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ORIGINAL RESEARCH

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On-farm study of walking ability in conventional broilers and those labelled as being higher welfare

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Abstract

Background: Multiple factors, including genetics and management practices, are known to influence the walking ability of broilers. This field survey aimed to assess the walking ability of broilers in two different production systems.

Methods: Thirty flocks of conventional (Ross 308) and 26 flocks of welfare-labelled (Level 1; Ranger Gold/Rustic Gold) broilers were evaluated, with maximum stocking densities of 40 and 38/38 kg/m^2 and growth rates of 62-63 g/day and 43-45/47-51 g/day, respectively. Gait scores were obtained for approximately 120 birds/flock prior to slaughter using the six-point Bristol scale, with scores ranging from 0 (no detectable abnormality) to 5 (complete lameness). Data on broiler age, target bodyweight on day of assessment and genotype were collected.

Results: The odds of birds having gait scores greater than 0 ($p = 0.011$), 1 ($p < 0.001$) and 2 ($p = 0.033$) increased significantly with a 100 g increase in bodyweight for conventional broilers, whereas no such effect was found for level 1 broilers. Within the level 1 system, the slower-growing Ranger Gold birds had lower odds of having gait scores greater than 1 than the faster-growing Rustic Gold birds ($p = 0.022$).

Limitations: Data on the bodyweight of individual birds were not collected.

Conclusion: The results obtained in this study are in line with previous research showing that walking ability is negatively associated with growth rate.

KEYWORDS
breeder age, chicken, gait score, genotype, lameness, production system

INTRODUCTION

Commercial broiler production has become increasingly intensified, with a focus on growth potential and feed efficiency. However, in recent years, consumer demand in some parts of the world has resulted in the production of a wider range of broiler genotypes with notable differences in growth rates, ranging from fast growing (>60 g/day) to intermediate growing (around 50 g/day) to slower growing (<45 g/day).[1] Even slow-growing broilers (<35 g/day) are increasing in frequency in the European Union (EU), with the resumption of raising dual-purpose chickens where the males are reared for meat and the females are kept for egg production.[2–4]

This change in consumer demand results from an increased awareness of the negative welfare consequences associated with rapid growth in broilers. Walking ability has repeatedly been demonstrated to be poorer in broilers with faster growth when compared to slower-growing broilers.[5–7] Walking ability is known to be affected by a range of factors, including genetics, management and nutrition.[8] As all these factors are dynamic, fluctuations in the walking ability of the broiler population are likely to occur. For example, existing genotypes are exposed to continuous selection, and new genotypes are regularly emerging. Improvements in walking ability may be applied as a selection goal, such as in the case of selection against tibial dyschondroplasia.[9,10] However, the opposite,

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that is, a deterioration in walking ability, may be an unintentional by-product of selection for other traits, such as faster growth. For instance, it has been shown that faster-growing birds are more likely to develop tibial dyschondroplasia than slower-growing birds of the same genotype, indicating that tibial dyschondroplasia is linked to growth rate.[11] Tibial dyschondroplasia is known to cause walking impairment of different degrees depending on the severity of the disorder.[7,12]

Similarly, management is changing with new practices being introduced. One example is the introduction of heat exchangers that reduce the thermal energy loss during air exchange, allowing for increased ventilation to be maintained during the winter season. This may contribute to improved litter condition and thus less footpad dermatitis,[13] which in turn can improve walking ability.[14] Another example is the move towards hatching broilers on-farm. Although this has not been shown to impact walking ability directly, a reduced risk of footpad dermatitis in on-farm hatched broilers has been found and is suggested to result from early feeding due to instant access to feed after hatch, which benefits the development of the gastrointestinal system, which in turn results in drier excreta.[15–17] Furthermore, many welfare labels have included an increase in space allowance as one of the requirements of management initiatives for improved welfare, for example, the Danish National Welfare label or the Dutch Better Life label. Several studies have shown an improvement in walking ability with reduced stocking density.[8,18–20]

Regarding nutrition, continuous adaptation of the diet to the needs of the birds and to the availability of ingredients means that the diet is also variable. With the current focus on reducing the environmental impact of animal production, changes to diets in terms of alternative protein sources and adaptations to minimise ammonia emissions occur. These changes may affect skeletal development, directly affecting walking ability, or the excreta content and texture, affecting the litter quality, which may influence the risk of footpad dermatitis and thereby indirectly the walking ability.[21]

Thus, the walking ability of broilers is affected by many factors and is hence expected to be dynamic. For this reason, the walking ability of broilers has been regularly monitored in Denmark over the past 25 years.[7,12,22,23] The overall aim of this study was to examine the walking ability of broilers in the most common current production systems in Denmark. At the time of commencement of the study, two types of broiler production systems dominated production in Denmark: the conventional system and a welfare-labelled system named level 1. The Danish National Welfare label includes 3 levels, but only Level 1 was included in this investigation. The main requirements for Level 1 are i) all broilers must be of a slower-growing genotype, with the average daily gain being at least 25% less than the one for Ross 308, and ii) the stocking density averaged over three consecutive flocks must not exceed 38 kg/m^2 of usable area and never at any time exceed 39 kg/m^2 of usable area in any single batch.[24]

For unknown reasons, previous surveys only sampled a sub-section of the conventional broiler population, as only broilers having parents aged between 40 and 60 weeks were included. A secondary aim of the current study was therefore to examine whether the age of the breeders influenced the walking ability of their offspring.

MATERIALS AND METHODS

Animals and housing

In total, 56 flocks from 37 farms across Denmark were included in this field survey, matching the sample size of previous field surveys on the topic performed in Denmark.[7,12,22,23] Farm visits were limited to the period between June and November 2022, as for the remaining part of the year, only highly necessary visits were allowed to poultry barns in Denmark due to the risk of avian influenza.

The two major slaughterhouses in Denmark, Danpo and HKScan, contacted their producers of conventional and level 1 broilers to ask them to participate in the study. Lists of the producers that agreed to have their contact details shared were then provided to us. All producers on the lists were contacted and asked to participate with at least one flock in the survey. The number of flocks from the same farm allowed to participate was set at a maximum of three. In the cases where a farm participated with more than one flock, visits could be to flocks kept in different barns but never on the same date. The order of farm visits to the two production systems was determined by availability and could be considered randomised as production occurred simultaneously in both systems.

Conventional broiler production consisted of mixed sex flocks of Ross 308 with stocking densities at slaughter age of around 40 kg/m^2 and growth rates of 62–63 g/day.[25,26] The visits occurred as close to slaughter as possible, that is, between days 29 and 35 of age (mean: 31.8 ± 1.4). In 2022, conventional broilers housed in barns that were up to 7 years old had a mean slaughter age of 34.2 days, whereas birds housed in barns that were a minimum of 8 years old were slaughtered at a mean age of 35.2 days.[25,26] The typical flock size ranged from approximately 32,000 to 40,000, but both smaller and larger flocks occurred (Anina Kjær, personal communication, 25 May 2023). When the data collection started in June 2022, there were approximately 165 conventional broiler producers in Denmark, but the number had dropped to 130 when the data collection ended in November 2022 (Brian M. Lauridsen and Bent Holten, personal communication, 30 May 2023 and 10 June 2023, respectively). This decrease in the number of conventional producers was due to the phasing out of conventional broilers (completely for Danpo, partly for HKScan) in 2022. Sixteen farms participated in the study with one flock, four farms with two flocks and two farms with three flocks. In total, 30 farms were visited.

The level 1 flocks consisted of mixed sex flocks of either Ranger Gold (n = 7) or Rustic Gold (n = 19), which are both slower-growing genotypes compared to Ross 308. In 2022, Rustic Gold broilers had a mean slaughter age of 41.5 and 45.8 days, depending on the slaughterhouse to which the birds were delivered (Brian M. Lauridsen and Bent Holten, personal communication, 30 May 2023 and 7 June 2023, respectively). Likewise, their respective growth rates were 51 and 47 g/day. For Ranger Gold, the mean slaughter age was 47.0 and 50.1 days, with corresponding growth rates of 45 and 43 g/day, respectively. Stocking density at slaughter age was a maximum of 38 kg/m^2. During the data collection period, some level 1 flocks were hatched on-farm, meaning that incubated eggs were transported to the farms on embryonic day 18, where they were placed in the barn for the hatching to take place. The visits occurred as close to slaughter as possible, that is, between days 44 and 50 of age (mean: 47.7 ± 2.1) for Ranger Gold and between days 38 and 49 of age (mean 44.5 ± 3.0) for Rustic Gold. The typical flock size was approximately 25,000 (Brian M. Lauridsen, personal communication, 30 May 2023). When the data collection started in June 2022, there were approximately 55 level 1 producers in Denmark, and the number had increased to 90 when the data collection ended in November 2022. Seven farms participated with one flock, five farms with two flocks and three farms with three flocks. In total, 26 farms were visited.

Both conventional and level 1 broilers were housed under an 18-hour light:6-hour dark schedule with ad libitum access to food and water. Litter was changed between flocks. According to EU legislation, the light intensity had to be a minimum of 20 lux in at least 80% of the house (Council Directive 2007/43/EC).

Data collection

Data on breeder age, broiler age, target weight on the day of visit and genotype were obtained from the producer for each flock visited. Breeder age refers to the age of the parents when the eggs resulting in the flock visited were laid, whereas target weight on the day of visit refers to the average live bodyweight of the individuals in the flock targeted for a specific age (in this case, the day of visit). Regardless of production system, the gait score of the broilers was assessed using a six-point scale ranging from 0 to 5, as described by Kestin et al.[27] (Table 1). The choice of this assessment method was based on its use in previous field surveys of the walking ability of broilers in Denmark.[7,12,22,23] During visits, the lights were dimmed or turned off completely before entering the broiler house. This encouraged the broilers to settle on the floor, allowing the observer to slowly approach a group of approximately 20 birds and encircle them with a portable metal fence, selecting them for assessment. This reduction in activity was important to ensure that broilers with all ranges of walking ability were evaluated, not only those not capable of moving away from the observers. Once a group of broilers was fenced off, the light in the broiler house was turned back on, and the assessment of walking ability was initiated. One bird at a time was released from the fence and encouraged to walk. The use of a stick was gently employed if the bird showed hesitation or unwillingness to walk. This procedure was repeated in six different parts of the broiler house until approximately 120 broilers were assessed (conventional—range: 100–128; mean: 117.2 ± 6.8; level 1—range: 105–124; mean: 117.9 ± 4.4). The number of birds scored per flock varied, as all birds fenced off were scored to avoid bias.

The gait assessments were performed by three experienced observers, who had each assessed more than 2000 broilers prior to the study. All visits were performed by a single observer at a time. The number of visits to conventional and level 1 flocks, respectively, was balanced between the three observers. Due to the nature of the study, the observers could not be blinded to the production system. Before the start of the data collection, the observers were regularly trained together on how to differentiate between each score using videos and live broilers and discussed different cases. Inter- and intraobserver reliability tests were also performed based on gait scoring of broilers from 36 different videos, done twice with 2–3-week intervals. At the commencement of the study, interobserver reliability for gait score observations was measured on two occasions (Kendall's coefficient of concordance—first round: 0.96; second round: 0.97), although only two of the three observers participated in the first round. The intraobserver reliabilities of these two observers were 0.97 and 0.98 (Kendall's coefficient of concordance), respectively.

TABLE 1 Bristol scale used for scoring of broiler walking ability

Gait score	Criteria
0	No detectable abnormality, fluid motion.
1	Slight defect. Difficult to define.
2	Definite and identifiable defect, but it does not hinder movement.
3	An obvious gait defect that affects the broiler's ability to manoeuvre and accelerate.
4	A severe gait defect. The broiler will only walk a couple of steps if driven before sitting down.
5	Complete lameness. Either cannot walk or cannot support weight on the legs.

Statistical analyses

All statistical analyses were conducted using SAS version 9.4 (SAS Institute). Both inter- and intraobserver reliabilities were calculated using Kendall's coefficient of concordance, as gait score is an ordinal value. A generalised linear mixed-effects model was fitted to assess differences in gait scores between the

TABLE 2 Number of farms, flocks and birds evaluated per production system, as well as information about the genotypes that were included in the survey and their target weight (g) on the day of assessment

Production system	No. of farms	No. of flocks	No. of birds	Genotype: no. of flocks, no. of birds[a]	Target weight on day of assessment (g), mean ± SD
Conventional	22	30	3517	Ross 308	1971 ± 153
Level 1	15	26	3064	Ranger Gold: 7, 812	2121 ± 99
				Rustic Gold: 19, 2252	2062 ± 148
Total	37	56	6581		

[a]Only given for level 1.

conventional and level 1 production systems, with gait scores included as a binary response variable with logit as the link function. Fixed effects comprised the production system (two levels: conventional [n = 30] and level 1 [n = 26]), observer (three levels), breeder age (26–88 weeks), bodyweight (1710–2546 g) and the interactions between production system and bodyweight as well as between production system and breeder age. Farm was included as a random effect. For analyses including breeder age, two conventional flocks and three level 1 flocks were excluded due to these flocks consisting of a mix of birds from two breeder flocks of different ages. Bodyweight was used to indicate the proximity to slaughter, as age could not be used in the statistical model due to a lack of overlap in age span between the broilers from the two production systems. The broilers were not weighed during visits to the farms because limited resources were available. Instead, we obtained the target weight on the day of the assessment from the producers. To address any uncertainty in the provided target weights, two alternative models were also fitted: (1) the relative age of the different genotypes or (2) the expected bodyweight on the day of visit, retrieved from the as-hatched performance objectives,[28–30] were included. The same overall conclusions were reached regardless of the model.

To assess differences between genotypes housed in the level 1 system, a generalised linear mixed model was fitted with gait score as a binary response variable. The fixed effects were genotype (two levels: Ranger Gold [n = 7] and Rustic Gold [n = 19]) and observer (three levels). Breeder age (26–88 weeks) and broiler age (38–50 days) were included as covariates, and farm was included as a random effect. In this instance, the age span for the two genotypes overlapped and broiler age was therefore used in the model to indicate the proximity to slaughter. Breeder age was missing from two flocks of Rustic Gold and one flock of Ranger Gold because these flocks consisted of a mix of birds from two breeder flocks of different ages, for which reason these three flocks were left out of the analysis when breeder age was included.

Three versions of the binary gait score variable were used, making it possible to analyse the odds of observing gait scores:

1. Larger than 0, compared to a gait score equal to 0 (GS > 0; GS0 vs. GS1–5). A gait score greater than 0 corresponds to any abnormality in walking ability.[27]
2. Larger than 1, compared to gait scores equal to or smaller than 1 (GS > 1; GS0–1 vs. GS2–5). A gait score greater than 1 is known to cause changes in the behaviour of the birds.[31]
3. Larger than 2, compared to gait scores equal to or smaller than 2 (GS > 2; GS0–2 vs. GS3–5). A gait score greater than 2 corresponds to obvious lameness.[27]

The results from the statistical analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The statistical values are provided for the production system and genotype, respectively, for the two models, regardless of significance level, whereas the other fixed effects, that is, breeder age, broiler age or weight and observer, are reported only when they are significant.

RESULTS

Descriptive statistics

A total of 56 flocks (6581 birds) from 37 farms with an average sample size of 118 (range: 100–128) birds per flock were included. The number of farms, flocks and birds per production system, as well as information about the genotypes and the target weight of each flock on the day of assessment are presented in Table 2. Descriptive statistics regarding broiler age and breeder age by production system for the flocks included in the survey are shown in Table 3.

An overview of the frequency distribution of birds given the different gait scores by production system, including descriptive statistics, is provided in Table 4. The results show that the vast majority of broilers, regardless of production system, had some kind of walking difficulty, that is, gait scores above 0. The frequency distribution of gait scores within each flock by production system is shown in Figure 1.

Comparison of walking ability in conventional and level 1 broilers

An interaction between production system and bodyweight was found for all binary responses (GS > 0: $F_{1,6542}$ = 6.44, p = 0.011; GS > 1: $F_{1,5942}$ = 11.58, p < 0.001; GS > 2: $F_{1,6542}$ = 4.53, p = 0.033), where the odds of having gait scores larger than 0, larger than 1 and larger than 2 increased significantly with a

TABLE 3 Number of flocks (*N*) and mean, median, minimum and maximum broiler age and breeder age by production system and genotype of the flocks included in the survey

Production system	*N*	Mean	Median	Minimum	Maximum
Broiler age (days)					
Conventional	30	31.77	32	29	35
Level 1—Ranger Gold	7	47.71	48	44	50
Level 1—Rustic Gold	19	44.47	45	38	49
Breeder age (weeks)					
Conventional	28	41.75	41	28	61
Level 1—Ranger Gold	6	59.67	52	36	88
Level 1—Rustic Gold	17	34.12	32	26	61

TABLE 4 Distribution of gait scores by production system and the median, minimum, maximum, mean and standard deviation (SD) of gait scores by production system

Production system	Gait score (%)						Gait score				
	0	1	2	3	4	5	Median	Minimum	Maximum	Mean	SD
Conventional											
All	4.58	53.91	35.51	5.35	0.57	0.09	1	0	5	1.4	0.70
Level 1											
All	5.61	59.17	30.42	4.24	0.39	0.16	1	0	5	1.4	0.68
Ranger Gold	6.90	60.84	25.62	5.91	0.49	0.25	1	0	5	1.3	0.73
Rustic Gold	5.15	58.57	32.15	3.64	0.36	0.13	1	0	5	1.4	0.67

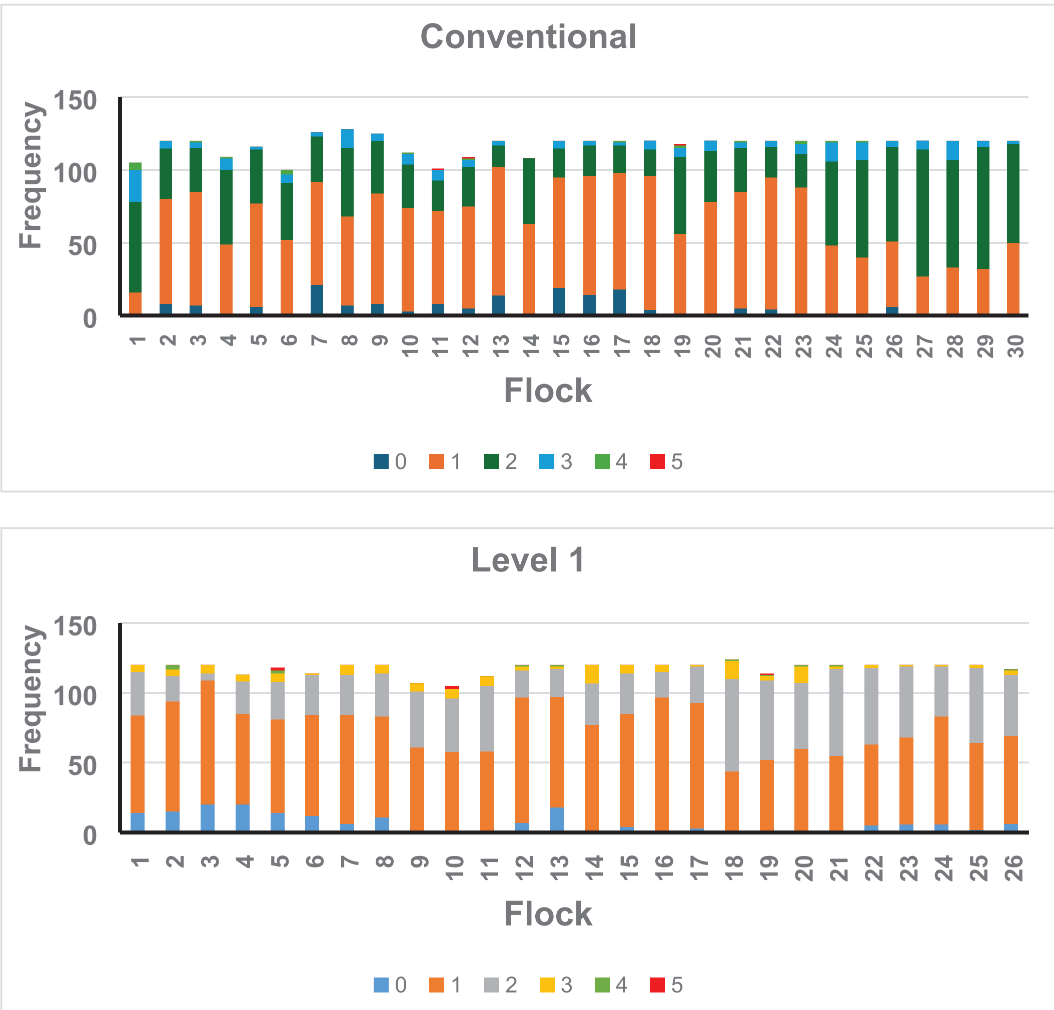

FIGURE 1 Frequency distribution of gait scores in conventional (a) and level 1 (b) broiler production in Denmark. Numbers on the *x*-axis represent the flocks involved in the study

TABLE 5 Odds ratios (ORs), 95% confidence intervals (CIs) and *p*-values for the effects of the variables production system, breeder age, bodyweight and observer on the three binary responses: gait score (GS) greater than 0, GS greater than 1 and GS greater than 2

Binary response	Variable	*p*-Value	OR variable	OR[a]	95% CI
Gait score > 0	Production system × bodyweight[b]	0.011	Conventional	*2.00*	*1.42–2.82*
			Level 1	1.16	0.87–1.54
Gait score > 1	Production system × bodyweight[b]	<0.001	Conventional	*1.37*	*1.26–1.49*
			Level 1	1.00	0.82–1.21
	Production system × breeder age[c]	0.016	Conventional	1.01	0.997–1.022
			Level 1	0.99	0.981–1.000
	Observer	<0.001			
Gait score > 2	Production system × bodyweight[b]	0.033	Conventional	*1.22*	*1.07–1.38*
			Level 1	0.94	0.77–1.15

[a]ORs in italics indicate that an increase in bodyweight by 100 g or in breeder age by 1 week had a significant effect.
[b]For 100 g increase.
[c]For 1 week increase.

100 g increase in bodyweight for conventional broilers (GS > 0—OR: 2.00, 95% CI: 1.42–2.82; GS > 1—OR: 1.37, 95% CI: 1.26–1.49; GS > 2—OR: 1.22, 95% CI: 1.07–1.38). However, no such effect was found for level 1 broilers (GS > 0—OR: 1.16, 95% CI: 0.87–1.54; GS > 1—OR: 1.00, 95% CI: 0.82–1.21; GS > 2—OR: 0.94, 95% CI: 0.77–1.15; Table 5). Thus, the odds of having a gait score of 1, 2, 3, 4 or 5 (GS > 0), of 2, 3, 4 or 5 (GS > 1) or of 3, 4 or 5 (GS > 2) as compared to lower gait scores were 2.00, 1.37 and 1.22 times higher, respectively, when bodyweight increased by 100 g for conventional broilers, whereas a similar increase in bodyweight did not influence the odds of having a gait score greater than 0, greater than 1 or greater than 2 in level 1 broilers.

An interaction between production system and breeder age was found for the analysis of having a gait score larger than 1 ($F_{1,5942} = 5.82$, $p = 0.016$). The confidence intervals showed that level 1 broilers had lower odds of having a gait score greater than 1 with increasing breeder age (OR: 0.990, 95% CI: 0.981–1.000), whereas breeder age did not affect the odds of having a gait score greater than 1 in conventional broilers (OR: 1.01, 95% CI: 0.997–1.022; Table 5). Breeder age had no influence on the odds of birds having gait scores larger than 0 or larger than 2.

Observer had an effect on the odds of the gait scores being larger than 1 ($F_{2,5942} = 20.99$, $p < 0.001$; Table 5) but had no effect on the analyses of gait scores greater than 0 and gait scores greater than 2.

Comparison of genotypes in the level 1 production system

Genotype within the level 1 production system was significant only when analysing the odds of gait scores larger than 1 (OR: 0.44, 95% CI: 0.22–0.89, $F_{1,3048} = 5.29$, $p = 0.022$), with the odds being lower for Ranger Gold compared to Rustic Gold (Table 6). Furthermore, the odds increased with increasing broiler age for gait scores greater than 1 (OR: 1.16, 95% CI: 1.07–1.27, $F_{1,3048} = 11.84$, $p = 0.0006$; Table 6). A higher breeder age only affected the odds of a gait score larger than 0,

TABLE 6 Odds ratios (ORs), 95% confidence intervals (CIs) and *p*-values for the effects of the variables genotype, breeder age and broiler age on the three binary responses: gait score (GS) greater than 0, GS greater than 1 and GS greater than 2 in the level 1 production system

Binary response	Variable	OR	95% CI	*p*-Value
Gait score > 0	Genotype[a]	1.63	0.28–9.62	0.592
	Breeder age[b]	0.97	0.95–0.99	0.004
Gait score > 1	Genotype[a]	0.44	0.22–0.89	0.022
	Broiler age[c]	1.16	1.07–1.27	0.0006
Gait score > 2	Genotype[a]	1.57	0.85–2.92	0.152

[a]Ranger Gold versus Rustic Gold.
[b]For 1 week increase.
[c]For 1 day increase.

with higher breeder age lowering the odds (OR: 0.97, 95% CI: 0.95–0.99, $F_{1,2690} = 8.23$, $p = 0.004$; Table 6). Observer had no effect on any of the binary responses.

DISCUSSION

The current survey of the walking ability of broilers kept within the two major production systems used in Denmark shows that the vast majority of broilers, regardless of production system, expressed some kind of walking abnormality, that is, a gait score greater than 0. However, for both production systems, the most common defect was the slightest, that is, a gait score of 1, which is described as 'a slight defect, which is difficult to define'.[27] With increasing bodyweight, the odds of having a walking impairment increased for conventional broilers but not for level 1 broilers.

The walking ability of conventional broilers has been monitored regularly in Denmark over the past 25 years, but the present study is the first one to include level 1 broilers. In addition, surveys of walking ability in large numbers of commercial broiler flocks have been reported from Norway,[32] the UK,[8,18,33,34] the Netherlands,[33,34] France,[34] Italy,[33,34] Belgium[35] and Brazil.[35,36] Comparisons of gait score prevalence between studies are difficult due to differences in the scoring method used, the reliability of the observers and how results are reported. Differences in the outcomes of the surveys may be explained by several causal factors, such as variations in the genotypes assessed, age/bodyweight at slaughter, management and diet, which may to a large extent be country specific. Therefore, the following discussion will mainly be based on a comparison between the current survey and the last survey performed in Denmark in 2016/2017.[7]

Compared to the last survey in 2016/2017,[7] there has been a major shift in the frequency distribution of gait scores in conventional broilers. A five-fold decrease in the frequency of gait scores of 0 and a 1.1–1.3-fold increase in gait scores of 1 to 3 were observed. The potential causes of this change are unclear. An increase in bodyweight on the day of assessment would be a potential explanation, as bodyweight has been shown to be positively associated with higher gait scores both in previous studies[37,38] and in the current study, but the average target weight on the day of assessment of each flock in the present survey was reported by the producers and in the guide on performance objectives to be 105 and 99 g lower, respectively, than the actual bodyweight recorded on the day of assessment in the 2016/2017 survey. Thus, bodyweight is unlikely to explain the increase in walking impairment, as the decrease in bodyweight should rather have a positive impact on walking ability. As documented in the present study and in previous studies,[8,39,40] the age, and hence the bodyweight, of the conventional broilers on the day of assessment influences their gait scores, that is, the older and heavier the broilers, the worse their gait score. Specifically, Knowles et al.[8] reported that across the range of 28–56 days of age, every extra day led to an average daily deterioration in gait score of 0.048 on the Bristol scale. However, the mean age of the broilers on the day of assessment only differed by 0.13 days between the present survey and the previous survey[7] and is therefore not a likely explanation for the observed deterioration in walking ability. We speculate that the continuous genetic selection of the Ross 308 genotype may have unintentionally resulted in a negative impact on walking ability. Again, changes in management and diet may also be potential explanations.

One factor we believe can be ruled out as an explanation for the shift in walking ability between the current and the previous survey is a lack of observer reliability. Two of the three observers participated in both surveys, and a high interobserver reliability was found between all three observers, including the newcomer. Observer had no effect on the outcome of the statistical analyses of the odds of having a gait score of 1–5 compared to a gait score of 0 or having a gait score of 3–5 compared to a gait score of 0–2, but an effect of observer was present for the analysis of the odds of having a gait score of 0–1 compared to a gait score of 2–5. This indicates that distinguishing between a gait score 1 and a gait score of 2 can be problematic, which supports the experience from practice, that is, the most difficult gait scores to distinguish between are reported by the observers to be gait scores 1 and 2. No previous studies have been identified reporting this, but attempts at making the method more objective, either by refining the definitions of each score[41] or simply by reducing the number of scores,[18] have been reported.

Previous surveys only included flocks of Ross 308 where the parents were between 40 and 60 weeks old when the eggs were laid.[7,12,22,23] No rationale for limiting the survey to only a part of the population was provided in any of the studies. In the current survey, Ross 308 flocks were included irrespective of the age of the parents. The main reason for this was to provide a complete overview of the walking ability within the population. However, practically, it was also a necessity to bring in flocks with parents younger than 40 weeks or older than 60 weeks, as fewer flocks were available due to many producers terminating conventional broiler production. Furthermore, the culling of many broiler breeder flocks in the EU due to avian influenza resulted in a rather young population of breeder flocks. Breeder age was not found to influence walking ability systematically, as we found a weak interaction between breeder age and production system for the odds of having a gait score greater than 1, but not in the other binary variables. Previous research on the impact of breeder age on offspring has primarily focused on performance. Studies indicate that older breeders may produce heavier offspring, whereas young breeders result in higher chick quality but also increased first-week mortality.[42,43] No impact of breeder age has been found on foot health.[44] The effects of breeder age on walking ability appear to have been examined only in the present study.

CONCLUSIONS

The vast majority of the broilers in this study, regardless of production system, expressed some kind of walking abnormality, that is, a gait score greater than 0. However, for all production systems, the most common defect was the slightest, that is, a gait score of 1. Increasing bodyweight resulted in higher odds of walking impairment in conventional broilers but not in level 1 broilers. Within the level 1 production system, the slower-growing genotype, Ranger Gold, had better walking ability than the faster-growing genotype, Rustic Gold. The present results are in line with previous research showing that walking ability is negatively associated with growth rate. The walking abilities of conventional broilers have deteriorated compared to the results of the survey conducted in 2016/2017, but the causes are not clear.

AUTHOR CONTRIBUTIONS

Study conception and design, and data acquisition: Anja B. Riber and Kaitlin E. Wurtz. *Data analysis*: Karen Thodberg. *Manuscript writing*: Anja B. Riber, Kaitlin E. Wurtz and Karen Thodberg.

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CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Research data will be made available upon reasonable request.

ETHICS STATEMENT

The study was conducted according to the guidelines of the Danish Animal Experiments Inspectorate with respect to animal experimentation and care of animals under study. As the study did not include any activities considered to be comparable to or exceeding the needle criteria, it was exempted from ethical approval.

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