone metabolites

Three pens of LB and three pens of LT hens, not previously scored for plumage condition, were used to investigate the effect of scoring method and genotype on stress hormone metabolites. One of three scoring methods was applied to each genotype: CLS, RLS or CON. In CLS, all birds of a pen were caught and crated before scoring 30 min later. Birds were scored while handled and released into the pen again. In RLS, the scorer went to the front of the pen, opened the door and scored the birds individually from a distance; scoring time was approximately 5 min per pen. In CON, there was no scoring or crating and no humans stood in front of the pen. Excreta samples (consisting of faeces and urates together) were taken from all hens in a pen beginning 120 min after initiation of the treatment. Excreta sampling lasted approximately 20 min per pen. Only samples of adequate size (>0.1 g) from 86 out of a total of 133 sampled birds were analysed. Samples were frozen at -21°C until later analysis for 3,11-dione glucocorticoid metabolites, as described by Rettenbacher *et al.* (2004) using a cortisone enzyme immunoassay previously validated for chicken excreta (Rettenbacher *et al.*, 2009). Data were expressed as ng hormone equivalent per g excreta.

Statistical analysis

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

137 ***Plumage scoring***

138 For each combination of method (CLS, RLS) and scoring team (A, B), a total feather score
139 for each hen was calculated by summing the scores for each body region and then calculating
140 the average score per pen. This score had a minimum of 4 points (1 p per body part × 4 body
141 parts) and a maximum of 16 points (4 × 4) for the RLS method, summing scores for neck,
142 back, wings and tail. For the CLS method, two sums were calculated; a partial sum used for
143 comparing methods was calculated exactly like for the RLS method, summing neck, back,
144 wings and tail. Further, a complete sum was calculated for testing repeatability of teams
145 within this method, summing neck, back, tail, wings, breast and cloaca, thus making the
146 maximum possible sum 24 points per hen.

147 Pen average plumage score was the statistical unit. Method (CLS, RLS), team (A, B),
148 the interaction between method and team, and genotype (LT, LB, TS, IW) were included as
149 fixed factors into a mixed model procedure in SAS (SAS Inst. Inc., Cary, IL, USA). Method
150 and team were included as repeated measures (Littell *et al.*, 1996), and normal distribution of
151 residuals was accepted after visual inspection.

153 ***Reliability of methods and teams***

154 The between-method and between-team reliability were estimated using several measures of
155 agreement, namely kappa, weighted kappa and prevalence-adjusted bias-adjusted kappa
156 (PABAK), since there is controversy as to the best statistic. The kappa statistic alone is
157 appropriate if the marginal totals for the 2 × 2 table are relatively balanced, but if the
158 prevalence of a given response is very high or low, the value of kappa may indicate poor
159 agreement even when the observed proportion of agreement is quite high. Therefore we also
160 present the prevalence-adjusted bias-adjusted kappa (PABAK) to more fully characterise the
161 extent of the agreement between the two methods and teams respectively (Byrt *et al.*, 1993).

The procedure FREQ of SAS was used to calculate kappa, asymptotic standard error, standardised test statistic, the P value for testing the two-sided hypothesis $Pr > |T|$, and weighted kappa. A custom-written SAS-program was used to calculate PABAK, following Cunningham (2009) and using the formula $PABAK = ([k + p] - 1) / (k - 1)$, where k is the number of categories and p the proportion of agreement. According to Fleiss *et al.* (1993), a PABAK score larger than 0.40 can be interpreted as good agreement and a score larger than 0.75 as excellent agreement.

169

Hormone data

Glucocorticoid metabolite concentrations, with pen mean as statistical units, were subjected to one-way analysis of variance using the GLM procedure of SAS. *Post hoc* inspection of the data revealed no effects of hybrid and the model included treatment only (CLS, RLS, CON).

174

RESULTS

Plumage scoring

Effects of method, team and genotype

Plumage scores were significantly higher for the wings and tail with the RLS method and for the neck and tail by team A. Total scores were subsequently significantly higher for the RLS method and team A (see Table 1). Significant interactions were found between method and team for neck, wings and tail score (Table 1). Only neck score showed a significant main effect of genotype, with LB and TS having slightly lower scores even though pair-wise differences were not significant (Table 1).

184

[Table 1 here]

186

1
2 187 *Agreement between methods and teams*

3
4 188 In general, kappa and weighted kappa values between methods and teams for the total
5
6 189 plumage score ranged from 0.25 to 0.34 and all were significantly larger than zero (Table 2).
7
8 190 PABAK values for total scores were higher (0.35 to 0.55). Scoring the single body parts gave
9
10 191 excellent PABAK scores ranging from 0.75 to 0.97, with a few (cloaca and breast) being
11
12 192 somewhat lower (0.73 and 0.40 respectively) (Table 2). Kappa values for these body parts
13
14 193 were also low (0.38 and 0.18 respectively).
15

16 194
17
18 195 [Table 2 here]
19

20 196
21
22 197 **Corticosterone metabolites**

23
24 198 Treatment had no overall significant effect on concentration of corticosterone metabolites, but
25
26 199 birds subjected to CLS tended to excrete more corticosterone metabolites 2 h after scoring
27
28 200 compared with birds in CON (158 ± 25 ng/ml vs. 88 ± 25 ng/ml, $P=0.19$). Concentrations
29
30 201 were intermediate after the RLS method (137 ± 36 ng/ml).
31

32 202
33
34 203 **DISCUSSION**

35 204 The results showed that it is possible to obtain good precision by scoring birds at a distance
36
37 205 compared with catching them and scoring while handling. Furthermore, we found that
38
39 206 adrenocortical activity tended to be highest when birds were scored after catching and
40
41 207 handling, intermediate when scored at a distance, and lowest when not scored at all.

42
43 208 RLS scored significantly higher on all body parts than CLS. The same finding (RLS
44
45 209 scoring lower damage than CLS) was reported by Bright *et al.* (2006). It makes sense that
46
47 210 more damage is recorded when (1) birds are closely inspected (handled) and (2) when the
48
49 211 number of body parts scored increase. In addition, teams scored significantly differently. This
50

is a well known risk and the effect is normally balanced and included in the statistical models used.

Agreement between teams using the CLS method, based mainly on PABAK scores, were high for total plumage scores and excellent for single body regions, except for the breast and cloaca. These findings are comparable to those found when validating the original version of the LayWel scoring system (Tauson *et al.*, 1984) and other plumage scoring systems (Adams *et al.*, 1978; Bright *et al.*, 2006). Interestingly, the somewhat lower agreement between teams within CLS for the body parts breast and cloaca indicates that these body parts are more difficult to score and special attention should be given here during the introduction and training phase for scoring teams. Agreement was very high for the back score, which is one of the most important areas for estimating the extent of feather pecking in the flock.

Our data support and extend those of Bright *et al.* (2006), who compared handling vs. scoring at a distance using a scoring method (Bilcik and Keeling, 1999) only slightly different to the one used in the present study. The two methods (handling vs. distance) used by Bright *et al.* (2006) were found to be significantly correlated. However, there was a potential risk of recapture in the investigation of Bright *et al.* (2006), thus possibly inflating the correlation. In the present study this problem was overcome by the experimental design.

To our knowledge, this is the first study to investigate the potential of plumage scoring to elicit physiological stress responses. The differences (45-65 ng/g) in corticosterone metabolite concentrations between controls and treated birds were smaller than those reported by Janczak *et al.* (2007), who found elevations of between 100 to 250 ng/g faecal corticosteroid metabolites when unpredictable feeding schedules were applied to hens. Baseline levels were very similar in the present experiment to those of Janczak *et al.* (2006), even though, among other things, genotypes differed (White Leghorns vs. medium-heavy strains). This is in accordance with findings of Fraisse and Cockrem (2006), who found no

1
2 237 differences in baseline concentrations of plasma corticosterone, but different stress response
3
4 238 patterns between two layer strains. Contrary to Janzak *et al.* (2006), severe feather pecking in
5
6 239 young pullets did not induce any significant change in the concentration of corticosterone
7
8 240 metabolites in excreta (Riber *et al.*, 2006).

9
10 241 In conclusion, a reduced version of the LayWel scoring system is a valid and reliable
11
12 242 scoring method which tends to induce less stress to the subjects than the original procedure.
13
14 243 The scores cannot, however, be expected to equal those obtained with the complete method.

15
16 244
17
18 245 ACKNOWLEDGMENTS
19
20 246 The authors thank Brigitte Müller and Anna-Lea Kopmann for valuable technical assistance.

21 247
22
23
24 248 REFERENCES
25
26 249 ABRAHAMSSON, P. (1996) Furnished cages and aviaries for laying hens. Effects on
27
28 250 production, health and use of facilities. *Dissertation*. Report 234. Department of Animal
29
30 251 Nutrition and Management, Swedish University of Agriculture, Uppsala.
31
32 252 ADAMS, A.W., CRAIG, J.V. & BHAGWAT, A.L. (1978) Effects of flock size, age at
33
34 253 housing, and mating experience on two strains of egg-type chickens in colony cages. *Poultry*
35
36 254 *Science*, **57**: 48-53.
37
38 255 BILCÍK, B. & KEELING, L. (1999) Changes in feather condition in relation to feather
39
40 256 pecking and aggressive behaviour in laying hens. *British Poultry Science*, **40**: 444–451.
41
42 257 BYRT, T., BISHOP, J. & CARLIN, J.B. (1993) Bias, prevalence and kappa. *Journal of*
43
44 258 *Clinical Epidemiology*, **46**: 423-429.
45
46 259 BRENNINKMEYER, C., DIPPEL, S., MARCH, S., BRINKMANN, J., WINKLER, C. &
47
48 260 KNIERIM, U. (2007) Reliability of a subjective lameness scoring system for dairy cows.
49
50 261 *Animal Welfare*, **16**: 127-129.

- 262 BRIGHT, A., JONES, T.A. & DAWKINS, M.S. (2006) A non-intrusive method of assessing
263 plumage condition in commercial flocks of laying hens. *Animal Welfare* **15**: 113-118.
- 264 CUNNINGHAM, M. (2009) More than Just the Kappa Coefficient: A Program to Fully
265 Characterize Inter-Rater Reliability between Two Raters. Paper no. 242-2009 in SAS Institute
266 Inc.: Proceedings of the SAS®Global Forum 2009 Conference (Cary, NC, SAS Institute
267 Incorporated).
- 268 FLEISS, J.L., LEVIN, B. & PAIK, M.C. (1993) Statistical methods for rates and proportions,
269 3rd edition (New York, John Wiley & Sons). Cit. from BRENNINKMEYER *et al.* (2007).
- 270 FRAISSE, F. & COCKREM, J.F. (2006) Corticosterone and fear behaviour in white and
271 brown caged laying hens. *British Poultry Science*, **47**: 110-119.
- 272 GUNNARSSON, S. (2000) Laying hens in loose housing systems. *Thesis*. Veterinaria 73,
273 Swedish University of Agriculture, Skara.
- 274 GUNNARSSON, S, ODÉN, K., ALGERS, B., SVEDBERG, J. & KEELING, L. (1995)
275 Poultry health and behaviour in a tiered system for loose housed layers. Report no. 35.
276 Swedish University of Agriculture, Skara.
- 277 HILL, A. (1980) Feather loss in layers. *MAFF Poultry Booklet* no.7, pp. 46-52. Gleadthorpe
278 Experimental Husbandry Farm.
- 279 HUGHES, B.O. (1982) Feather pecking and cannibalism in domestic fowls. *Hohenheimer*
280 *Arbeiten: Disturbed Behaviour of Farm Animals*, **121**: 138-146.
- 281 HUGHES, B.O. & DUNCAN, I.J.H. (1972) The influence of strain and environment upon
282 feather pecking and cannibalism in fowl. *British Poultry Science*, **13**: 525-547.
- 283 JANCZAK, A.M., TORJESEN, P., PALME, R. & BAKKEN, M. (2007) Effects of stress in
284 hens on the behaviour of their offspring. *Applied Animal Behaviour Science*, **107**: 66-77.
- 285 KANNAN, G. & MENCH, J.A. (1996) Influence of different handling methods and crating
286 periods on plasma corticosterone concentrations in broilers. *British Poultry Science*, **37**: 21-

1
2 287 31.
3
4 288 KJAER, J.B. (2000) Diurnal rhythm of feather pecking behaviour and condition of
5
6 289 integument in four strains of loose housed laying hens. *Applied Animal Behaviour Science*,
7
8 290 **65**: 331-347.
9
10 291 LAYWEL (2005) <http://www.laywel.eu>.
11
12 292 LITTELL, R.C., MILLIKEN, G.A., STROUP, W.W. & WOLFINGER, R.D. (1996) SAS
13
14 293 System for Mixed Models (Cary, NC, SAS Institute Inc.). ISBN 1-55544-779-1.
15
16 294 RETTENBACHER, S., MÖSTL, E., HACKL, R., GHAREEB, K. & PALME, R. (2004)
17
18 295 Measurement of corticosterone metabolites in chicken droppings. *British Poultry Science*, **45**:
19
20 296 704-711.
21
22 297 RETTENBACHER, S. & PALME, R. (2009) Biological validation of a non-invasive method
23
24 298 for stress assessment in chickens. *Berliner und Munchener Tierarztliche Wochenschrift*, **122** :
25
26 299 8-12.
27
28 300 RIBER, A.B., PALME, R. & FORKMAN, B. (2006) Effect of brooders on feather pecking
29
30 301 and cannibalism in domestic fowl (*Gallus gallus domesticus*). *Applied Animal Behaviour*
31
32 302 *Science*, **99**: 287-300.
33
34 303 TAUSON, R. & HOLM, K.-E. (2003) Evaluation of “Aviplus” - Big Dutchman - furnished
35
36 304 cage for 10 laying hens according to the §7 in the Swedish Animal welfare Ordinance and
37
38 305 according to the New-Technique Evaluation Program at the Swedish Board of Agriculture.
39
40 306 Report 251. Swedish University of Agriculture, Uppsala.
41
42 307 TAUSON, R., AMBROSEN, T. & ELWINGER, K. (1984) Evaluation of procedures for
43
44 308 scoring the integument of laying hens – Independent scoring of plumage condition. *Acta*
45
46 309 *Agricultura Scandinavica*, **34**: 400-408.
47
48 310 TAUSON, R., KJAER, J.B., MARIA LEVRINO, G. & CEPERO BRIZ, R. (2005) Applied
49
50 311 scoring of integument and health in laying hens. Proc. 7th European Symposium on Poultry
51
52
53
54
55
56
57
58
59
60

- 312 Welfare, 15-19 June, Lublin, Poland. *Polish Academy of Sciences* **23(Suppl. 1)**: 153-159.
- 313 TAUSON, R., KJAER, J.B., MARIA LEVRINO, G., CEPERO BRIZ, R. & HOLM, K.-E.
- 314 (2007) Applied scoring of integument and health in laying hens. URL:
- 315 <http://poultry.huv.slu.se/hen/scoringsystem/scoringsystem.pdf>.

Table 1. Plumage score (least squares means) for methods (CLS = complete LayWel scoring; RLS = reduced LayWel scoring), teams and genotypes (IW = ISA Warren, LB = Lohmann Brown, LT = Lohmann Tradition and TS = Tetra SL)

Body part	Method		Team		Genotype				P values ¹			
	CLS	RLS	A	B	IW	LB	LT	TS	Meth.	Team	M*T	Genotype
Neck	2.28	2.29	2.36	2.21	2.35	2.22	2.36	2.21	ns	**	*	* ²
Back	3.68	3.77	3.71	3.74	3.62	3.68	3.76	3.84	ns	ns	ns	ns
Wings	3.58	3.78	3.71	3.65	3.74	3.62	3.71	3.65	***	ns	*	ns
Tail	3.62	3.84	3.76	3.70	3.65	3.71	3.86	3.71	***	*	**	ns
Total (CLSP)	13.2	13.7	13.5	13.3	13.4	13.2	13.7	13.4	***	*	ns	ns

¹*, ** or *** indicates a significant effect with $P < 0.05$, $P < 0.01$ or $P < 0.001$ respectively
²After Tukey-Kramer adjustment for multiple tests, no pair-wise differences between genotypes were significant

Table 2. Measures of agreement between methods (CLS = Complete LayWel Scoring; RLS = Reduced LayWel Scoring) within teams (A and B) and between-teams within methods. SE(kappa), Z and $P < |Z|$ are the asymptotic standard error, the standardised test statistic and the P value of the two sided test of the simple kappa, respectively

Comparison	Variable	Neck	Breast	Back	Wings	Tail	Cloaca	Total ¹
Method CLS vs. RLS								
<i>Within team A</i>								
	Kappa	0.59	-	0.62	0.51	0.23	-	0.28
	SE(kappa)	0.05	-	0.05	0.05	0.05	-	0.04
	Z	11	-	13	10	5	-	9
	$P < Z $	***	-	***	***	***	-	***
	Weighted Kappa	0.63	-	0.70	0.54	0.26	-	0.52
	PABAK	0.84	-	0.90	0.84	0.75	-	0.47
<i>Within team B</i>								
	Kappa	0.69	-	0.74	0.45	0.32	-	0.34
	SE(kappa)	0.06	-	0.05	0.05	0.05	-	0.04
	Z	13	-	16	9	6	-	11
	$P < Z $	***	-	***	***	***	-	***
	Weighted Kappa	0.73	-	0.79	0.53	0.40	-	0.61
	PABAK	0.94	-	0.95	0.78	0.77	-	0.53
Team A vs. B								
<i>Within method CLS</i>								
	Kappa	0.60	0.18	0.78	0.72	0.64	0.38	0.25
	SE(kappa)	0.05	0.04	0.05	0.05	0.05	0.06	0.03
	Z	11	5	15	13	12	6	11
	$P < Z $	***	*	***	***	***	***	***
	Weighted Kappa	0.64	0.41	0.83	0.76	0.69	0.42	0.61
	PABAK	0.87	0.40	0.96	0.90	0.87	0.73	0.35

1
2
3
4
5
6
7
8
9
10
11
12

<i>Within method RLS</i>						
Kappa	0.44	-	0.78	0.59	0.34	0.33
SE(kappa)	0.06	-	0.05	0.06	0.07	0.04
Z	9	-	15	10	6	9
$P < Z $	***	-	***	***	***	***
Weighted Kappa	0.51	-	0.82	0.62	0.42	0.59
PABAK	0.79	-	0.97	0.90	0.88	0.55

¹When comparing CLS with RLS the total score includes 4 body parts only (neck+back+wings+tail)

13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47