HARRAN ÜNİVERSİTESİ VETERİNER FAKÜLTESİ DERGİSİ

Prevalence Of Health-Based Welfare Indicators, Feather And Keel Bone Damages In Commercial Broiler Breeder Hens

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Received: 23.06.2025

Accepted: 16.09.2025

How to cite this article: PETEK M, ÇAVUŞOĞLU E. (2025). Prevalence of health-based welfare indicators, feather and keel bone damages in commercial broiler breeder hens. Harran Üniversitesi Veteriner Fakültesi Dergisi, 14(2): 114-121. DOI:10.31196/huvfd.1674007.

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Available on-line at: https://dergipark.org.tr/tr/pub/huvfd

Abstract: This study was made to investigate the on-farm welfare of commercial broiler breeder hens using data collected during ante-mortem inspections of flocks at a commercial slaughterhouse in Bursa, Türkiye, during spring season between February to April. In total, 160 hens randomly selected from four flocks (Ross308; 40 hens from each flock) were subjected to a comprehensive visual examination by an observer to assess welfare conditions. Feather coverage on various body parts and tails of the hen was assessed to determine the level of feather loss. Keel bone condition was evaluated through palpation and visual inspection to identify any deviations or keel fractures. It was found that the flocks' average dead-on-arrival (DOA) mortality rate ranged from 0.072 to 0.125%. Body weight uniformity values in the flocks indicated less variability among the hens (from 8.98 to 14.07%). The distribution of hens having various levels of feather damage was found to be significantly different among the body regions of hens in all flocks. Severe feather damage was commonly observed on all flocks' back, tail, breast-abdomen, and belly-cloaca as a percentage of 78, 83, 97, and 90%, respectively. The average prevalence of keel bone deviation and fracture across the flock was found to be 13 and 33%, respectively. In conclusion, the study revealed a very high prevalence of severe feather damage and keel-tip deformities in the observed broiler breeder flocks. Further study involving more flocks and higher densities hens would be very beneficial.

Keywords: *Broiler breeder, Feather loss, Keel bone damage, Pododermatitis.*

Introduction

Feather and keel bone damage are a health and main welfare problem of hens in table egg production. These damages can occur in all non-cage housing systems and almost all kinds of poultry (Göransson et al., 2023; Nicol, 2018; Rufener and Makagon, 2020). Unsuitable claw length and higher mortality are the other potential threats to welfare in commercial-layer chickens (Wall et al., 2022). Keel bone fractures are recognized as one of the most critical health and welfare issues for commercial laying hens (FAWC, 2013). Keel bone fracture incidence may lead to extensive pain in any hen and potentially cause the death of a hen, especially in non-cage housing.

Lots of papers have been published about the prevalence of feather and keel bone damage in layer chickens in all types of commercial egg production systems (Kittelsen et al., 2020; Petek and Çavuşoğlu, 2020; Riber et al., 2018) and in different strains (Eusemann et al., 2020; Rufener and Makagon, 2020). The prevalence of keel bone and feather damage varies among the studies. Kittelsen et al. (2023) diagnosed the keel bone fractures at the end of the layer and showed that the prevalence of fractures ranged from 14-58%. In some countries, the prevalence of keel bone fractures in layer flocks exceeded 80% (Thøfner et al., 2021). Hardin et al. (2019) reported that keel bone damage may be observed in poultry housed in cage-free systems from 30.00 to 95.00%, while it was 15.00 to 55.00% in furnished cages. Although there are many findings on the plumage and keel bone quality of commercial laying flocks, little is known about the prevalence of feather and keel bone damage in commercial broiler breeder hens. Keel damages not only negatively affect the life of breeder hens but also reduces their productivity by impairing egg production, mating efficiency and feed intake. Therefore, there was a need to assess its prevalence in breeder flocks. This study was carried out to investigate the on-farm welfare of broiler breeder hens by using data collected during post-mortem inspections at the slaughterhouse.

Materials and Methods

Ethical Statement

Data from this study were collected by visual observations and scoring in breeder hens, without any harmful treatment, and thus, ethical approval by an ethics committee was not required according to Turkish legislation article 8-19 k (Official Gazette, 2014).

Birds and pre-slaughter handling

The data were collected from the hens of four commercial broiler breeder flocks (Ross308), selected with the typical case sampling (Baltacı, 2018), in a commercial poultry slaughterhouse in Bursa, Türkiye. The hens of all flocks were raised under identical conditions for breeder hens across the laying period in a litter and slat system; two-thirds slat floor and one-third litter, in closed barn (De Jong and Guémené, 2011; Leeson and Summer, 2009). According to the breeder company guide, the female ratio for each flock was 8-10/100 (Cobb-Vantress, 2008). The catching and transportation of hens and lairage procedures including bird density and water withdrawal time were conducted in compliance with the relevant Turkish regulation (Official Gazette, 2011). The lighting regime in the poultry houses consisted of 14 hours of light and 10 hours of darkness. Feed and water were provided in accordance with the breeder's company regulations. The company's staff manually caught the spent birds for depopulation in all flocks. Once at the slaughterhouse, the vehicle was unloaded, and the crates with the breeder hens were placed in a holding area equipped with fans and cooling systems for 4 hours. The study included transportation up to a maximum 200 km distance from the slaughterhouse. Solid roof curtains are on both sides of all trucks to prevent cold weather. A corridor ran the length of the vehicle between the two blocks of crates, which also contributed to ventilation. Each block generally consisted of 12 fixed crates in rows and 12 fixed crates in columns. The average bird density in each crate was between 14 and 16 hens, depending on air temperature and the live body weight of the hens (550–600 cm2 per bird). The slaughter age of the flocks was varied from 64 to 66 weeks of age.

Data collection

The data collection took place from February 2020 to April 2020, with birds randomly selected within a total of 43328 breeder laying hens (10838 hens, in average), all beak trimmed. A total of 40 hens were randomly chosen from each flock (one birds from each crate) for welfare assessments, representing approximately one percent of the birds in each vehicle, during the pre-slaughter lairage. Initially, the individual body weights of live birds in all flocks were measured, and then the birds were assessed by an observer for feather damage, as described in the study by Grafl et al. (2017). The plumage condition of the head and neck, back, breast and abdomen, belly-cloaca, tail, and wing of birds was scored from no or very little damage (score 0) to severe (score 2) damage (RSPCA, 2017). Score 0 indicated perfect feather cover, score 1 indicated a featherless area less than 5 cm in diameter, and score 2 indicated a featherless area on the skin bigger than 5 cm in diameter. Then, keel bone scoring was made by palpation and visual inspection by the same assessor who was experienced and had participated in a one-day Training School of the COST Action CA15224 "Identifying causes and solutions of keel bone damage in laying hens," in addition to several numbers of live bird and dead bird keel palpations in their different purposes research. Keel bone deviation in birds was evaluated according to (score 0: no lateral, dorsal or ventral deviation from straight axis ≥ 0.2 cm; score 1: damaged, visible callus; dislocation or deviation from straight axis > 0.2 cm), which were modified from the study by Jung et al. (2019). Keel bone fractures and tip of keel were scored as 0 (no fracture or tip) and 1 (existing fracture or tip or both), as well. The tip of the keel bone was also scored palpable callus/pieces of fracture. The presence of foot pad dermatitis, including bumble foot, was assessed based on

the Welfare Quality protocol for welfare of laying hens as 0; no or minimal proliferation of epithelium, no swollen-dorsally visible bumble foot; score 1; Necrosis or proliferation of epithelium or chronic dorsally visible bumble foot with no swelling, score 2; necrosis and swollen dorsally visible bumble foot. The other health-based indicators measured in the study were scored based only on their absence score of 0 (missing toe, toe wound, lesion in the comb) and a score of 1 (existence of swollen-dorsally visible bumble foot, missing toe, toe wound, lesion in the comb). The uniformity level for the average body weight of each flock was calculated with a formula as CV% = Standard Deviation/Average of Body Weight x 100 (Toudic, 2006).

Statistical analysis

Statistical tests were conducted using SPSS Statistics 22. The CV of BW for each flock was used to measure body weight uniformity. Prevalence of feather damage, health-based indicators, and keel bone damage were calculated as the percentage of birds monitored.

Results

The descriptive statistics from the flocks are given in Table 1. The overall stocking size of the flocks were 8642, 9684, 12000, and 13000 breeder hens, respectively. The average body weight of the breeder hens of the flocks varied from 3845 to 4293 g. The flock uniformity of four flocks was 11.04, 14.07, 8.98, and 9.22, respectively. The summary statistics of plumage quality in different body regions of the breeder birds are presented in Table 2. The highest plumage score was observed in the breast abdomen (1.97) and belly-cloaca (1.90), while it was lowest (best) in the head-neck (1.67) of the body. The average total feather score for all birds involved in this study was 9.23, representing the sum of each plumage score across the five body regions.

Table 1. The descriptive data of the flocks examined at the slaughterhouse.

Flock Number	Flock Size	DOA*	DOA	Body Weight	Body Weight CV
	n	n	%	g	%
1	8642	7	0,081	4215±75	11,04
2	9684	7	0,072	4135±65	14,07
3	12000	15	0,125	3845±35	8,98
4	13000	16	0,123	4293±34	9,22
Average	10832	11,25	0,104	4122±23	10,82

Table 2. Mean and confidence interval of feather damage variables and foot pad dermatitis (FPD) of the flocks.

	Head-Neck	Back	Tail	Breast-Abdomen	Belly-Cloaca	Wing	FPD*
Mean	0,50	1,67	1,82	1,97	1,90	1,37	0,99
SEM	0,063	0,056	0,035	0,018	0,025	0,055	0,066
Median	0,00	2,00	2,00	2,00	2,00	1,00	1,00
Minimum	0	0	0	0	1	0	0
Maximum	2	2	2	2	2	2	2

Table 3. Statistics for keel bone deviation (KBD), keel bone fracture (KBF) and tip-keel in broiler breeder hens.

	KBD*	KBF**	Tip-Keel
Mean	0,13	0,33	0,58
SEM	0,028	0,039	0,041
Median	0,00	0,00	1,00
Minimum	0	0	0
Maximum	1	1	1

The statistics about keel bone deviation, keel bone fracture, and tip-keel in breeder hens are shown in Table 3.

The distribution of plumage damage differed between body regions of all flocks, as presented in Figure 1. A higher level of severe feather loss (score 2) was predominantly observed on the back, tail, breast, and belly cloaca in the flocks. All scores of 0, 1, and 2 for foot pat dermatitis were observed at about the same level.

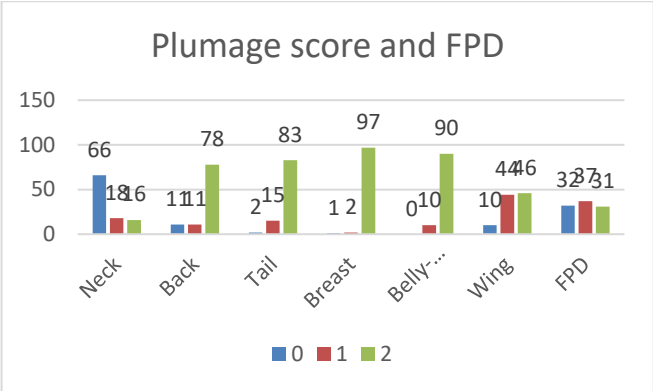

Figure 1. Prevalence of foot pad dermatitis and plumage quality in the different body regions of hens.

In our study, 24% of the birds we observed had a lesion on their comb, and 24% of them missed their toe at the end of the laying period. At the same time, 9% of the birds examined also had a wound on their toe.

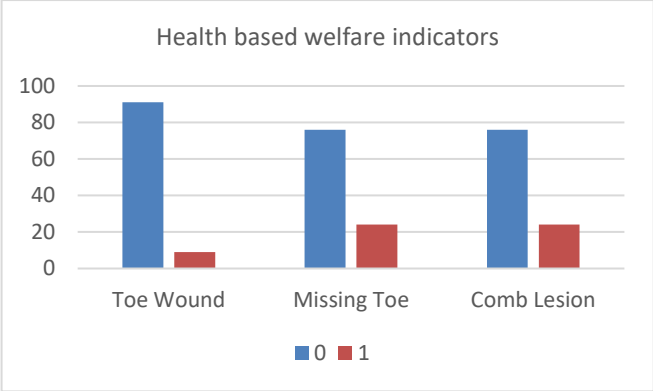

Figure 2. Distribution of birds according to occurrence of health-based indicators

Keel bone deviations were present in 13.0% of the total birds, of which 33.0% also had fractures, while the localisation of the fractures at the distal end of the keel bone was 58.0% of the birds (Figure 3).

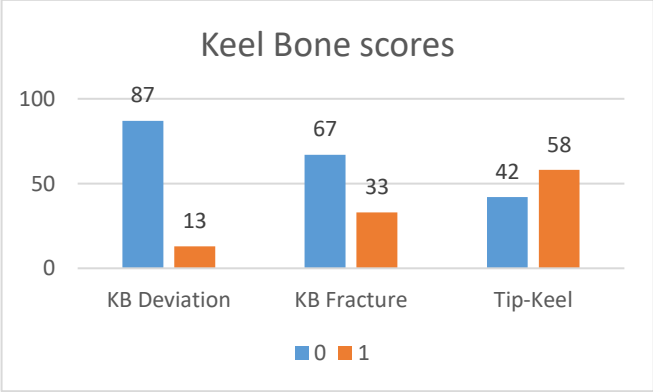

Figure 3. Prevalence of keel bone deviation, keel bone fracture and keel-tip in the flocks.

Discussion

Broiler breeder hens are genetically predisposed to grow very fast, which increases their risk of experiencing poor welfare conditions. Distress and certain conditions in farms for breeder hens, such as hunger, feeding competition, inadequate feed, nest, drinker, and higher stocking density, might develop poor feather coverage and pododermatitis (Arrazola et al., 2019). These issues caused reduced welfare of the layers and also increased economic losses due to increased mortality, increased feed consumption, and reduced egg production. The pre-slaughter stage of broiler meat production has an adverse effect on animal welfare, sometimes including high levels of mortality and wounds. Dead on arrival (DOA), injuries, and footpad dermatitis determined at slaughterhouses are the most important indicators of the on-farm welfare of meat-type birds (Nielsen et al., 2023). DOA rate is the most important indicator of pre-slaughter poultry welfare in commercial conditions. In this study, the flocks' average DOA mortality rate ranged from 0.072 to 0.125%. These values are lower than the findings of Jacobs et al. (2017) and Teke (2019) for DOA, as reported at 0.30 and 0.39 for commercial broilers. At the same time, it should also be taken into account that pre-slaughter factors, transport time, cage bird density, distance of transport, length of lairage, and water withdrawal time may have influence on DOA in broiler chickens (Pirompud et al., 2023; Saraiva et al., 2020). Jacobs et al. (2017) identified chick quality and on-farm mortality as the main risk factors for DOA in broiler meat production. Almost all these pre-slaughter factors in all flocks were similar in this study, except for some minor effects such as a driver, weather differences on the way, catching time, and catching team. Flock weight uniformity (Coefficient of variation, CV) is an objective parameter that might potentially be used as an animal welfare indicator and is associated with several production traits (Vasdal et al., 2019). There is a link between high flock uniformity, increased total mortality, carcass rejection in the slaughterhouse for various reasons, and poor FCR and growth rates (Karimi, 2021). Inadequate management conditions in the farm are usually the first cause of poor uniformity. Uniform poultry flocks are considered healthier flocks, and poor flock uniformity may indicate reduced animal welfare on the farm. It was reported that a uniform flock has a low CV, usually under 10 (Toudic, 2007), whereas Griffin et al. (2005) showed flock uniformity in six-week-old broiler chickens, which was 14.2% in males and 12.8% in females. It was reported as 11.5% for a uniform conventional broiler flock (Hubbard Technical Bulletin, 2018). Generally, in a broiler flock, 10-12 % CV at 40-42 days represents a uniform flock. If we compare the broiler breeder hen flock uniformity obtained in this study with commercial broiler flocks, the results were found to be similar. In the current study, the average uniformity rate of the flocks was around ten, which means the less variable a flock with excellent uniformity. The average live body weight of the breeder hens in the flocks ranged from 3845 to 4293 g according to slaughter age and husbandry conditions.

Feather pecking and cannibalism are some of the most critical risk factors for conventional or organic layer hens on the farm (Göransson et al., 2023). Management practices such as correct feeder and drinker space, feed distribution time, and house environmental conditions play an important role in the development of pecking behaviour and unwanted feather damage in poultry (Mens et al., 2020; Petek et al., 2015; Petek and Çavuşoğlu, 2020; Tuijl, 2019; Xu et al., 2022). Floor type, such as slatted floors, were significantly associated with greater plumage damage in laying hens (Decina et al., 2019). Skin lesions of breeder hens may be caused by feather pecking and cannibalism. In this study, feather loss from the head and neck of the birds was significantly lower than from other part of the body. More than 75 % of the birds had a feather loss bigger than 5 cm in diameter, especially in their tail, breast-abdomen, and cloaca. The most severe feather loss among the body regions was seen in the breast-abdomen in 97% of the birds. In agreement with our study, Tahamtani et al. (2020) reported that the worst plumage conditions were seen in the wings, tail, breast, and belly of the birds. The broiler breeders had significantly lower feathering scores for the wings than the commercial layers, and bird feathering scores for the breast in both layers (commercial and breeder) were considerably lower than for other parts of the body. As commercial layers or breeders, the laying hens can be predisposed to feather damage due to different factors. Managing birds to correct body weight and nutritional requirements, monitoring behaviour, and understanding the biology of feather development play critical roles in protecting plumage quality in broiler breeders. Dacina et al. (2019) showed that the slatted floor type had an increase in feather damage in flocks by approximately 38%. The condition of the feather cover during the egg production period is essential for preventing skin damage in layers. Low daily protein intake during the growth period and the first-period of egg production resulted in an inferior feather cover as compared to diets with medium or high protein content at these ages (Van Emous et al., 2014). Low stocking density in growth and laying periods may contribute to improving the quality of the feather cover. Gebhardt-Henrich et al. (2018) showed that Ross 308 hens had lower plumage quality (worse) than Sasso hens at 46 weeks of age. In agreement with these findings, Arrazola and Torrey (2021) reported that slower-growing broiler breeder pullets had perfect feather quality and a low prevalence of footpad lesions and hock burns during rearing. Chronic feed restriction in broiler breeders is accepted as one of the main reasons for severe feather pecking (Girard et al., 2017) and poor feather coverage (Morrissey et al., 2014).

In this study, all flocks developed foot pad dermatitis, but no differences in the occurrence of foot pad dermatitis were found to exist between the flocks. The lesions appeared on mild (score 1) or severe (score 2) levels in more than 70% of the hens in all flocks. In general, heavier hens had a worse score of foot pad dermatitis. Bumblefoot was observed in 38% of hens, while the prevalence of missing toe and comb lesions was 24.0%, respectively. It was found that less than 10% of the birds in four flocks had a wound in their toe. Pododermatitis, or bumblefoot, is painful and a major concern in broiler meat production, and it is often related to high manure pH, the proportion of soybean meal in feed content, and, most importantly, the moisture of litter (van den Oever et al., 2020). It is used as an audit parameter for broiler health control in the United States and Europe. In a study, the prevalence of bumble foot and pododermatitis in broiler breeder flocks was found to be 2.1 and 44.96%, respectively (Kromann et al., 2022).

Keel bone deviation and fracture of keel tips can be found in all commercial laying hens with different prevalence. Still, it is hard to identify the exact differences between keel bone fractures and keel bone deviations (Thøfner et al., 2021). In our study, keel bone deviation (KBD) was present in 13.0% of the total birds, of which 33.0% also had fractures (KBF), while the tip-keel (distal end of the keel bone) was 58.0% of the birds (Figure 3). Our results for keel bone fractures are in agreement with the findings of Kittelsen et al. (2023), who reported that the prevalence of KBF at the end of the laying period for two Ross 308 breeder hens, as diagnosed by necropsy, was 54 and 58%, respectively. Thofner et al. (2021) reported that the post-mortem prevalence of keel bone fractures in a layer parent stock was 81.55%, and there was a significant decrease in fracture prevalence with increased body weight in hens from organic-free range and parent stock flocks. One of the predisposing factors for keel bone damage is the genetics of the birds, and it can be seen in all types of housing systems in all laying hens (Campbell, 2020; Candelotto et al., 2017; Kittelsen et al., 2023; Rufener and Makagon, 2020). In a study, Gebhardt-Henrich et al. (2018) reported that Sasso breeder hens had more keel bone damage than Ross 308 hens and perches or aviaries had increased the keel bone damage in hens. In another study, Baldinger and Bussemas (2021) reported that 34-45% of the dual-purpose hens showed keel bone deviations. The strength level of bones may be a risk for the development of keel bone fracture in laying hens (Stratmann et al., 2016). In comparison with conventional cages, bone problems were not as prevalent in loose-housed hens due to their increased exercise activity (Campbell, 2020). Parent birds in Danish flocks had significantly fewer fractures than other birds from cage-free systems, and none of the male birds had any signs of keel bone fractures. In this study, it was reported that the body weight at the end of the laying period and daily egg size at the onset of lay might be a risk factor for fractures (Thøfner et al., 2021). In general, keel bone fracture is not prevalent in broiler roasters, but it can be a prevalent problem in broiler breeder hens of several hybrids (Kittelsen et al., 2023). For that reason, we investigated the keel bone hazards only in breeder hens. Feather loss and muscle weakness might be risk factors for keel bone fracture (Garant et al., 2022).

Unfortunately, it was not possible to assess production data from the flocks included in the study. Data such as egg production, age of onset of lay, and egg weight may contribute to establishing a link between keel bone deformation and production data. Palpation has, until now, been the most commonly used diagnostic method to identify

and differentiate bone deformations in laying hens in the field. However, there is increasing evidence that diagnosis by palpation underestimates the actual prevalence in a flock (Baur et al., 2020; Kittelsen et al., 2023; Tracy et al., 2019). Therefore, the proportion for keel bone damage can differ according to the diagnostic methods, such as palpation, necropsy, or radiography. The diagnostic accuracy for detecting palpation for keel bone fractures in broiler breeder hens can be less sensitive and different between observers.

The results of this study indicated that fast-growing broiler breeders exhibited minimal or severe feather and keel bone damage, similar to that observed in commercial laying hens. This situation negatively affected animal health, welfare, and production costs. Currently, there is not much more information about the predisposing factors and innovative solutions to reduce poor welfare conditions in breeder hens. Therefore, future research topics should be more attention to improving management practices such as providing adequate feed, opportunities for hens to perch and forage, optimum stocking density, environmental enrichment, and active monitoring of the birds to prevent welfare deficiencies in breeder flocks.

Acknowledgement

We would like to thank the staff of the slaughter plant for allowing us to do an ante-mortem examination of the birds. This research is partly supported by Bursa Uludag University Scientific Research Projects Coordination Unit, grant number BAP KUAP (V) 2020-14.

Availability of Data and Materials

Datasets used in this experiment are available from the corresponding author on request.

Declaration of Generative Artificial Intelligence (AI)

The authors have declared that the article, tables and figures were not written/created by AI and AI-assisted technologies.

Conflict of Interest

The authors stated that they did not have any real, potential or perceived conflict of interest.

Ethical Statement

This study was approved by the Bursa Uludağ University Animal Experiments Local Ethics Committee (05.05.2020, 2020-05/11 Number Ethics Committee Decision). In addition, the authors declared that Research and Publication Ethical rules were followed.

Funding

This research is partly supported by *Bursa Uludag University Scientific Research Projects Coordination Unit* (grant number BAP KUAP (V) 2020-14).

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Author Contributions

Motivation / Concept: MP, EÇ
Design: MP, EÇ
Control/Supervision: MP, EÇ
Data Collection and / or Processing: MP, EÇ
Analysis and / or Interpretation: MP, EÇ
Literature Review: MP, EÇ
Writing the Article: MP, EÇ
Critical Review: MP, EÇ

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