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Effects of Keel Bone Deviation on Post-Peak Egg Production in a Commercial Laying Hen Flock With Different Breast Condition

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Abstract

This study was made to investigate the effects of breast condition and keel bone deviations on post-peak egg production of a commercial laying hen housed in a multi-tier conventional battery cage. The birds divided into two groups according to presence of keel bone deviation at first. Then the birds further divided into two groups according to breast condition as well developed or relatively well developed. The laying hens were kept under identical management conditions for commercial laying hens during the study. Data about daily egg production, feed intake, mortality and egg weight was collected from 62 to 77 weeks of age in the groups. There were no significant effects of keel bone deviation on body weight and egg weight of the layer hens. The initial and final body weight of the birds are significantly different between the breast condition groups (P<0.001). The birds with well developed breast condition had significantly better hen-housed and hen-day egg production (P<0.001). The significant keel bone deviation x breast condition interaction for egg production revealed that presence of keel bone deviation was effective in birds only had relativelly well developed breast condition (P<0.001). Daily feed intake per hen and survival rate between the groups were not affected by presence of keel bone deviation and breast condition of the birds. Results from this study indicated there was a link among breast condition, presence of keel bone deviation and egg performance of laying hens.

Key words: Laying hen, keel bone deviation, breast condition, performance.

Introduction

The presence of keel bone damages and plumage damages in commercial egg production represents one of the greatest challenges due to the negative impact on the health and welfare of laying hens [1, 2, 3]. British Farm Animal Welfare Council is determined that the keel bone damages are one of the most important welfare issues in commercial layer flocks[4, 5]. An EU Cost action which involved a large number of scientists and institutions from Europe and that the overall goal understood the causes of keel bone damage and to reduce its occurrence, has been completed recently (Keel Bone Damage-Cost project, 2016-2021). The keel bone deviations result from a prolonged pressure on the keel especially during perching [6, 7, 8] and prolonged pressure might cause hematomas, wounds and fractures of the surrounding tissue of the keel bone [9]. It was reported that the prevalance of fractures in layer flocks was exceeding 80% in different countries[10] and it was highly prevalent at the beginning of lay up to 8% of a flock [6, 11, 12, 13,14]. In organic and conventional layer flocks in Austria and Germany, it was found no difference between the flocks, with 28% and 27% of the birds showing keel bone deviations or fractures [15]. In another study, Bestman and Wagenaar[16] reported keel bone deformations in 4–48% of the hens, with an average of 21%, including 49 flocks of organic layers in Denmark. Jung et al[17] showed that type of housing systems, natural daylight inside the house, proportions of underweight hens and laying performance were significantly affected the development of keel bone damage in organic layer flocks in

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several European countries.

The bird age, housing condition, nutrition, the age at first egg, ossification time of the keel bone, bone diseases, inactivity of the birds and genetic stock health could be predisposing factors for presence of keel bone hazards[3,18,19, 20, 21]. In modern production, commercial layers have been selected for greater egg numbers and optimized egg quality over the years[23, 24]. In general, high level egg production is assumed one of the major contributing factors for keel bone deviation and fractures in laying hens[25, 26]. Although higher egg numbers per hen and extended calcium resorption from cortical bone are believed to be the major factor of development of bone fragility and increased keel bone damage susceptibility, it is not clear how a layer's productivity is affected after a keel bone damage has occurred. Despite the egg production being affected by the breast condition of the birds[27], until now, no specific studies have yet been identified the effects of keel bone deviation and breast condition x keel bone deviation interaction on laying hen performance. The objective of this study was to investigate the effects of breast condition and presence of keel bone deviation on laying hen performance under commercial condition.

Material and Methods

The data was collected from a commercial layer flock housed in three-tier conventional battery cages with 3500 laying hens (Lohmann LSL) at Research and Production Farm of Bursa Uludag University. The experimental procedures were employed in accordance with the principles and guidelines set out by the Committee of Bursa Uludag University on animal care and management. This study doesn't require ethical permission according to Animal Experiments Ethics Committees Regulation on Working Procedures and Principles, Article 8 19-k [28].

Management

At the beginning of the experiment, the birds were divided into two groups according to presence of keel bone deviation with keel bone palpation. Keel bone status of the birds was recorded on a scale from 0 to 1 (1: moderate to severe deformity; 0: slight or no deformity). Then, the birds in each deviation groups further divided into according to breast condition as score 0 or score 1 by photographic specifications based on palpating the protuberance of the keel bone, and the development of the layer breast muscles (29). According to this, the breast condition score 0 is indicated a well-developed round breast muscle with limited protuberance at the keel bone, while score 1 showed relatively well-developed breast muscle with a distinct protuberance at the keel bone.

The layer barn was furnished with a commercial battery cages with 3 tiers. Animal density was 4 hens/per cages (625 cm2 per hen). During the 105 days of the experiment (from 62 weeks of ages) all laying hens in the groups were kept under identical management conditions for commercial egg production [30]. A 16 h lighting including daylight and artificial light were provided during the experiment. Hens in all groups were fed ad libitum with a second phase of soybean and maize based commercial layer feed.

Data collection

Data collection started after the formation of the groups and a 15-day adaptation period. Daily egg production, weekly feed consumption and number of dead birds when it occurred were recorded from 62 and 77 weeks of age. Egg production traits were calculated on the basis of hen-housed and hen-day, whereas survival rate and feed intake were calculated on hen-housed basis [30]. Initial and final live body weights with initial and final egg weights of the hens was recorded at 62 and 77 weeks of age.

Statistical tests

The statistical tests for the traits measured were performed using SPSS® Computer Software 13.00[31]. ANOVA test was used to analyze the effects of, and interactions between breast condition and presence of keel bone deviation on egg production, feed intake and egg weight [32]. The model used in the analyses was the following:

$Y_{ij} = \mu + A_i + B_j + AxB + e_{ij}$

A; breast condition, B; presence of kell bone deviation; A×B; an interaction; also i:1,2 (1: well developed breast condition, 2: relatively well developed breast condition), j:1,2 (1:presence of keel bone deviation, 2:without kell bone deviation), μ; constant; e; error term.

Results

The effects of presence of keel bone deviations and breast condition on initial and final live body weight and egg weight were showed in table 1. There were no significant effects of keel bone deviation on initial and final live body weight and egg weight of the birds in the groups. Breast condition of the birds was significantly affected initial and final body weight of the laying hens between the groups ($P<0.001$, $P<0.001$). Keel bone deviation x breast condition interaction for initial body weight and final egg weight were found significantly important ($P<0.048$, $P<0.015$).

Table 1 : Effect of presence of keel bone deviation (KBD) and breast condition (BC) on body weight and egg weight in laying hens.

Groups	Body Weight		Egg Weight	
	Initial	Final	Initial	Final
Keel Bone (KB)				
With deviation (D)	1608±19	1577±25	62.01±0.66	62.22±0.85
Without deviation (WD)	1581±17	1566±18	60.34±0.70	62.86±0.59
Breast Condition (BC)				
Well developed (WD)	1693±15	1635±21	63.01±0.53	62.69±0.59
Relatively well developed (RWD)	1495±21	1508±22	59.34±0.80	62.40±0.85
BC x KB				
WD x D	1681±21	1610±24	63.44±0.76	61.09±0.80[b]
WD x WD	1705±22	1659±25	62.59±0.75	64.49±0.86[a]
RWD x D	1534±32[a]	1543±37	60.58±1.07	63.35±1.23[a]
RWD x WD	1456±27[b]	1473±34	58.07±1.19	61.45±1.17[b]
ANOVA				
KB	0.279	0.728	0.084	0.529
BC	0.001	0.001	0.001	0.782
KB x BC	0.048	0.053	0.395	0.015

a-b; represent a significant BC x KB interaction (RWDXD and RWD X WD) for initial body weight and final egg weight within columns.

Table 2: Data on egg production, feed intake and survival rate in the groups

Groups	Egg Production				Survival rate	Daily feed intake/hen/d
	Hen-Day		Hen-Housed			Hen-Housed
	%	Number	%	Number	%	g
Keel Bone (KB)						
With deviation (D)	79.05±0.6	83.00±0.6	73.34±0.59	77.07±0.64	87.50	105.78±1.54
Without deviation (WD)	76.56±0.7	80.35±0.7	65.80±0.61	69.09±0.63	88.75	108.83±1.45
Breast Condition (BC)						
Well developed (WD)	81.03±0.7	85.08±0.7	74.51±0.62	78.24±0.63	85.45	106.25±1.56
Relatively well developed (RWD)	74.51±0.6	78.31±0.6	64.68±0.61	67.92±0.64	94.00	108.35±1.49
BC x KB						
WD x D	79.84±0.89	83.84±0.89	73.92±0.86	77.62±0.90	87.27	105.30±2.54
WD x WD	82.21±0.81	86.32±0.81	75.10±0.85	78.86±0.91	83.63	107.21±2.00
RWD x D	78.25±0.93[a]	82.16±0.93[a]	72.88±0.86[a]	76.52±0.91[a]	88.00	106.25±2.42
RWD x WD	70.91±0.92[b]	74.45±0.92[b]	56.49±0.84[b]	59.31±0.92[b]	100.00	110.46±2.04
ANOVA						
KB	0.005	0.005	0.001	0.001	n.s	n.s
BC	0.001	0.001	0.001	0.001	n.s	n.s
KB X BC	0.001	0.001	0.001	0.001	n.s	n.s

a-b; represent a significant BC x KB interaction (RWDXD and RWD X WD) for egg production within columns.

The egg production percentage, number of eggs during the study, feed intake per birds and survival rate in the groups were presented in table 2. It was found that the effects of keel bone deviation and breast condition on hen-housed and hen-day egg production traits were significantly important between the groups (P<0.001, P<0.005). The hen-day egg ratio in well developed and relatively well developed breast condition gropus were found 81.03 and 74.51% whereas the hen-housed egg production were 74.51 and 64.68%, respectively. Hen-housed daily feed intake per hen and survival rate in both keel bone and breast condition groups were found similar.

Discussion

In this study the relationship between breast condition and presence of keel bone deformations on egg production traits in a white layer hens at post-peak production period were investigated. As expected, the birds with well developed breast condition had significantly greater initial and final live weight than birds had a relatively well developed breast condition[33]. Compare to the birds with relatively well developed breast condition, the birds with well developed breast condition had significantly greater hen-housed and hen-day egg production. The birds with relativelly well developed breast condition without keel bone deviation had significantly lower egg production compare to the other groups (Table 1). Breast condition is an important indicator of body condition in poultry. The breast muscle development may also be a good indicator of protein mobilisation for egg production and subsequent muscle atrophy[34]. In practice, the body condition scores in animal are used for evaluating the adequacy of nutrition, assessing the health status of individual animals. Jung et al.[17] have showed that heavier birds are less likely to develop fractures than lighter birds in organic layer flocks. Dunn et al.[35] reported that some traits such as genetic, some environmental and management factors can positively impact the overall quality of the skeleton of layer hens.

In this study, the egg production of the birds with keel bone deviation was significantly higher than the birds without keel bone deviation. This was probably due to the influence of other factors affecting egg production. To support this, Dunn et al. [35] showed that no evidence for a relationship between post-peak egg production and bone quality, and the longer laying periods will not adversely affect the bone quality of the birds. Similarly, Eusemann et al.[25] showed that there was no relationship between egg production and keel bone deviations in a layer line. In another study, it was reported that the layer stock with the highest egg production had better bone quality [12]. Fleming et al. [36] showed that selection for better bone quality was possible without reducing egg production. As in the current study, Podisi et al. [37] reported that there was limited evidence for a phenotypic association between egg productivity and bone stability among the layer genotypes. Baldinger and Bussemas[38] reported that 34–45% of the dual-purpose layer showed keel bone damage at the end of the laying period and dual-purpose crosses housed in floor system had less keel damage and low laying performance. In general, the end of layer hens have eggs with poor eggshell and bone quality[39, 40]. It is clear that high level of egg calcium requirements for eggshell makes hens more susceptible to skeletal problems such as osteoporosis[18]. Keel bone hazards can occur in all types of poultry housing systems and in all types of commercial layer hens[21]. In comparison with conventional cage systems, osteoporosis is not as prevalent in hens that are non-cage housing system, due to greater exercise opportunities in these systems[41]. A significant keel bone deviation x breast condition interaction for egg production revealed that presence of deviation was effective in birds only had relativelly well developed breast condition ($P<0.001$).

High egg production and high calcium requirements for egg shell formation make layers more susceptible to the skeletal problems[2]. Birds with keel bone hazards experience pain[42, 43], reduced egg production, reduced egg size and egg quality, increased feed and water consumption [44, 45, 46]. In other side, Gebhardt-Henrich and Fröhlich[47] observed no correlation between keel damage and egg production in laying hens. Non-laying layer hens show increased keel density and a lower risk of fractures than do hens producing eggs, but there is no similar relationship reported for keel deviations[25]. In another study, Eusemann et al.[48] reported that there was a significantly lower prevalence of deviations and fractures in the low performing brown layers when compared to the high performing brown layers. Whereas, Alfonso-Carrillo et al.[40] reported that egg production, bone and eggshell quality traits are independent each other and can be improved separately. They also showed that laying hens with low egg production and poor eggshell quality had better bone quality.

In this study, daily feed intake of the birds and survival rate in all groups were not affected by breast condition or presence of keel bone deviation. But, it might be possible that presence of deviation in keel bone affected feed intake where affected hens consumed more feed in response to increased metabolic demands.

Conclusion

On the basis of the results of this study, the effects of breast condition on egg production traits are very clear but no significant associations were found between flock level prevalence of keel bone deviation. Further research especially in more dense populations including different housing systems, genetic material, environmental condition etc. would be very helpful to understand the role of keel bone damages on egg production traits.

Competing interests

The authors declare that they have no conflict of interest for this manuscript.

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