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Field trial on animal-based measures for animal welfare in slow growing broilers reared under an alternative concept suitable for the German market

Feldversuch zu tierbasierten Tierwohlindikatoren einer langsamer wachsenden Masthühnerlinie unter den Bedingungen eines in Deutschland marktfähigen alternativen Aufzuchtkonzeptes

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Summary

Broiler chickens are usually reared in deep litter systems without any enrichment, and animal welfare related issues occur on a regular basis. Publicizing the problems has led to better consumer awareness and the demand for animal-friendly produced food. We established and tested an alternative rearing concept to improve bird welfare by introducing an intermediate product between organically and conventionally produced meats to the German market. Within the frame of this project 6 rearing periods per concept and farm were evaluated in parallel on 3 to 4 predetermined days per rearing period. Ross 308 broilers (conventional farm) were reared according to the minimum requirements regulated by law and the slower growing Cobb SassoTM 175A broilers (alternative farm) were housed with provision of perches, straw bales, pecking stones and a winter garden with lower stocking densities. Broilers of both strains showed an increasing prevalence and severity of foot pad alterations with increasing age and exposure duration in the barn. Shortly before slaughter, 2.5% of the alternative broilers (day 40) and 16.8% of the conventional broilers (day 35) showed various degrees of foot pad dermatitis. The variable farm/strain had a significant effect ($P < 0.001$) on the occurrence of hyperkeratosis and foot pad dermatitis. Live weight had a significant effect ($P < 0.001$) on the prevalence of hock burn in both strains. Obvious lameness (0.8%) and immobility (0.5%) could only be identified in conventional broilers. The results of this study indicate a higher animal well-being of slower growing broilers reared under enriched environmental conditions compared to conventionally reared broilers of this study. However, because of the study design and the confounding of farm/rearing concept and strain these results can only be seen as hypothesis generating and should be investigated in further studies.

Keywords: foot pad dermatitis, hock burn, gait score, chicken, Cobb Sasso

Zusammenfassung

Masthühner werden üblicherweise in eingestreuter Bodenhaltung ohne spezielles Angebot von Struktur- und Beschäftigungselementen gemästet und tierschutzrelevante Probleme treten regelmäßig auf. Öffentlich bekannt werdende Probleme haben zu einem besseren Verbraucherbewusstsein geführt und damit zu der Forderung nach tiergerechterer Lebensmittelproduktion. Um das Tierwohl zu steigern, haben wir ein alternatives Aufzuchtkonzept zusammengestellt und getestet. Dieses wurde dem deutschen Markt als ein Produkt zwischen biologisch und konventionell produziertem Fleisch vorgestellt. Im Rahmen des Projektes wurden 6 Aufzuchtdurchgänge pro Konzept und Farm parallel an 3 bis 4 vorher festgelegten Tagen pro Durchgang wissenschaftlich begleitet. Masthüh-

ner der Linie Ross 308 (konventionelles Konzept) wurden nach den gesetzlichen Mindestanforderungen gemästet, während Hühnern der Linie Cobb SassoTM 175A (alternatives Konzept) zusätzlich Sitzstangen, Strohballen, Picksteine und Zugang zu einem Wintergarten bei insgesamt geringerer Besatzdichte angeboten wurden. Beide Masthühnerlinien zeigten einen Anstieg sowohl im Vorkommen als auch im Schweregrad von Fußballenveränderungen im zeitlichen Verlauf der Mast und mit Expositionsdauer im Stall. Kurz vor der Schlachtung zeigten 2,5 % der alternativ aufgezogenen Masthühner (Tag 40) und 16,8 % der konventionell gemästeten Hühner (Tag 35) unterschiedliche Schweregrade an Fußballendermatitis. Die Variable Farm/Hühnerlinie hatte dabei einen signifikanten Einfluss ($p < 0{,}001$) auf das Vorkommen von Hyperkeratose und Fußballendermatitis. Das Lebendgewicht nahm bei beiden Hühnerlinien einen signifikanten Einfluss auf das Auftreten von Sprunggelenkdermatitis. Deutliche Lahmheit (0,8 %) und Unvermögen zur Fortbewegung (0,5 %) trat ausschließlich bei den konventionell aufgezogenen Ross 308 Hühnern auf. Obwohl die Ergebnisse stark abhängig von dem Management der beiden untersuchten Mastbetriebe sind, geben sie Hinweise darauf, dass langsamer wachsende Cobb-Sasso-Masthühner, aufgezogen mit dem alternativen Konzept, ein mehr an Tierwohl genießen im Vergleich zu konventionell gemästeten Masthühnern der vorliegenden Studie. Die Ergebnisse können aufgrund des Studiendesigns und des Zusammenhangs zwischen der Farm/dem Aufzuchtkonzept und der Broilerlinie zur Hypothesenaufstellung verwendet werden und sollten in Folgestudien noch weiter untersucht werden.

Schlüsselwörter: Fußballendermatitis, Fersenhöckerveränderungen, Gangbildanalyse, Masthuhn, Cobb Sasso

Introduction

Because chickens are good feed converters and can be raised under space-restricted conditions, the production expands continuously while the meat stays at a low price level. Broiler chickens are usually raised in deep litter systems, and the stocking density is as high as 39 kg/m², regulated by the German Order on the Protection of Animals and the Keeping of Production Animals (2006) (German designation: Tierschutz-Nutztierhaltungsverordnung). Animal welfare problems such as foot pad dermatitis (FPD) and poor gait occur on a regular basis not only in broilers. Numerous authors described FPD and the possible causal factors in turkeys, laying hens and broilers over the past years, for example Berk and Bartels (2014), Hashimito et al. (2013), Bergmann et al. (2013), Abd El-Wahab (2012), Kamphues et al. (2011), Krautwald-Junghanns et al. (2011), Youssef et al. (2011), Shepherd and Fairchild (2010), Keppler et al. (2009), Haslam et al. (2007), Mayne et al. (2007), Kjaer et al. (2006), Thomas et al. (2004), Sørensen et al. (2000) and Greene et al. (1985). Multiple predisposing factors such as poor litter quality, high litter moisture, duration of exposure to moist or wet litter material, stocking density, nutrition and genetic traits have been made responsible for the occurrence of foot pad alterations and poor gait. Alterations can occur on the hocks as well as on the pads and digits. At first, alterations appear as light brown to black discoloration and hyperkeratosis of the epidermis (de Jong and van Harn, 2012). Extensive and severe foot pad alterations constitute an infringement against the German Animal Welfare Act (Lower Saxonian State Office for Consumer Protection and Food Safety, 2014). As of 1 February 2014, a self-monitoring is mandatory for all farmers who keep livestock, and the evaluation of animal-based indicators in the sense of the German Animal Welfare Act (2006) (German designation: Tierschutzgesetz) is indispensable to prevent serious injuries to the animals. The publication of the above mentioned and other problems especially in broiler farming has led to increased consumer awareness. The introduction of an intermediate level between conventional and organic chicken meat production, with higher demands compared with the minimum requirements regulated by law, could represent a meaningful solution to link the increasing demand for affordable meat with the production under improved animal welfare standards. Aim of the study was to investigate the outcome of alternatively reared broilers with provided resources and a slower growing broiler strain concerning especially animal-based measures for animal welfare. In addition the rearing of broilers under conventional conditions also of a contract farm to the Wiesenhof Geflügel-Kontor GmbH, Visbeck, Germany, was evaluated. We scientifically supported the alternative rearing concept on its way to market suitability concerning animal health aspects in compliance with the requirements for the German Animal Welfare label by the German Animal Welfare Association (Deutscher Tierschutzbund e. V.).

Material and Methods

Animals

One-day-old chicks of the 2 broiler strains Cobb SassoTM 175A (alternative broilers) and Ross 308 (conventional broilers) were obtained from the hatchery Brüterei Süd ZN (branch) of the BWE–Brüterei Weser–Ems GmbH & Co. KG, Regenstauf, Germany. All broilers were slaughtered at the Donautal Geflügelspezialitäten Zweigniederlassung (branch) of the Lohmann & Co. AG, Bogen, Germany.

FIGURE 1: *Photographic illustration of scoring categories 0/1a/1b/2a/2b for the presence and severity of foot pad dermatitis (FPD) according to the scoring system of Welfare Quality (2009), slightly modified.*

Animal housing and management

Both broiler farms participating in this study were contract farmers to the Wiesenhof Geflügel-Kontor GmbH, Visbeck, Germany and additionally acted according to the identical internal management standard regulations. Both farms were selected because of their similar fattening results in conventional broiler rearing prior to our studies. A commercial multiphase diet was provided to the birds (starter, rearing I, rearing II [conventional] plus 20% farm-produced wheat [alternative], finisher). Type and composition of animal feed were prescribed by the company, and feed was obtained from MEGA Tierernährung GmbH & Co. KG Visbek, Rechterfeld, Germany. Shredded, hydrothermally dried, germ-free and pelletized straw as "Strohcobs" (Trocknungsgenossenschaft Röckersbühl eG, Bernau, Germany) were used as litter material.

Alternative rearing concept

32 500 day old Cobb Sasso chicks were housed per rearing period in a barn measuring 105.3 x 19.3 m (2032 m^2). A winter garden of altogether 624 m^2 was attached along both long sides of the barn and was accessible via 27 openings that measured 1.18 x 0.45 m each. With an estimated mortality of 3%, a stocking density of 16 birds/m^2 or 28.7 kg/m^2 (including the winter garden area) was reached at slaughter age. The total window area measured 61 m^2. Flicker-free and dimmable high-frequency lamps were arranged in 2 longitudinal rows with 14 light units each (5,19 Watt/m^2). A dark phase of 1 hour was then introduced and continuously increased over the period of 1 week until a continuous 6 hour dark phase was reached. Altogether, 2 heat exchangers, 7 Casablanca ceiling fans and 6 summer ventilators with a total output of 258 000 m^3/hour ensured fresh air supply and air exchange. The temperature was between 30 and 33°C at the beginning, and was reduced automatically to 15 to 19°C at the end of each rearing period (RP). 6 drinking lines with 515 nipple drinkers each and 4 feeding belts with altogether 548 feeding pans were provided. The provision of perches, pecking stones, straw bales and access to an outdoor area (winter garden) is mandatory. 5 height-adjustable perches made of polyvinyl chloride material (LAE-Anlagenbau GmbH, Cuxhaven, Germany) with a total length of 515 m (15.85 m/1000 birds) were installed in the barn. At the beginning of each new RP, 54 "small" pure wheat straw bales with the approximately dimensions 100 x 50 x 40 cm and a weight between 10 to 15 kg (1.66 bales/1000 birds) and 34 pecking stones (1.05 pecking stones/1,000 animals) were distributed evenly throughout the barn. The pecking stones consisted at first of porous concrete (Ytong). Because of possible ingested residues grain pecking stones manufactured by SWB Kraftfutter, Baldramsdorf, Germany, were used. The first RP of the alternative concept was used for training purposes.

Conventional rearing

The barn for conventional rearing measured 63.7 x 23.8 m (1516 m^2) with the maximum capacity of Ross 308 broilers set at 34 900 individuals. With an estimated mortality of 3.5%, the average stocking density was 23 birds/m^2 or 34.9 kg/m^2. The total window area measured 45.5 m^2. For additional lighting, flicker-free and dimmable high-frequency lamps were installed in 3 longitudinal rows consisting of 12 units each (8.95 watt/m^2). A permanent light phase was practiced during the first 48 hours after the arrival of the day-old chicks. A dark phase of 1 hour was then introduced and continuously increased over the period of 1 week until a continuous 6 hour dark phase was reached. 6 circulation fans (144 000 m^3/hour) and 3 summer fans (120 000 m^3/hour) ensured fresh air supply and air exchange via a vacuum air venting system. During the RP, the temperature was automatically reduced from a starting temperature of 30 to 33°C to an end temperature of 15 to 19°C. Water and feed were provided by 8 drinker lines (300 nipple drinkers each) and 5 feeding belts (80 feeding pans each), respectively.

The cross-over evaluation of Ross 308 broilers reared under the conditions of the alternative concept and Cobb Sasso broilers reared according to the by law regulated minimum requirements (conventional rearing) in the field, was unfortunately not accomplishable at the same time of the project due to organizational and economic reasons. At present results are being evaluated for Ross 308 broilers under similar alternative rearing conditions in a follow-up study.

On-farm animal-based measures

Depending on the rearing concept, the barns were visited 3 (conventional rearing: days 5, 15, 35) or 4 times (alternative rearing: days 5, 15, 30, 40). Over 6 RPs each, 100 randomly picked individuals from different locations in the barn were examined during each visit to assess foot pad dermatitis and hock burn (hock dermatitis). Altogether 4200 individuals were examined. The

occurrence of hyperkeratosis was scored as follows: 0 – no hyperkeratosis; 1 – moderate hyperkeratosis; 2 – intermediate hyperkeratosis; and 3 – severe hyperkeratosis. The following modified categories were used to score occurring FPD and hock burn: 0 – no evidence of FPD or hock burn; 1a – moderate, superficial lesions < 0.5 cm in diameter; 1b – moderate, superficial lesions > 0.5 cm in diameter; 2a – clear, deep lesions < 0.5 cm in diameter; 2b – extensive deep lesions > 0.5 cm in diameter (Fig. 1). The gait score of an additional 100 broilers (n = 1200) per visit per barn was recorded shortly before slaughter on day 35 (conventional) and day 40 (alternative). The classification of the broilers' gaite was as follows: 0 – normal, dextrous and agile; 1 – slight abnormality, but difficult to define; 2 – definite and identifiable abnormality; 3 – obvious abnormality, affects ability to move; 4 – severe abnormality, bird takes only a few steps; 5 – bird incapable of walking. The assessment of the parameters was performed on the basis of the scoring system of the "Assessment protocol for poultry" (Welfare Quality®, 2009). All examined birds were weighted separately with a digital scale Type Valor 2000 W (OHAUS Europe GmbH, Nänikon, Switzerland).

TABLE 1: *Prevalence and severity of on-farm assessed hyperkeratosis, foot pad dermatitis and hock burn according to the examination day (n = 2400 alternative Cobb Sasso broilers and n = 1800 conventional Ross 308 broilers). All six rearing periods per rearing concept are summarized*

Cobb Sasso, alternative															
		Hyperkeratosis (Scores)				Foot pad dermatitis (Scores)					Hock burn (Scores)				
Age (d)	Total number	0	1	2	3	0	1a	1b	2a	2b	0	1a	1b	2a	2b
5	n	592	8	0	0	599	1	0	0	0	600	0	0	0	0
	%	98.7	1.3	0	0	99.8	0.17	0	0	0	100	0	0	0	0
15	n	596	3	1	0	600	0	0	0	0	599	1	0	0	0
	%	99.3	0.5	0.2	0	100	0	0	0	0	99.8	0.2	0	0	0
30	n	583	15	2	0	598	1	1	0	0	575	24	1	0	0
	%	97.2	2.5	0.3	0	99.7	0.2	0.2	0	0	95.8	4.0	0.2	0	0
40	n	533	39	26	2	585	15	0	0	0	478	107	15	0	0
	%	88.8	6.5	4.3	0.3	97.5	2.5	0	0	0	79.7	17.8	2.5	0	0
Ross 308, conventional															
5	n	600	0	0	0	600	0	0	0	0	587	13	0	0	0
	%	100	0	0	0	100	0	0	0	0	97.8	2.2	0	0	0
15	n	593	7	0	0	597	0	3	0	0	593	6	1	0	0
	%	98.8	1.2	0	0	99.5	0	0.5	0	0	98.8	1.0	0.2	0	0
35	n	455	92	46	7	499	54	40	4	3	389	163	37	11	0
	%	75.8	15.4	7.7	1.2	83.2	9.0	6.7	0.67	0.5	64.8	27.2	6.2	1.8	0

Post-mortem assessment of foot pad dermatitis

Over the whole duration of the slaughter process, detached feet were collected randomly from the slaughter belt every 10 minutes and then bundled with a rubber band until the amount came up to 100 pairs of feet. These then were packed for a later examination in the laboratory.

Environment-related measures

Temperature in °C and relative humidity in % were evaluated on an hourly basis via a Thermologger LogBox RHT (B&B Thermotechnik GmbH, Donaueschingen, Germany) during each RP. Gaseous ammonia (ppm) and litter quality were assessed during each visit (3 or 4 times during each rearing period) and represent snapshot measurements. To measure gaseous ammonia, 2 measuring devices were used (Pac III E/S with the Dräger sensor XS EC NH3, Dräger Safety AG&Co. KGaA, Lübeck, Germany). Gaseous ammonia was assessed at 30 measuring points throughout each barn. To evaluate the litter quality, the litter-quality-score according to the Welfare Quality® protocol (Welfare Quality®, 2009) was chosen. Litter quality was assessed at 10 measuring points including drinking, feeding and resting areas. Classifications used were 0 – completely dry and flaky, i. e. moves easily with the foot; 1 – dry but not easy to move with foot; 2 – leaves imprint of foot and will form a ball if compacted, but ball does not stay together well; 3 – sticks to boots and sticks readily in a ball if compacted; 4 – sticks to boots once the cap or compacted crust is broken.

Statistical analysis

For the statistical analysis of the data, R version 3.0.2 (R Core Team, 2013) was used. To analyze the complex relationships between a binary dependent variable and multiple explanatory variables we used logistic mixed models with covariates live weight, temperature, relative humidity, gaseous ammonia and farm/strain and a random effect for the RP per farm. Interpretation of fixed effects is the conditional on the random effects. For estimations, we used methods outlined in Wood (2011) and implemented in the R package mgcv. Parameter estimates of fixed effects were interpreted in terms of odds ratios. Note that, for all analyses, 1 bird constituted 1 observation, therefore risk changes also refer to the comparison of (hypothetical) individual birds. Results were considered significant if the P-value was smaller than 0.05. Potential effects of rearing concept, strain and farm could not be separated due to the study design and statements regarding differences in strain/concept describe the results of the current study and are not meant as general statements regarding strain or concept. Data of the more severe foot of each examined pair was chosen for the statistical analysis and graphical presentation. All data are graphically presented using Microsoft Excel® and SigmaPlot version 11.0 (Systat Software, Inc., San Jose, California, USA, www.sigmaplot.com).

Results

On-farm assessment of live weight, hyperkeratosis, foot pad dermatitis and hock burn

The average live weight (± SD) at the age of 5 days was 111.7 g (± 27.97) for the alternatively reared Cobb Sasso broilers and 118.0 g (± 37.96) for the conventionally reared Ross 308 broilers. Shortly before slaughter, the weight was 1888,2 g (± 310.63) for the alternative broilers (day 40) and 2177.9 g (± 288.39) for the conventional broilers (day 35). Foot pad alterations with hyperkeratosis of score 1 (moderate hyperkeratosis) occurred as early as day 5 in 1.3% of the alternative broilers and as early as

TABLE 2: *Results of the logistic regression for the occurrence of hyperkeratosis, foot pad dermatitis and hock burn. Explanatory variables live weight, barn/strain, temperature, relative humidity and gaseous ammonia were interpreted in terms of odds ratios (exp[Estimate]). The calculations were performed with on-farm data from the last visits on day 35 (conventional rearing) and day 40 (alternative rearing) shortly before slaughter. P-values in bold indicate statistical significance*

Variables	Hyperkeratosis			Foot pad dermatitis			Hock burn		
	Estimate	Factor	P-value	Estimate	Factor	P-value	Estimate	Factor	P-value
Live weight	−0.0016	0.9984	< **0.001**	−0.0009	0.9991	**0.016**	0.0024	1.0024	< **0.001**
Barn/strain	2.2395	0.1065	< **0.001**	2.9009	0.0549	< **0.001**	−0.2730	0.7610	0.510
Temperature	−0.4210	0.6564	< **0.01**	−0.2183	0.8039	**0.022**	0.0395	1.0403	0.539
Humidity	−0.1193	0.8875	0.131	−0.0199	0.9802	0.687	0.0414	1.0424	0.433
Ammonia	0.0149	1.0145	0.441	−0.0175	0.9826	0.234	0.0081	1.0082	0.576

day 15 in 1.2% of the conventional broilers (Tab. 1). Clear differences between the farms were detectable during the last visits before slaughter on day 40 (alternative) and day 35 (conventional). Here, 6.5% (alternative) and 15.8% (conventional) of the examined broilers showed moderate hyperkeratosis, 4.3% and 7.7% intermediate hyperkeratosis and 0.3% and 1.2% severe hyperkeratosis (Tab. 1). Because hyperkeratosis was noticed mainly during the last visit of each RP, results from these visits were subjected to the logistic regression analyses. For this live weight, farm/strain, temperature, relative humidity and gaseous ammonia were assumed as independent variables. Weight and farm/strain had a significant ($P < 0.001$) influence on the occurrence of hyperkeratosis (Tab. 2). Broilers of the Cobb Sasso strain (reared with the alternative concept) had a 9 times higher chance for feet without hyperkeratosis compared with the conventionally reared Ross 308 broilers. An increase in temperature by 1 unit (1.00°C) reduced the risk for the occurrence of hyperkeratosis by the factor 0.05638 (exposed value, $P < 0.01$; Tab. 2).

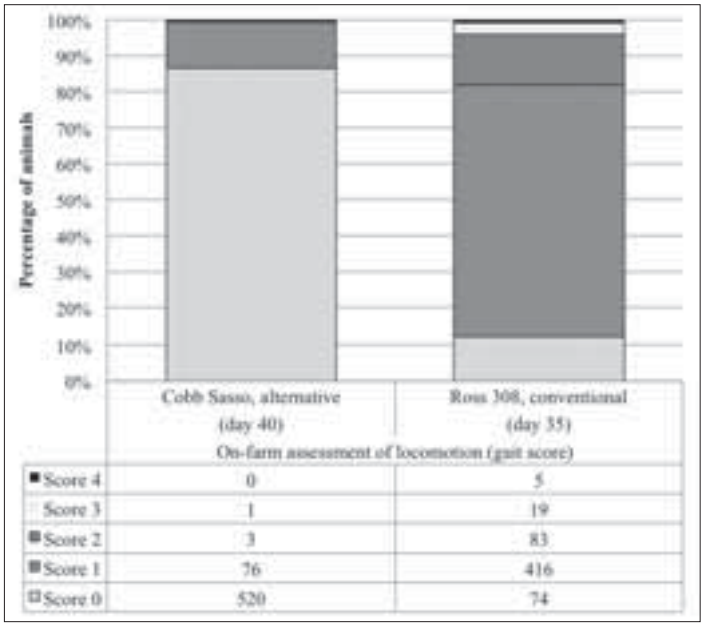

FIGURE 2: *Locomotion assessment (gait score 0: normal, dextrous and agile to 5: incapable of walking, score 5 not detected on examined birds), examined on day 40 (Cobb Sasso, alternative rearing) and day 35 (Ross 308, conventional rearing) and summarized for all six rearing periods; n = 600 per broiler strain.*

FPD with superficial lesions (score 1a) occurred on day 5 in 0.2% of the Cobb Sasso and in none of the Ross 308 broilers (Tab. 1). On day 15, the opposite situation was seen, with no lesions found in the Cobb Sasso broilers, but superficial lesions (score 1b) found in 0.5% of the Ross 308 broilers (Tab. 1). On day 40, 97.5% of the alternatively reared Cobb Sasso broilers showed score 0 and 2.5% score 1a (Tab. 1). In contrast, the foot pad health of the conventional broilers continuously deteriorated until the last examination on day 35, when a small number of broilers even showed deep lesions (score 2a: 0.7% and score 2b: 0.5%; Tab. 1). When we separately analyzed each RP for the alternative broilers, broilers in RP 2 on day 30 were scored 1a and 1b at 1.0% each, and on day 40 were scored 1a at 4.0%. No lesions were seen in RPs 3, 5 and 7 until day 30 and only mild lesions in RP 4 (day 5: 1.0% score 1a). On day 40, lesions of score 1a were found (2.00% in RPs 3 and 7, 3.00% in RP 4 and 4.0% in RP 5). In RP 6, the alternative broilers consistently scored 0. We found different results for the conventional broilers. On day 35 (last visit), 14.0% of the broilers in RP 3, 7.0% in RP 4 and 5.0% in RP 5 showed score 1a, and 10.0% in RP 3, 3.0% in RP 4 and 1.0% in RP 5 showed score 1b. In RP 6, 13.0% were rated score 1a, 15.0% score 1b, 4.0% score 2a and 3.0% score 2b. During this rearing period the birds were suffering from intestinal problems due to a bacterial infection that needed medical treatment. Otherwise the flocks of all RPs and both farms showed a good general state of health and no special treatment became necessary. In the logistic regression model for FPD (using the last visit and the same explanatory variables as described for the hyperkeratosis regression), the variable farm/strain showed a significant effect ($P < 0.001$). With regard to FPD, the alternative broilers had an 18 times higher chance of having healthy feet compared with the conventional broilers. Because of the small number of statistical settings for the variable temperature, one must be careful to draw reliable conclusions. Concerning alterations in the hock area, no substantial differences between the barns occurred at the beginning of the RPs; 100.0% of the alternative broilers and 97.8% of the conventional broilers were free of hock burn on day 5 (Tab. 1). Whereas a low percentage of superficial hock burn (0.2 to 1.0%) could be detected in broilers of both strains on day 15, the prevalence of mild hock burn increased until the last examination day (Tab. 1). On day 40, 20.3% of the alternative broilers showed superficial hock burn (17.8% score 1a and 2.5% score 1b; Tab. 1). On day 35, 33.3% of the conventional broilers showed superficial hock burn (27.2% score 1a and 6.17% score 1b; Tab. 1) and 1.8% showed severe hock burn of score 2a (Tab. 1). For the logistic regression analysis, the results from the last visit before slaughter were used and dichotomized (Y = score > 0), using the same covariates as described for the hyperkeratosis and FPD regressions. Only the live weight had a significant effect ($P < 0.001$) on the occurrence of hock burn. The risk for alterations of the hocks increased with increasing live weight of the broilers.

The locomotion was examined with a gait scoring that was performed on 100 additional broilers during each RP shortly before slaughter. Over all RPs, 86.7% of the alternative broilers showed a normal and agile gait (score 0) compared with 12.3% of the conventional broilers (Fig. 2). Slight and difficult-to-define abnormalities (score 1) could be found in 12.7% of the Cobb Sasso and 69.3% of the Ross 308 broilers (Fig. 2). 1 of the Cobb Sasso broilers in 1 RP was scored with a 3 (obvious abnormality), and none showed gait abnormalities of scores 2 (identifiable abnormality), score 4 (severe abnormality) and 5 (incapable of walking). Of the conventionally reared Ross 308 broilers, 13.8% showed identifiable abnormality (score 2), 3.2% were affected in their ability to move (score 3), 0.8% could take only a few steps (score 4) and 0.5% could not walk (score 5) (Fig. 2). When we analyzed each RP separately, RP 6 in the conventional barn stood out. Here, many broilers showed a poor mobility (score 0: 0.0%, score 1: 34.0%, score 2: 50.0%, score 3: 9.0%, score 4: 4.0% and score 5: 3.0%). Live weight and farm/strain were the 2 chosen variables for the statistical analysis. Weight had a significant effect ($P < 0.001$). No significant influences were detected for the variable farm/strain. However, RP 6 in the conventional barn appeared to be abnormal regarding locomotion, which caused convergence problems of the estimation. After removal of those observations from the analysis, the variable farm/strain was significant ($P < 0.001$) and indicated a 26 times higher risk of poor mobility for the conventionally reared Ross 308 broilers compared with the alternatively reared Cobb Sasso broilers. The average mortality rate for Cobb Sasso broilers over all rearing periods was 3.4 % (1.8–5.3 %) and for Ross 308 was 3.5 % (2.1–6.2 %).

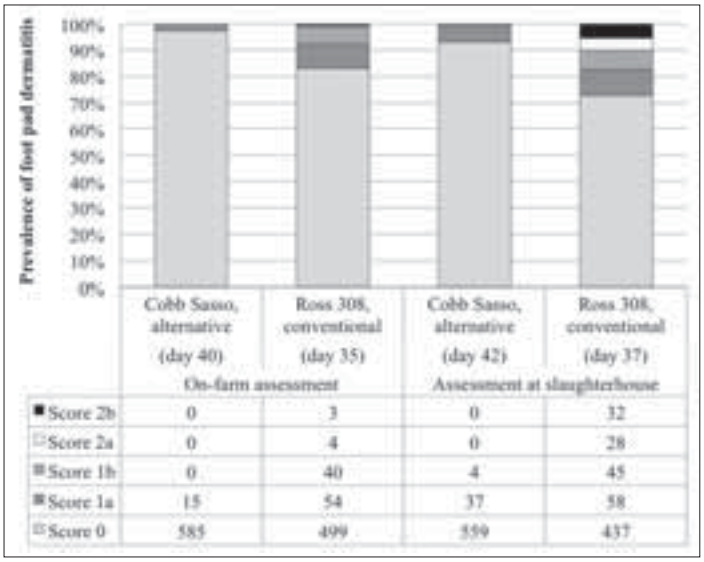

FIGURE 3: *Prevalence and severity of foot pad dermatitis in percentage during the last on-farm examination and the post-mortem examination (days 40 and 42, respectively, for the Cobb Sasso strain, alternative rearing and days 35 and 37, respectively, for the Ross 308 strain, conventional rearing) with scores from 0 (no evidence of foot pad dermatitis) to 2b (evidence of extensive foot pad dermatitis); numbers in the table show the numbers of recorded broilers per foot pad condition score (all 6 rearing periods summarized: n = 600 per day and strain).*

Post-mortem assessment of foot pad dermatitis

Substantial differences occurred between the 2 barns concerning the occurrence of FPD evaluated from the pairs of feet taken from the slaughter belt (n = 600 Cobb Sasso and n = 600 Ross 308, Fig. 3). Because the feet were mechanically clipped off at the joint, the evaluation of hock burn was not feasible. Concerning the occurrence of FPD, severe lesions (scores 2a and 2b) could not be detected in the alternatively reared Cobb Sasso strain. Superficial lesions of score 1a occurred from 3.0% (RP 6) to 13.0% (RP 2), and of score 1b from 0.0% (RPs 5, 6 and 7) to 2.0% (RP 3) in this strain. In the conventionally reared Ross 308 strain, superficial lesions of score 1a were diagnosed in 2.0% (RP 5) to 22.0% (RP 4) and those of score 1b in 1.0% (RPs 1 and 5) to 12.0% (RP 6) of all examined cases. Furthermore, severe lesions of score 2a (0.0% to 15.0%) and score 2b (0.0% to 25.0%) were found in this strain. Comparison of the results from the on-farm assessment with those obtained from the pairs of feet taken from the slaughter belt showed that the fraction of score 0 decreased from the last on-farm assessment (days 35 and 40) until slaughter (days 37 and 42) by 0.10 (r = 0.74). In contrast, the fractions of scores 1a and 1b increased until slaughter by 0.05 (r = 0.61) and 0.01 (r = 0.78), respectively (Fig. 3). This finding indicates that the foot pad condition continues to deteriorate during the last days in the barn until slaughter. A better differentiation of foot pad lesions on feet taken from the slaughter belt might also result from the thorough cleaning during the slaughter process and therefore better view on lesions.

Environment-related measures

With a decreasing average temperature from 28.29°C (day 5) to 19.97°C (day 40) in the alternative-concept barn and from 30.57°C (day 5) to 21.75°C (day 35) in the conventional barn, the relative humidity increased from 52.28% (day 5) to 69.37% (day 40, alternative) and from 56.32% (day 5) to 65.45% (day 35, conventional) over the duration of each RP (Tab. 3). Temperature and relative humidity were negatively correlated (r = –0.73). The average amount of gaseous ammonia

TABLE 3: *On-farm measurements of environmental factors on days 5, 15, 30 and 40 (Cobb Sasso strain, alternative rearing) and on days 5, 15 and 35 (Ross 308 strain, conventional rearing), including temperature (°C), relative humidity (%), and gaseous ammonia (ppm). All 6 rearing periods per rearing concept are summarized, average values are shown*

Age (d)	Temperature (°C)				Humidity (%)				Gaseous ammonia (ppm)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Cobb Sasso, alternative												
5	28.29	1.01	23.40	30.00	52.28	4.09	42.90	61.40	0.33	0.67	0.00	2.50
15	25.91	1.08	23.30	28.10	61.57	5.79	48.10	75.90	0.34	1.28	0.00	8.00
30	22.10	2.40	16.50	28.60	63.65	5.39	48.60	74.30	6.44	6.89	0.00	33.00
40	19.97	4.86	10.70	32.60	69.37	7.59	48.20	79.40	13.96	8.66	0.00	36.50
Ross 308, conventional												
5	30.65	1.31	24.10	32.20	56.58	6.88	34.50	67.40	2.07	2.22	0.00	10.00
15	27.10	0.89	25.20	29.20	59.16	6.20	48.20	72.00	8.21	10.89	0.00	37.00
35	21.75	1.78	15.00	23.80	65.45	5.35	54.30	83.60	18.15	11.83	0.00	44.50

increased from 0.33 ppm (day 5) to 13.96 ppm (day 40) in the alternative-concept barn, and from 2.07 ppm (day 5) to 18.15 ppm (day 35) in the conventional barn. The maximum reached values were 36.50 ppm (alternative) and 44.50 ppm (conventional), each measured during the last visit (Tab. 3). The correlation analysis showed a moderate negative correlation between temperature and gaseous ammonia ($r = -0.52$). With decreasing temperature, the gaseous ammonia content increased throughout each RP.

Differences in litter quality concerning the different functional areas drinking, feeding and resting could not be detected in the alternative-concept barn. The litter in the 2 measured areas in the front section of the barn showed a mean score of 3 (sticks to boots and sticks readily in a ball if compacted), whereas the litter in all remaining resting areas, the drinking area in the middle and the feeding area in the back section of the barn showed maximum scores of 1 (completely dry and flaky, i. e. easy to move with the foot). In the conventional barn, a low litter quality was found especially in the middle resting area and the drinking areas in the front barn section. These areas were each evaluated with a score of 4 (sticks to boots once the cap or compacted crust is broken). Other than that, the litter in all areas except the front resting area (score 1) was rated with at least score 2 (leaves imprint of foot and will form a ball if compacted). Litter quality in general deteriorated with the duration of each RP. A positive correlation ($r = 0.52$) was found between the gaseous ammonia content and litter quality. This shows that with higher litter scoring the ammonia content also increased.

Discussion

The prevalence of alterations in the foot pads and hocks increased with ongoing duration of the rearing period and thus with increasing age and weight of the broilers under both rearing conditions. Kjaer et al. (2006) described the occurrence of foot pad alterations in Ross 308 broilers as early as the second week of age and an increasing severity with the duration of fattening (i. e. the rearing period), whereas slower-growing (dual-purpose) strains showed hardly any alterations. Allain et al. (2009) compared a fast-growing with a slow-growing strain and found higher rates of FPD in the fast-growing strain. The occurrence of both FPD and hock burn coincided with a genetic variation between commercial broiler lines (Ask, 2010). In our study, variations between the 2 used broiler strains were present concerning the prevalence and severity of FPD, hock burn and gait impairment. At all times, the alternatively reared Cobb Sasso strain performed better than the conventionally reared Ross 308 strain, and the alternative broilers had an 18 times higher chance for healthy feet without FPD compared with the conventional broilers. Litter quality, especially the litter moisture level, has been described to influence the foot pad health of broilers. Because litter quality was scored worse in the conventional than in the alternative-concept barn, the consistently worse foot pad health of the conventionally reared Ross 308 broilers in our study may be related to litter quality. Haslam et al. (2007) also found a positive correlation between litter score and FPD, whereby the risk for FPD increased with increasing litter scores by 1 unit. Feed composition, previously described to impact litter quality (Kamphues et al., 2011), was identical in both barns and can be neglected as cause for the differences in litter quality seen in the present study. Likely, the stocking density (number of broilers per square meter) of the 2 rearing concepts of our study influenced litter quality, because higher stocking densities lead to an increasing amount of excrements (Thomas et al., 2004). As broilers aged in a study by Eichner et al. (2007), litter moisture and the occurrence of FPD increased. Taira et al. (2014) reared broilers on either wet or dry litter, and compared with the broilers kept on wet litter, which developed FPD as early as day 14, those kept on dry litter did not develop FPD until day 28. Also, de Jong et al. (2013) observed significantly more cases of FPD and hock burn in a group of broilers kept on litter with high moisture than in a control group kept on litter of good, dry quality. The authors concluded that litter moisture also affected other bird welfare aspects such as mobility in a negative way. Broom and Reefmann (2005), who investigated alternative production systems such as organic chicken production, found that compared with commercially raised chicken, the organically reared chicken showed half the prevalence of hock burn. Again litter moisture, besides the leg strength, was suggested to be responsible for this finding (Broom and Reffmann, 2005). Litter quality also decreases with increasing ambient relative humidity. Reduced ventilation during the wintertime with a cooler air supply can be made responsible for an increase in relative humidity and worsening in litter quality (Kyvsgaard et al., 2013). As we found the worst litter quality and highest relative humidity in the 6th rearing period during summertime, the high incidence of FPD and poor gait during this specific rearing period was most likely the consequence of intestinal problems, which also most probably led to decreased litter quality with high moisture content.

Live weight as a possible cause had very little impact on the occurrence of FPD and turned out not to be significant in a study by Kjaer et al. (2006). Although an association of live weight with the occurrence of hyperkeratosis and hock burn could be seen in the present study, causal interpretations are difficult because Ross 308 broilers are generally heavier than Cobb Sasso broilers, so that the factor weight was confounded with the factor farm/strain and needs to be carefully interpreted. However, Akbaş et al. (2009) and Sørensen et al. (2000) also found a positive correlation between live weight and the occurrence of hock burn. Hepworth et al. (2010) identified 17 risk factors for the prevalence of hock burn at the age of 5 weeks and the average slaughter weight was amongst the 8 factors associated with an increased risk. Live weight as a cause for abnormal gait can be neglected according to Stojcic and Bessei (2009) because slow-growing broiler strains still showed a normal gait even when burdened with additional weight, whereas fast-growing broiler strains still showed an oscillating gait when they were disburdened. The stronger-developed chest muscles in the latter were identified as a cause for abnormal gait (Stojcic and Bessei, 2009). An influence of the broiler strains could be assumed in the present study whereby the heavier broiler strain Ross 308 reared under conventional conditions had a higher risk for a poor gait compared with the lighter, slower-growing Cobb Sasso strain reared with the alternative concept. Sørensen et al. (2000) further detected a connection between the locomotion and the occurrence of

hock burn. This may be explained by an increased resting behavior of immobile birds. Finally, our post-mortem evaluations at the slaughterhouse reflected the on-farm examined foot pad health condition. The relatively high variation of results between the rearing periods within the same farm can be explained by the so called rearing period effect. Also Knierim (2013) experienced this effect and assumed as reason influencing factors such as quality of the chicks, feed and season. The by Fanatico et al. (2008) evaluated much lower mortality rate for slow-growing broilers could not be confirmed in our study. The mortality rate between the 2 strains and rearing concepts did not differ noteworthy, but was consequently lower in Cobb Sasso broilers. The results of the present study indicate that Cobb Sasso broilers, reared under enriched environmental conditions of the new alternative rearing concept, had a measurably higher level of animal well-being concerning the aspects FPD, hock burn and gait compared with conventionally reared Ross 308 broilers. Especially the foot health concerning the occurrence of food pad dermatitis, hock burn and mobility was considerably better.

Chicken meat produced under the alternative rearing concept with a slow-growing genetic broiler strain meets the consumer demands for reasonably priced meat linked with improved animal welfare standards and good performance. The design of the alternative rearing concept was scientifically accompanied during the duration of the study and then the participating farm received the qualification for the Animal Welfare Label by the German Animal Welfare Association (Deutscher Tierschutzbund e. V.). Meat, produced under the described alternative concept, has been introduced to the market in 2011 and is at present available at 30 % higher costs compared to conventionally produced meat. According to in-house results obtained by the Donautal Geflügelspezialitäten Zweigniederlassung (branch) of the Lohmann & Co. AG, Bogen, Germany, over the period of 12 months in 2014, 3.46 Mio. Cobb Sasso broilers were slaughtered. This market development reflects the positive results of the alternative concept. Because studies performed under field conditions with several tens of thousands of animals require complex logistics, the results of the present study can only be carefully interpreted because of the missing cross-over design. Results represent nevertheless valuable base data for further investigations required concerning Ross 308 broilers reared with an alternative concept and Cobb Sasso broilers reared under conventional conditions. Investigations concerning Ross 308 broilers reared under similar conditions (no winter garden, different stocking density and amount of provided enrichment) of the alternative concept are being evaluated at present.

Conflict of interest

The authors confirm that no conflicts of interest are associated with this publication and no financial support was given that could have influenced the outcome of the present study.

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