Assessment of the feather score and health score in laying hens reared at different cage densities

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ARTICLE INFO

Article History
Received : 21.04.2021
Accepted : 24.10.2021
DOI: 10.33988/auvfd.925177

Keywords
Cage density
Feather score
Health score
Laying hen

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How to cite this article: Özentürk U, Yıldız A, Genç M (2023): Assessment of the feather score and health score in laying hens reared at different cage densities. Ankara Univ Vet Fak Derg, 70 (1), 1-8. DOI: 10.33988/auvfd.925177.

ABSTRACT

This study aimed to investigate plumage conditions, injuries in the comb, cloaca, and feet at the end of the laying period (73 weeks of age) in native Atak-S (A-S) and foreign Isa Brown (IB) and Novogen White (NW) genotypes reared at two different cage densities. A total of 480 hens, including 160 of each hybrid, were used in the present study. Each hybrid group was divided into subgroups containing eight (468.75 cm^2/hen) and 12 animals (312.50 cm^2/hen) each with eight replications. The feathering status in six different regions of the body (neck, breast, back, wing, tail, and cloaca) was assessed by scoring these regions both separately and as a whole. To detect injuries in the body, the comb, cloaca, and foot regions were examined. In the study, the effect of genotype on the feather score was found to be significant in all body regions except for the tail region (P<0.05). In all hybrids, the highest plumage loss was in the tail region, while the lowest was in the cloaca region in IB and the neck and wing regions in NW and A-S. The best results were obtained from the IB hybrid in terms of the total plumage condition. Genotype had a significant effect on the health scores in all body regions except for the comb (P<0.05). In terms of the feather score, the effect of cage density was determined to be significant in all body regions (P<0.01). It was observed that plumage loss increased as the cage density increased.

Introduction

The integument of hens is associated with animal health (16) and behavior (33). In the assessment of the effects of factors that influence the health and welfare levels of hens such as genotype, breeding systems, cage density, and nutrition on integument, the scoring method is extensively used. Integument is frequently determined based on scoring the feathers, feet and skin (30). Feathers protect hens from the abrasive effect of the cage material and injuries (14). The feather score is a relatively neglected parameter in commercial laying poultry in comparison to some other classical performance data such as egg yield and feed consumption. Nevertheless, feathering status is an important indicator in interpreting health, performance and welfare (21). This is because a disruption occurring in feathers may lead to injuries and deaths by triggering cannibalistic behavior (14). In addition to the economic loss brought about by deaths, the increase in feed consumption observed for the preservation of body temperature due to plumage loss also raises economic costs (14, 38). It was also reported that the egg yield of hens decreases in relation to increased stress in broods where feather pecking occurs (11, 38).

It has been emphasized that the easiest method of assessing the welfare of laying hens is to assess the state of their feathers and injuries (9, 14, 29). In a study that included expert opinions for the purpose of creating a protocol to assess welfare, it was reported that the plumage condition in hens was the most significant indicator among 17 different parameters (32). It was stated that the main cause of plumage loss leading to reduced welfare is the behavior of feather picking and pecking (4). It is specified that this behavior cannot be eliminated even though the most suitable conditions are provided, and thus, to reduce the effect of the behavior of feather picking and feather pecking, it is needed to regularly observe the brood and visually assess the integument (3). Factors such as cage systems (23), cage density (20), and nutrition affect the formation of the behavior of feather picking and pecking (1, 32). Additionally, it was stated that the

formation of this behavior varies in different hybrids (5). This situation suggests a genetic background (8, 24).

In Türkiye, which is one of the most prominent countries in the world in terms of egg production, native laying hybrids constitute approximately 2.5% of the hens used in production (12). In the poultry farming program of the 2016-2020 Master Plan of the General Directorate of Agricultural Research and Policies of the Turkish Ministry of Agriculture and Forest Affairs, it has been planned to conduct efforts towards supplying breeding stock resources for laying and broiler hen production from domestic sources and to create feeding and breeding methods appropriate for this objective. For this reason, it was emphasized that it is needed to carefully investigate breeding and nutrition techniques in native hybrids and yields under private sector conditions with the effects of environmental factors (18).

This study aimed to investigate plumage conditions, injuries in the comb and cloaca, and feet in relation to bumblefoot syndrome at the end of the laying period (73 weeks of age) in native (Atak-S) and foreign (Isa Brown, Novogen White) genotypes reared at two different cage densities.

Materials and Methods

The study was carried out at the Food and Animal Farming Research and Application Center of Atatürk University. This study was approved by the Animal Ethics Committee of Animal Experiments of the Veterinary Medicine Faculty at Atatürk University (2020/07).

As the animal material, native Atak-S (A-S) and foreign Isa Brown (IB) and Novogen White (NW) hens, all at the same age (73 weeks old), were used. In the trial, 3 different genotypes (A-S, NW, and IB) and 2 different cage housing densities (8 hens/cage and 12 hens/cage) were utilized. A total of 480 hens, including 160 of each hybrid, were used, and each hybrid group was divided into subgroups containing 8 and 12 animals, each with 8 replications. Cage density-1 (CD-1) was defined as 468.75 cm^2 cage floor space per hen, while Cage Density-2 (CD-2) was defined as 312.50 cm^2 of cage floor space per hen. All cage units had equal dimensions to each other. The cage dimensions were as a depth of 60 cm, a width of 62.5 cm, the rear height of 46 cm, the front height of 51 cm, feeder length of 62.5 cm, and base slope of 7°. Each cage had 2 nipple waterers. The animals were grown in the same poultry house during both rearing and laying periods. The in-house temperature was kept at 16-24°C with sensors connected to the ventilation and heating systems. Lighting was adjusted as 17 hours of light per day with fluorescent bulbs giving white light. In the laying period, the animals were given egg starter feed (2750 ME 17.50 HP) in the 16th-20th weeks, 1-st period laying feed (2750 ME 16.26 HP) in the 21st-45th weeks, 2-nd period laying feed (2720 ME 15.83 HP) in the 46th-65th weeks, and 3-rd period laying feed (2720 ME 15.65 HP) after the 65th week in granule form as *ad libitum*.

Feather Scoring Method: At the end of the laying period (73 weeks of age), each hen was individually examined by visual examination for feathering score. Two methods are frequently used in scoring integuments. The first one of these is the assessment of the body as a whole, while the other is the assessment of body regions separately. While the former provides the opportunity for a faster and simpler assessment, it cannot explain the reasons for plumage loss occurring in different regions of the body (30). In the study, the feathering status in 6 different regions of the body (neck, breast, back, wing, tail, and cloaca) was assessed by scoring these body regions both separately and as a whole. The scoring was made in the range of 1-4 (Table 1) (8, 30). In total scoring, scores lower than 10 to 12 indicate a significant plumage loss in the entire body. Scores of 3 and higher locally and higher than 18-20 in total scoring show that the state of the plumage and integument is good (30).

Health (Integument) Scoring Method: To detect injuries in the body, the comb and cloaca regions were examined, and the feet were checked in relation to bumblefoot syndrome. The scoring was made in the range of 1-4 (Table 1) (8, 30). Scores of 2 and lower by body region show that the integument and plumage are significantly damaged, or they indicate the presence of heavy injury, abrasion, aggressive behavior in the brood, and bumblefoot syndrome (8, 30).

Table 1. Description of the scoring scheme used for the assessment of plumage and integument condition.

Parameter/Score	Feather Loss	Integument Damage
1	>75% of the feathers of the body region missing	Single or multiple injuries of >1.0 cm
2	>50% and <75% of the feathers of the body region missing	Multiple injuries of <0.5 cm or single injuries of >0.5 cm and <1.0 cm
3	>25% and <50% of the feathers of the body region missing	Single injury of <0.5 cm diameter or length
4	No feather loss or <25% of the feathers of the body region missing	No integument damage

DOI: 10.33988/auvfd.925177

Statistical analysis: The non-parametric Kruskal-Wallis H test was used for the genotypes (IB, A-S and NW) for plumage damage and injuries observed in different regions of the body on a Likert-type scale, whereas the non-parametric Mann-Whitney U test was utilized for the pairwise comparisons of density (CD-1 and CD-2) and the genotypes. By analyzing the normality of the distribution of the data with the Shapiro-Wilk test, it was determined that the data were non-normally distributed. The statistical analyses were carried out using the SPSS package software.

Results

The feather and health scores of the different genotypes are presented in Table 2. In the study, the effect of genotype on the feather score was found to be significant in all body regions except for the tail region ($P<0.05$). The mean total feather score was determined for IB, A-S, and NW as 11.53±0.250, 10.55±0.193 and 10.69±0.284, respectively. In terms of the feather score, the difference between the A-S and IB hybrids was found to be significant in all regions except for the tail region ($P<0.05$). Between the A-S and NW hybrids, the feather scores showed differences in the breast, cloaca and back regions ($P<0.05$). In all hybrids, the highest plumage loss was in the tail region, while the lowest was in the cloaca region in IB and the neck and wing regions in NW and A-S. Genotype had a significant effect on the health scores in all body regions except for the comb ($P<0.05$). The hybrid with the lowest health score in the cloaca region was IB. The NW hybrid showed higher values in terms of both foot scores than the other hybrids ($P<0.05$).

The feather and health scores of the hens at different cage densities are shown in Table 2. In terms of the feather score, the effect of cage density was determined to be significant in all body regions ($P<0.01$). It was observed that plumage loss increased as the cage density increased. While the total feather score was 12.94±0.211 for CD-1, it was 9.62±0.136 for CD-2. In the CD-1 conditions, the lowest plumage loss was in the cloaca region with a score of 2.40±0.056, while the highest one was in the tail region with a score of 1.93±0.050. In the CD-2 conditions, the lowest plumage loss was in the neck region with a score of 1.98±0.036, while the highest one was in the tail region with a score of 1.25±0.028. In terms of the health scores, both the comb and foot scores were found to be higher in the hens reared at the cage density-1 ($P<0.01$).

The feather and health scores of the hybrids in the cage density groups are presented in Table 3 and Figure 1. According to the findings of the study, in the IB and NW hybrids, as the cage density increased, the feather score showed a significant decrease in all body regions ($P<0.01$). In the A-S hybrid, in all body regions except for the breast region, as the cage density increased, the presence of plumage significantly decreased. In both density conditions, in terms of the total presence of plumage, the scores of the IB hybrid were higher than those of the others. In terms of the health score, it was observed that the cloaca region was not significantly affected by cage density in all hybrids. It was determined that the cage density showed a significant effect on the foot scores of the IB and A-S hybrids and the comb scores of the A-S and NW hybrids.

Table 2. The effects cage density on feather and health scores in laying hen hybrids.

	IB	A-S	NW	CD-1	CD-2	P				
	$\bar{x}$ ± SE	$\bar{x}$ ± SE	$\bar{x}$ ± SE	$\bar{x}$ ± SE	$\bar{x}$ ± SE	Cage Density	Hybrid	IB-AS	IB-NW	AS-NW
Feather Score										
Neck	2.20±0.047^{a}	2.00±0.044^{b}	2.06±0.065^{ab}	2.25±0.047^{x}	1.98±0.036^{y}	0.001	0.010	0.002	0.075	0.466
Breast	1.95±0.060^{a}	1.53±0.046^{b}	1.81±0.072^{a}	1.99±0.059^{x}	1.58±0.039^{y}	0.001	0.000	0.000	0.133	0.001
Cloaca	2.25±0.063^{a}	1.92±0.052^{b}	1.59±0.069^{c}	2.40±0.056^{x}	1.68±0.041^{y}	0.001	0.000	0.000	0.000	0.000
Back	1.77±0.059^{a}	1.58±0.046^{b}	1.73±0.065^{a}	2.09±0.054^{x}	1.42±0.033^{y}	0.001	0.025	0.015	0.850	0.037
Wing	1.81±0.044^{b}	2.00±0.038^{a}	2.04±0.051^{a}	2.30±0.034^{x}	1.71±0.029^{y}	0.001	0.000	0.001	0.001	0.457
Tail	1.54±0.050	1.53±0.047	1.46±0.059	1.93±0.050^{x}	1.25±0.028^{y}	0.001	0.518	0.715	0.253	0.395
Total	11.53±0.250^{a}	10.55±0.193^{b}	10.69±0.284^{b}	12.94±0.211^{x}	9.62±0.136^{y}	0.001	0.009	0.003	0.035	0.839
Health Score										
Comb	2.70±0.040	2.66±0.038	2.68±0.048	2.79±0.033^{x}	2.61±0.033^{y}	0.001	0.796	0.534	0.596	0.992
Cloaca	2.82±0.037^{a}	2.91±0.025^{b}	2.92±0.025^{b}	2.90±0.026	2.87±0.024	0.518	0.025	0.010	0.001	0.565
Right Foot	2.91±0.023^{b}	2.88±0.025^{b}	2.97±0.015^{a}	2.99±0.009^{x}	2.86±0.022^{y}	0.001	0.029	0.419	0.039	0.007
Left Foot	2.88±0.031^{b}	2.86±0.028^{b}	2.97±0.015^{a}	2.99±0.007^{x}	2.83±0.026^{y}	0.001	0.017	0.517	0.018	0.004

IB: Isa Brown, A-S: Atak-S, NW: Novogen White, CD-1: Cage density-1, CD-2: Cage Density-2.
^{a,b,c} Values within a row with different superscripts differ significantly at $P<0.05$.
^{x,y} Values within a row with different superscripts differ significantly at $P<0.01$.

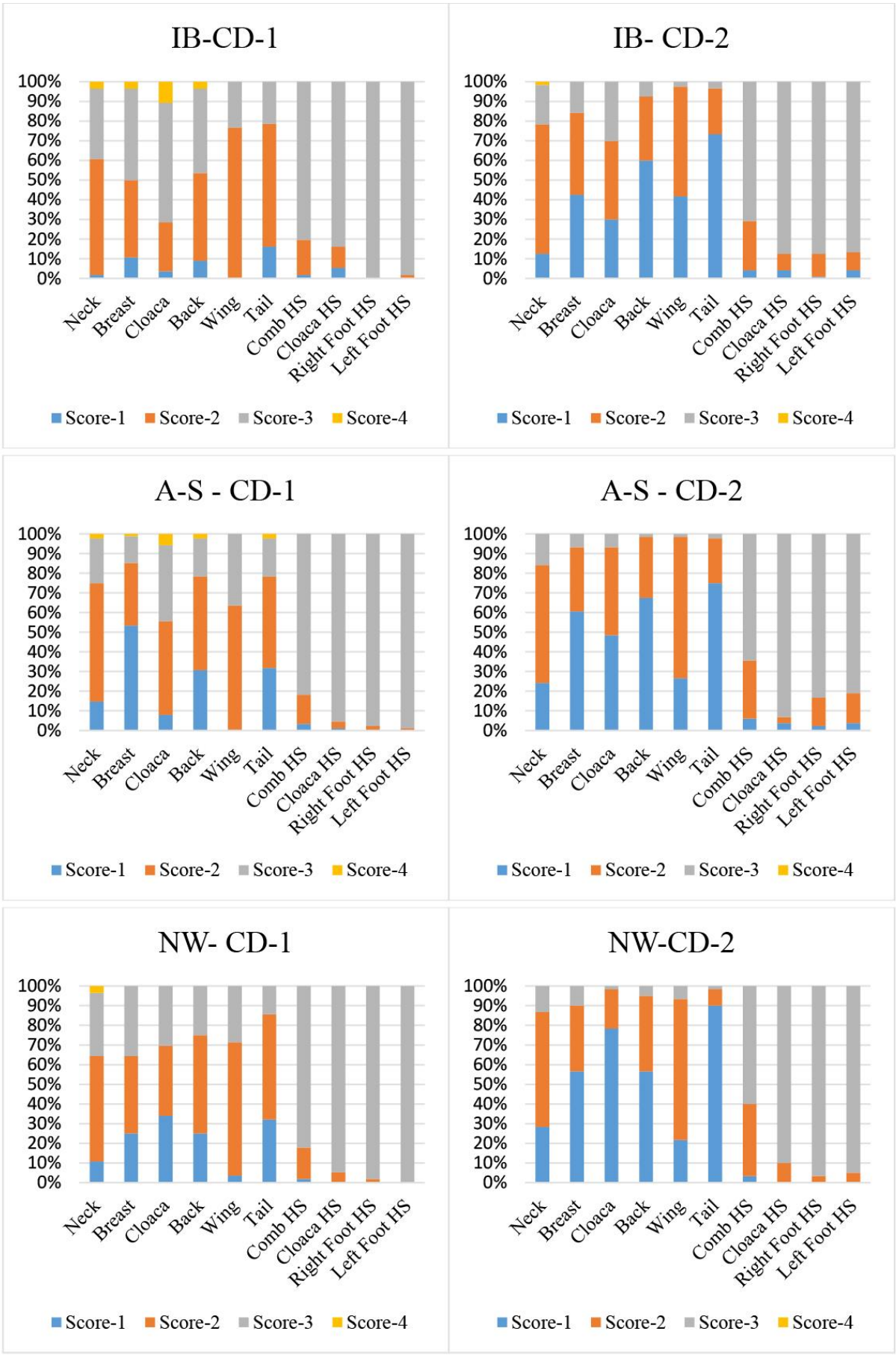

Figure 1. Feather and health scores of the hybrids in the cage density groups (%).

Table 3. The effects laying hen hybrids on the feather and health scores in the cage density groups.

	IB			A-S			NW		
	CD-1	CD-2		CD-1	CD-2		CD-1	CD-2	
Feather Score	**x̄ ± SE**	**x̄ ± SE**	**P**	**x̄ ± SE**	**x̄ ± SE**	**P**	**x̄ ± SE**	**x̄ ± SE**	**P**
Neck	2.41±0.080^{a}	2.11±0.057^{b}	0.003	2.13±0.072^{x}	1.92±0.055^{y}	0.029	2.29±0.094^{k}	1.85±0.082^{l}	0.001
Breast	2.43±0.098^{a}	1.73±0.066^{b}	0.000	1.63±0.081	1.46±0.054^{y}	0.157	2.11±0.104^{k}	1.53±0.087^{l}	0.000
Cloaca	2.79±0.091^{a}	2.00±0.071^{b}	0.000	2.42±0.077^{x}	1.58±0.054^{y}	0.000	1.96±0.108^{k}	1.23±0.060^{l}	0.000
Back	2.41±0.095^{a}	1.48±0.058^{b}	0.000	1.93±0.082^{x}	1.34±0.044^{y}	0.000	2.00±0.095^{k}	1.48±0.077^{l}	0.000
Wing	2.23±0.057^{a}	1.61±0.049^{b}	0.000	2.36±0.052^{x}	1.75±0.041^{y}	0.000	2.25±0.069^{k}	1.85±0.066^{l}	0.000
Tail	2.05±0.082^{a}	1.30±0.048^{b}	0.000	1.92±0.083^{x}	1.27±0.043^{y}	0.000	1.82±0.089^{k}	1.12±0.048^{l}	0.000
Total	14.32±0.342^{a}	10.23±0.254^{b}	0.000	12.39±0.316^{x}	9.33±0.177^{y}	0.000	12.43±0.400^{k}	9.07±0.268^{l}	0.000
Health Score	**x̄ ± SE**	**x̄ ± SE**	**P**	**x̄ ± SE**	**x̄ ± SE**	**P**	**x̄ ± SE**	**x̄ ± SE**	**P**
Comb	2.79±0.061	2.67±0.051	0.171	2.78±0.052^{x}	2.58±0.053^{y}	0.006	2.80±0.059^{k}	2.57±0.073^{l}	0.010
Cloaca	2.79±0.071	2.83±0.043	0.522	2.94±0.030	2.89±0.036	0.467	2.95±0.030	2.90±0.039	0.352
Right Foot	3.00^{a}	2.87±0.033^{b}	0.006	2.98±0.016^{x}	2.81±0.039^{y}	0.001	2.98±0.018	2.97±0,023	0.601
Left Foot	2.98±0.018^{a}	2.83±0.044^{b}	0.015	2.99±0.011^{x}	2.77±0.044^{y}	0.000	3.00	2.95±0.028	0.091

IB:Isa Brown, A-S: Atak-S, NW: Novogen White, CD-1: Cage density-1, CD-2: Cage Density-2.
^{a,b} Values within a row with different superscripts differ significantly at P<0.05.
^{x,y} Values within a row with different superscripts differ significantly at P<0.05.
^{k,l} Values within a row with different superscripts differ significantly at P<0.05.

Discussion and Conclusion

In this study, the integument status of native and foreign laying hybrids that were at the end of their laying period was assessed by the method of scoring by checking each animal one by one.

It was found in this study that the feather score in all body regions except for the tail region and the health score in the cloaca and feet showed a significant difference among the genotypes (P<0.05). It has been reported that feather pecking originates from behavioral disorders in hens, and this behavior shows genetic differences (8, 19, 26). When the plumage status in different body regions was examined in the study, it was observed that the highest plumage loss was in the NW hybrid in the cloaca region, in the A-S hybrid in the breast and back and in the IB hybrid in the wings. Studies have stated that, in animals with different feather colors, the genes that determine feather pigmentation may affect pecking behavior (2, 19). The IB, A-S, and NW hybrids that were used in this study had the respective feather colors of brown, black and white. Supporting this result, the effect of feather colors on the feather score was found significant in hens with white, black, and gray feathers (2). In some other studies, too, the changes in plumage conditions have been explained by the color of the feathers in brown, and white hens (4, 5, 8, 37).

It was explained that the feather and health scores in hens showed genetic differences between white- and brown layer hens (9, 27). Onbaşılar et al. (23) reported that feather scores differed in the neck, back, wings and tail regions of brown and white layer hens. In the study, while the NW hybrid had a white layer, the other two hybrids had brown-layers. White-layer hybrids are lightweight hybrids, while brown-layer hybrids have a medium-weight body structure (6, 23, 31). For this reason, their animal-specific area requirements should be kept in mind (32). Additionally, the different egg weights of the hybrids (22) may explain the differences in cloaca injuries as they lead to prolapse (25).

In the study, the highest amount of plumage loss occurred in the tail and back regions. It was reported that the reason for this is the behavior of pecking directed frequently towards these body regions (38). Giersberg et al. (8) also reported that, at the end of the laying period, the region's most affected in hens are the back and the tail. Studies where body regions were separately assessed and reported the highest plumage loss values in the cloaca and tail (3), and back, cloaca, and tail (10) regions have supported the results of this study.

In this study, the total feather score values for the IB, A, S and NW hybrids were 11.53, 11.00 and 10.55, respectively. Also, it was determined that the lowest loss of plumage was in the IB hybrid (P<0.05). However, in a study evaluating five different body regions, the total feather score was determined to be 14.7 in the LB hybrid and 14.8 in the LW hybrid. In the study, it was stated that there was no difference between hybrids in terms of total feather score (23). Tauson et al. (30) considered a total whole-body score of 10-12 and lower as a serious loss of plumage. It was reported that the plumage condition deteriorates in time throughout the laying period (23, 37), and loss of plumage reaches the highest level at the end of

the laying period (4, 14). These reports supported the finding in this study on the severe loss of plumage that was observed.

Assessment of the total feather score cannot explain the causes of plumage losses occurring in different regions of the body. Plumage and integument damage are affected by different causes in different genotypes (9). This situation is attributed to some behaviors that are genetically observed. The behavior of feather pecking in animals is expressed by animals non-aggressively pulling each other's feathers off. The basis of this behaviors is associated with the behaviors of searching for food and inadequate nutrition. This behaviors is frequently observed in the form of pecking the back, tail and cloacal regions (26, 32). Feather pecking is a significant problem in commercial breeding. Today, genetic selection and management programs that aim to reduce feather pecking are being applied at commercial coops (19). Aggressive pecking behaviors, on the other hand, is seen frequently in the form of pecking the head and neck region, which is associated with the formation of social hierarchy among the animals (26, 28). It is stated that this behavior becomes prevalent in the brood through social learning and that it leads to cannibalism and injuries involving blood through the pecking of the skin (8, 26). Besides these, the loss of plumage observed in the breast and abdomen regions is associated with the mobility of the animals within the cage and abrasion caused by the cage material (32, 34).

In this study, the effects of two different cage densities on the feather and integument health scores were examined. It was determined that, as the cage density increased, loss of plumage in all body regions and injuries in the comb and feet in the hens increased ($P<0.01$).

To increase their revenue, laying hen farmers have a tend to utilize their coops to the maximum extent (27). On the other hand, reducing the cage density has a significant effect on animal health and welfare (13, 25, 35). Providing hens with more area will affect their ability to move (36) and increase their welfare by allowing them to show their natural behaviors (i.e., stretching, turning around, walking, standing and wing flapping) (15).

Factors such as breeding, cage systems and cage density affect the formation of the behavior of feather picking and pecking (21). It was reported that reducing cage density affected pecking behavior in a positive direction (38). In the study by Weimer et al. (32) where 6 different housing densities (465-484, 581-606, 652-677, 754-780, 799-832, and 923-955 cm^2) were created, plumage conditions in 6 different body regions were investigated throughout the laying period. In their study, it was reported that, as the housing density increased, the presence of plumage significantly decreased in all body regions. Onbaşılar and Aksoy (20) examined the total feather scores (5 body regions) in their study, in which they formed a cage density of 1968 cm, 656 cm and 393.8 cm, and determined them as 16.56, 14.85, and 12.42, respectively. In the study, it was emphasized that the feather score was low in chickens that were raised intensively. Similarly, another study (35) stated that hens reared within 520 cm^2 had a poorer plumage condition than those reared within 748 cm^2. In support of the result of this study, different studies have reported that, by reducing cage density, plumage conditions (7, 13, 27, 35) and foot health (7, 29) were positively affected. It was reported that plumage loss is affected by an increase in cage density due to a reduction in feeder distance per animal and increased stress (7). The competition during feeding may increase the tendency of pecking by affecting social behaviors (32). In hens housed at high densities, as a result of the increased time of contact with the feeder area in the front of the cage, plumage loss and injuries may ocur, especially in the breast region (13). The poorer plumage score of densely populated cages can be caused by abrasion against cage wire or other hens (20). As opposed to the result of this study, Campe et al. (4) determined the effect of the factor of housing density on the feather score to be insignificant. In the housing density groups they created, Liebers et al. (17) examined plumage conditions (neck, back, wing), body injures (neck, breast, back, wing, leg, tail, cloaca), and head injuries, and they reported that housing density did not create a significant effect in any of the parameters. Onbaşılar and Aksoy (20) reported that cage density did not have a significant effect on foot health scores. The fact that the density groups in the aforementioned studies were close to each other and that the area per animal was broader in comparison to this study may explain the differences between the results. Also, some strains have a greater ability to adapt to high-density environments, and this may explain the differences between experiments (20).

Consequently, in all genotypes, a severe loss of plumage was observed at the end of the laying period. In the study, the best results were obtained from the IB hybrid in terms of the total plumage condition. Values observed in different body regions allow the assessment of animal welfare and poultry management. The highest plumage loss values were in the NW hybrid in the cloaca region, the A-S hybrid in the breast and back regions, and the IB hybrid in the wings. With the increase in cage density, the highest plumage loss occurred in the tail region in all hybrids. It was also concluded that, as the cage density increased, plumage loss and injuries in the comb and feet increased.

Financial Support

This research study was funded by Scientific Research Project Coordination Unit of Ataturk University, (Grant number: PRJ2014/25).

Conflict of Interest

The authors declared that there is no conflict of interest.

Author Contributions

UÖ, AY and MG conceived and planned the experiments. UÖ and MG carried out the experiments. UÖ, AY and MG contributed to the interpretation of the results. UÖ took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Data Availability Statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Ethical Statement

Approval was obtained specifying that conducting the study was appropriate in terms of ethical principles with the decision dated 25.06.2020 and numbered 2020/7 of the Ethics Committee of the School of Veterinary Medicine at Atatürk University.

Animal Welfare

The authors confirm that they have adhered to ARRIVE Guidelines to protect animals used for scientific purposes.

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