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Original scientific paper

The effect of keel bone damage, housing system, hybrid, and phase of production cycle on the plumage condition of laying hens

Anna Dedousi[1*], Mirjana Đukić Stojčić[2] and Evangelia N. Sossidou[1]

[1]Veterinary Research Institute/Hellenic Agricultural Organization - DIMITRA, Thermi, Thessaloniki, Greece
[2]Department of Animal Science, Faculty of Agriculture, University of Novi Sad, Novi Sad, Serbia

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ABSTRACT

The aim of this study was to investigate the effect of keel bone damage, housing system, hybrid, and phase of production cycle on the plumage condition of laying hens. The trials were conducted in five industrial farms using different housing systems: enriched cage system, floor system, free range system and aviary system. The hybrids presented were Isa Brown, Hy-Line Brown, Hy-Line Silver Brown and Lohmann Brown. Fifty laying hens *per* farm were randomly selected for the assessment of keel bone damage and plumage condition. According to their age during assessment of feather cover and keel bone damage, the birds were categorized as being at the beginning (22-38 weeks of age) or in the middle of the production cycle (43-56 weeks of age). Total plumage score and the individual scores of seven body parts were assessed. Plumage scoring was not significantly affected by keel bone damage. Housing system and hybrid significantly ($P<0.05$) affected both total plumage score and individual plumage scoring. Hens in aviary and floor systems had significantly ($P<0.05$) higher total plumage score compared to hens farmed in enriched cage and free range systems, with a significantly ($P<0.05$) lower total plumage score found in free range compared to enriched caged hens. Hy-Line Silver Brown and Isa Brown had significantly ($P<0.05$) lower total plumage score compared to Lohmann Brown hens. The phase of production cycle had no significant effect on total plumage score, yet, significant ($P<0.05$) differences in individual plumage scores were observed between hens of different ages. This study showed that the feather cover of laying hens was affected by housing system, genotype, and phase of production cycle, but not by keel bone damage.

Key words: laying hens; plumage condition; keel bone damage; housing system; hybrid; production cycle

Introduction

The plumage condition (PC) of laying hens is considered to be an indicator of animal health and behavior (CAMPE et al., 2018). Nowadays, feather damage still remains a significant welfare issue for laying hens documented in all types of production system (LAMBTON et al., 2010; RELIĆ et al., 2019). It is a multifactorial problem that has been associated with housing system, phase of production cycle, and genetic factors, but also with abnormal behavior such as feather pecking, nutrition deficiencies, stress, the physical environ-

* Corresponding author:
Anna Dedousi, DVM, PhD, Associate Researcher, Veterinary Research Institute, HAO – DIMITRA, Campus of Thermi, P.O. Box 60272, 57001 Thermi, Thessaloniki, Greece, phone: +302310365381, e-mail: dedousi@elgo.gr

ment such as light intensity, social factors, and sex differences, with males pecking less than females (SEDLAČKOVÁ et al., 2004; LABRASH and SCHEIDELER, 2005; YAMAK and SARICA, 2012; DECINA et al., 2019; RELIĆ et al., 2019). Feather loss increases the risk of abrasion and infection due to exposed areas of skin; it causes thermoregulation problems due to increased heat loss, difficulties in retaining balance and flight control, and severe injuries that can lead to cannibalism outbreaks and bird mortality (DECINA et al., 2019; RELIĆ et al., 2019). Additionally, the removal of feathers (aggressive pecking and feather pecking) is a painful condition for the re- cipient bird, while the expression of such behavior can indicate incompletely met behavioral needs in the pecking birds (LAMBTON et al., 2010; RE- LIĆ et al., 2019). Thus, feather damage not only diminishes bird health and welfare, but also has a negative impact on farmers' income as it has been associated with increased flock mortality and feed consumption, and reduced egg production (SEDLAČKOVÁ et al., 2004; LABRASH and SCHEIDELER, 2005; LAMBTON et al., 2010; DECINA et al., 2019).

Another very frequent problem of commercially raised laying hens is keel bone damage (KBD) (HARLANDER-MATAUSCHEK et al., 2015; ĐUKIĆ STOJČIĆ et al., 2017), a term that refers to both deformations and fractures of the keel bone. Like feather damage, this is also a multifactorial problem strongly related to the rearing system, the hens' age and strain, and its prevalence ranges between 1% and 97% (PETRIK et al., 2015; REGMI et al., 2016; CASEY-TROTT et al., 2017; ĐUKIĆ STOJČIĆ et al., 2017; EUSEMANN et al., 2018). Keel bone damage is a painful condition that negatively influences the welfare and productivity of laying hens. It has been shown to restrict the birds' mobility, increase time spent in the nest while egg laying, and also prevent the expression of natural behavior such as perching (RIBER et al., 2018). Furthermore, KBD has been found to be linked with bumble foot (RIBER et al., 2018) and poor feather cover (RIBER and HINRICHSEN, 2017), as well as with increased consumption of feed and water (NASR et al., 2013).

The primary goal of this study was to investigate the effect of KBD on the PC of laying hens. Complementarily, the association of PC with housing system, hybrid and phase of production cycle were also evaluated.

Materials and methods

The study was conducted in five farms of commercially raised laying hens using different housing systems: enriched cage (EC) system, floor (FL) system, free range (FR) system and aviary (AV) system. Enriched cage system consisted of three tiers of cages that were fully equipped with a nest, a litter, a perch, nipple drinkers and a feed trough according to the requirements of COUNCIL DIRECTIVE 1999/74/EC. The FL system consisted of plastic grade floor, and part of the pen floor was covered with rice husk litter. In the FR system, hens had access to a grass-covered run during the day and remained inside a barn similar to that in the FL system during the night. The AV system consisted of two rows covered with a perforated floor that created a portal, providing layers with a large amount of room to scratch. The pen floor was covered with wood shavings that were replaced regularly. In the FL, FR and AV systems, the hens were housed according to COUNCIL DIRECTIVE 1999/74/EC for alternative productions systems. All farms had similar management. Hens from all production systems were kept under a 14h light-10h dark cycle (15 lx), they were beak trimmed and were fed standard commercial layer diets containing approximately 17.5% crude proteins, 2750 kcal ME/kg, 4.4% Ca and 0.58% available P. Feed and water were offered *ad libitum*. In FR system, feeders and drinkers were also available in the run.

The hybrids studied were Isa Brown, Hy- Line Brown, Hy-Line Silver Brown and Lohmann Brown; their distribution per farm and production system is presented in Table 1. According to their age at the time of assessment of feather cover and KBD, the birds were categorized as being at the beginning of production cycle (22-38 weeks of age) or in the middle of the production cycle (43-56 weeks of age).

Table 1. The hybrids used in the study and their distribution (number of hens) *per* farm, housing system and phase of production cycle

Farm	Housing system	Hybrid	Phase of production cycle	
			BPC	MPC
1	EC	HB	25	25
2	EC	HSB	25	25
3	AV	LHB	25	25
4	FR	ISA B	25	25
5	FL	ISA B	25	25

EC: enriched cage system, AV: aviary system, FR: free-range system, FL: floor system. HB: Hy-Line Brown, HSB: Hy-Line Silver Brown, LHB: Lohmann Brown, ISA B: Isa Brown. BPC: beginning of production cycle (22-38 weeks of age); MPC: middle of production cycle (43-56 weeks of age)

As shown in Table 1, a sample of 50 laying hens *per* farm (25 *per* phase of production cycle) was randomly selected for assessment of KBD and feather scoring. Keel bone damage was determined according to the WILKINS et al. (2004) palpation technique. Within the FL and FR systems laying hens were fenced in, while within the EC and AV systems they were taken from different cages and levels, on again the basis of random sampling. Palpation was performed by running fingers alongside and over the keel bone. Each hen was held gently by one person, and another person examined and palpated the keel bone. It was only determined whether KBD was present (fracture, deformation) or not (completely straight and flat keel bone). During KBD assessment, the feather condition of 7 body parts (head, neck, breast, tail, wings, back and belly/vent) were scored on a 4 point scale adapted from the TAUSON et al. (2006) scoring system. A score ranging from 1 to 4 was given to each body part, in which the highest score indicated the best PC, and the lowest represented the worst PC. Score 1 = high grade damage of plumage and bare regions, score 2 = obvious damage to feathers and/ or bare areas, score 3 = completely or nearly completely feathered, but with damaged feathers, and score 4 = a very good PC with nearly no damaged feathers. For a total plumage score (TPS), the average of the scores of the 7 individual body parts was taken. Both KBD and feather scoring evaluation were performed by the same person, specially trained for those procedures.

Data were analysed using the statistical program IBM SPSS Statistics v. 25.0 (IBM Corp., 2017). Normality of data distribution was assessed with the Kolmogorov-Smirnov test, and homogeneity of variances was evaluated with Levene's test. The Student t-test was conducted to determine the effect of KBD and phase of production cycle on TPS and individual body part feather scores. One- way ANOVA was applied to evaluate the respective effect of housing system and hybrid, and the Bonferroni test was used for adjustment of the confidence interval. A value of $P<0.05$ was considered significant in all comparisons.

Results

In the light of the results of the present study, plumage scoring was not significantly affected by KBD (Table 2).

On the other hand, TPS was significantly affected by the type of housing system. Hens reared in AV and FL systems had significantly ($P<0.05$) higher feather scores compared to the hens reared in the other two farming systems, with the lowest feather score found in hens housed in the FR system, which was significantly ($P<0.05$) lower compared to the EC system (Table 3). Individual plumage scoring was also significantly affected by the type of housing system. As demonstrated in Table 3, hens housed in the FR system had significantly ($P<0.05$) lower feather score on the head, neck, breast, back and belly/vent compared to the hens in all other housing systems observed. Moreover, the wings and tail of hens housed in the FR system, and the EC system, scored significantly ($P<0.05$) lower compared to hens housed in the AV and FL systems.

Table 2. The effect of keel bone damage on the plumage condition of laying hens, data are presented as mean±SE

Plumage scoring	Keel bone damage	
	DK (n=81)	NK (n=169)
Head	3.87±0.03	3.88±0.02
Neck	3.87±0.03	3.88±0.02
Breast	3.77±0.06	3.79±0.03
Back	3.87±0.03	3.88±0.02
Belly/vent	3.87±0.03	3.88±0.02
Wings	3.39±0.07	3.52±0.04
Tail	3.56±0.06	3.68±0.04
TPS	3.74±0.04	3.79±0.02

DK: damaged keel bone: deformation and/or fracture; NK: normal keel bone: no signs of deformation or fracture present; TPS: total plumage score

Table 3. The effect of housing system on the plumage condition of laying hens, data are presented as mean±SE

Plumage scoring	Housing system			
	AV (n=50)	EC (n=100)	FL (n=50)	FR (n=50)
Head	4.00^{a}±0.00	3.94^{a}±0.03	4.00^{a}±0.00	3.36^{b}±0.05
Neck	4.00^{a}±0.00	3.94^{a}±0.03	4.00^{a}±0.00	3.36^{b}±0.05
Breast	4.00^{a}±0.00	3.83^{a}±0.05	4.00^{a}±0.00	3.14^{b}±0.09
Back	4.00^{a}±0.00	3.94^{a}±0.03	4.00^{a}±0.00	3.36^{b}±0.05
Belly/vent	4.00^{a}±0.00	3.94^{a}±0.03	4.00^{a}±0.00	3.36^{b}±0.05
Wings	4.00^{a}±0.00	3.26^{b}±0.05	4.00^{a}±0.00	3.14^{b}±0.11
Tail	4.00^{a}±0.00	3.55^{b}±0.05	4.00^{a}±0.00	3.14^{b}±0.10
TPS	4.00^{a}±0.00	3.77^{b}±0.03	4.00^{a}±0.00	3.25^{c}±0.05

^{a,b,c} values within a row with different superscripts differ significantly ($P<0.05$)

AV: aviary system, EC: enriched cage system, FL: floor system, FR: free-range system; TPS: total plumage score

As summarized in Table 4, hybrid had a significant impact on both TPS and individual plumage scoring. Hy-Line Silver Brown and Isa Brown had significantly ($P<0.05$) lower TPS compared to Lohmann Brown laying hens. Regarding the PC of individual body parts, Isa Brown had significantly ($P<0.05$) lower plumage scoring on the head, neck, back and belly/vent compared to that recorded for the same body parts of the other hybrids observed. A significantly ($P<0.05$) higher breast feather score

Table 4. The effect of hybrid on plumage condition of laying hens, data are presented as mean±SE

Plumage scoring	Hybrid			
	HB (n=50)	HSB (n=50)	ISA B (n=100)	LHB (n=50)
Head	$4.00^{a}\pm0.00$	$4.00^{a}\pm0.00$	$3.71^{b}\pm0.03$	$4.00^{a}\pm0.00$
Neck	$4.00^{a}\pm0.00$	$4.00^{a}\pm0.00$	$3.71^{b}\pm0.03$	$4.00^{a}\pm0.00$
Breast	$3.88^{a,b}\pm0.13$	$3.75^{b}\pm0.06$	$3.61^{b}\pm0.06$	$4.00^{a}\pm0.00$
Back	$4.00^{a}\pm0.00$	$4.00^{a}\pm0.00$	$3.71^{b}\pm0.03$	$4.00^{a}\pm0.00$
Belly/vent	$4.00^{a}\pm0.00$	$4.00^{a}\pm0.00$	$3.71^{b}\pm0.03$	$4.00^{a}\pm0.00$
Wings	$3.14^{a}\pm0.15$	$2.61^{b}\pm0.07$	$3.61^{c}\pm0.06$	$3.81^{d}\pm0.05$
Tail	$3.56^{a}\pm0.14$	$2.98^{b}\pm0.07$	$3.61^{a}\pm0.06$	$4.00^{c}\pm0.00$
TPS	$3.80^{a,b}\pm0.08$	$3.62^{a}\pm0.04$	$3.66^{a}\pm0.03$	$3.97^{b}\pm0.03$

^{a,b,c,d}values within a row with different superscripts differ significantly ($P<0.05$)

HB: Hy-Line Brown, HSB: Hy-Line Silver Brown, ISA B: Isa Brown, LHB: Lohmann Brown; TPS: total plumage score

Table 5. The effect of phase of production cycle on plumage condition of laying hens, data are presented as mean±SE

Plumage scoring	Phase of production cycle	
	BPC (n=125)	MPC (n=125)
Head	$3.83^{a}\pm0.03$	$4.00^{b}\pm0.00$
Neck	$3.83^{a}\pm0.03$	$4.00^{b}\pm0.00$
Breast	$3.74^{a}\pm0.04$	$3.88^{b}\pm0.05$
Back	$3.83^{a}\pm0.03$	$4.00^{b}\pm0.00$
Belly/vent	$3.83^{a}\pm0.03$	$4.00^{b}\pm0.00$
Wings	$3.59^{a}\pm0.05$	$3.11^{b}\pm0.06$
Tail	$3.68^{a}\pm0.05$	$3.49^{b}\pm0.05$
TPS	$3.75^{a}\pm0.03$	$3.78^{a}\pm0.03$

^{a,b}values within a row with different superscripts differ significantly ($P<0.05$)

BPC: beginning of production cycle (22-38 weeks of age); MPC: middle of production cycle (43-56 weeks of age); TPS: total plumage score was recorded in Lohmann Brown hens compared to Hy-Line Silver Brown and Isa Brown hens. Furthermore, the wing plumage scoring significantly ($P<0.05$) differed between the hybrids, with the highest score recorded for Lohmann Brown, followed by Isa Brown, Hy-Line Brown and Hy-Line Silver Brown. Similarly, a significantly ($P<0.05$) higher tail plumage score was found in Lohmann Brown laying hens, and it was significantly ($P<0.05$) lower in Hy-Line Silver Brown hens as compared to other hybrids. There was no significant difference in tail plumage coverage between Hy-line Brown and Isa Brown hens.

The phase of production cycle had no significant effect on TPS (Table 5). However, the laying hens in the middle of the production cycle had significantly ($P<0.05$) higher plumage scoring in the areas of the head, neck, breast, back and belly/vent compared to the beginning of the production cycle. The opposite was observed for wing and tail plumage scoring. Younger hens (22-38 weeks of age) had significantly ($P<0.05$) higher wing and tail feather scores compared to older ones (43-56 weeks of age) (Table 5).

Discussion

Similar to our findings, DONALDSON et al. (2012) observed no significant relationship between KBD and feather coverage, although in their study there was a tendency of decreasing total feather coverage score with increasing keel-inju- ry score. According to RIBER and HINRICHSEN (2017), the prevalence of KBD was significantly higher in hens with poor PC compared to that found among hens with good/moderate PC. Moreover, they observed that injurious pecking damage was positively associated with KBD. These authors suggested that in flocks experiencing high levels of injurious pecking, fearfulness increases, and as a result flighty birds have a higher risk of both keel bone fractures, due to more uncontrolled landings and lift-offs, and keel bone deviations, because scared birds may spend more time perching. In the present study, no hens with poor or moderate PC were recorded since hens with either damaged or normal keel bones had plumage scoring ≥3, indicating good feather cover (TAUSON et al., 2006).

The present study demonstrated the significant impact of housing system on the PC of laying hens, confirming the findings of previous reports (HÄNE et al., 2000; SEDLAČKOVÁ et al., 2004; LAMBTON et al., 2010; SHERWIN et al., 2010; HABIG and DISTL, 2014; PICHOVÁ et al., 2017; DECINA et al., 2019). The total plumage scoring of laying hens housed in AV and FL systems was significantly higher than that recorded in hens in FR and EC systems. Also, in the EC system as compared to the FR system. The significantly lower plumage scoring recorded in head, neck, breast, back and belly/vent of FR hens compared to these areas in hens housed in AV, EC and FL housing systems, as well as the significantly lower wing and tail plumage scorings of hens kept in FR and EC housing systems compared to hens in AV and FL systems, can explain the differences in TPS observed in this study.

The lower feather scoring recorded in hens housed in FR and EC systems compared to AV and FL systems, and FR compared to the EC system in this study could be due to both abrasion and feather pecking. Abrasion of the plumage against cage walls or towards other hens has been previously suggested as a reason of lower feather quality in caged hens (BLATCHFORD et al., 2016; PICHOVÁ et al., 2017). According to HUGHES and MICHIE (1982), even in cages, most of the plumage damage is caused by feather pecking by cage mates or hens from adjacent cages rather than by abrasion. Feather pecking exists in all commercial laying hen production systems, however, it presents a significant problem in alternative housing systems, where pecking birds have access to a large num- ber of potential victims, and perpetrators cannot be easily identified (LAMBTON et al., 2010). Similar to our results, other researchers also found lower feather scoring in enriched caged hens compared to those housed in alternative production systems, such as deep litter pens (PICHOVÁ et al., 2017) or aviaries (BLATCHFORD et al., 2016). In contrast, RÖNCHEN et al. (2007) observed that hens kept in furnished cages had better total PC than those kept in a small AV system. Opposed to our findings, better plumage coverage was recorded by

SHERWIN et al. (2010) in free range hens compared to those housed in conventional cages, furnished cages and barns (indoor single-tier aviary), while a higher prevalence of poor PC was observed in barn housed hens. A better feather score in free range hens compared to cage housed hens was also recorded by YILMAZ DIKMEN et al. (2016). In the comparative study by MOLLENHORST et al. (2005), the TPS did not differ between caged and deep litter housed hens, however individual plumage scores showed significant differences between housing systems. Specifically, it was observed that the wings and breast feathers were more damaged in the caged hens, whereas the head and under-neck feathers were more damaged in the birds housed in a deep litter system. In the present study, the access of laying hens to an outdoor run did not seem to affect their PC positively compared to hens housed in the other alternative housing systems, including in cages. The available research findings are conflicting regarding whether the provision of access for laying hens to a grassy free range area affects the incidence of feather pecking and PC of birds (HÄNE et al., 2000; SEDLAČKOVÁ et al., 2004; HEERKENS et al., 2015). The differences in plumage scores recorded in the present study in comparison with those obtained in former reports are probably due to differences in the hybrids and scoring systems used, as well as the housing design and management conditions.

In agreement with other authors (SEDLAČKOVÁ et al., 2004; YAMAK and SARICA, 2012; BRINKER et al., 2014; HABIG and DISTL, 2014; HEERKENS et al., 2015; GIERSBERG et al., 2017; DECINA et al., 2019), the PC of individual body regions, and accordingly the TPS, was significantly influenced by the hens' genotype. The differences of TPS observed among the hybrids in this study are due to similar differences recorded in the plumage cover of the birds' individual body parts. In the study by KJAER (2000), the feather pecking behavior was recorded of four commercial strains kept in aviary systems. It was demonstrated that the feather pecking activity of Isa Brown hens was higher than Lohmann Brown hens, and that across strains the bout length was on average significantly longer for feather pecking directed to the tail in contrast to other body parts. These findings support the higher plumage scoring of Lohmann Brown compared to Isa Brown hens observed in this study, and may also explain the significant differences in tail feather scoring between them. Contrary to our results, HEERKENS et al. (2015) recorded a better PC in the wings of Isa Brown compared to Lohmann Brown hens housed in AV systems. However, their study was performed in older hens (60 weeks of age) than those used in this study. Former investigations carried out on various lines have demonstrated that different body areas are prone to feather damage during the laying period, such as the back and rump (BILCÍK and KEELING, 1999), the rump and tail (BRIGHT et al., 2006), the back, rump, and tail (HARTCHER et al., 2015) or the back and tail, and the breast/belly (GIERSBERG et al., 2017). Furthermore, there is research evi- dence indicating that there is a genetic correlation across breeds for feather condition score between different body regions (BRINKER et al., 2014). The trend where some breeds demonstrate feath- er pecking activity towards specific body areas, as well as the probability of certain body parts in some strains presenting plumage deterioration over time could partly explain the differences in individual PC across the hybrids used in this trial.

Many researchers have observed aggravation of the PC of laying hens with increasing age (BILCÍK and KEELING, 1999; SEDLAČKOVÁ et al., 2004; LABRASH and SCHEIDELER, 2005; SHERWIN et al., 2010; HABIG and DISTL, 2014; DECINA et al., 2019). In agreement with these authors, deterioration of the wing and tail PC in hens that were in the middle of the production cycle compared to that recorded in younger hens was also observed in this study. It has been previously documented that the major reason for feather damage is feather pecking (HABIG and DISTL, 2014). In this study, the lower wing and tail feather scoring recorded in hens in the middle of the production cycle could be attributed to feather pecking, which has been proved to increase during the laying period (SHERWIN et al., 2010). However, this finding could also be due to abrasion of these body parts of birds on the walls of the pen, or against other hens. This mechanism has been previously indicated by other authors as being the main reason for tail plumage deterioration during the laying period (BILCÍK and KEELING, 1999). Similarly, the feather loss on the breast and belly region of the younger hens observed in this study may be attributable to abrasion of these body areas on housing equipment such as perches, as previously suggested by other investigators (GIERSBERG et al., 2017), or it could be due to feather pecking activity. On the other hand, the lower feather scoring observed on the heads and necks of hens that were at the beginning of the production cycle compared to older ones, could be due to the development of aggressive pecking behavior among hens in order to establish and maintain dominance hierarchies. This assumption is also confirmed by the behavioral observations of BILCÍK and KEELING (1999) carried out in commercial laying hens at the ages of 22, 27, 32 and 37 weeks. These authors indicated that aggressive pecks are the cause of most of the feather damage on the head as increasing amounts of aggressive pecks received were associated with increased feather damage at the ages of 27 and 32 weeks. Both in nature and farm conditions, ranking begins from the moment unfamiliar birds are put together (RELIĆ et al., 2019), so the transportation of young pullets from the rearing environment to the final production system could trigger such behavior. The significant loss of feathers on the head, neck, breast, back and belly/vent of 22-38 week old hens compared to older ones, in combination with the significantly increased feather damage recorded on the wings and tails of older hens resulted in the non-significant differences in TPS among hens at the beginning and in the middle of the production cycle.

Despite the fact that TPS was unaffected by some of the parameters evaluated in this study, the scores for individual body parts were significantly affected. These results provide evidence that when investigating potential risk factors for plumage deterioration in laying hens, individual body part scores should always be analyzed and not only the TPS. Otherwise, if only an overall plumage score is used, the influences might be underestimated or even missed, leading to misinterpretation and wrong conclusions. This finding is in compliance with earlier reports (MOLLENHORST et al., 2005; CAMPE et al., 2018).

Conclusions

The results obtained in this study indicated no impact of KBD on the feather cover of commercially raised laying hens. Housing system, genotype and phase of production cycle affected the PC. The study results suggest individual body plumage scoring as a recommendable option when searching for influences on PC. Taking into consideration the limited number of studies reporting on the effect of KBD on the feather cover of laying hens, and the different findings observed, the relationship between KBD and PC should be further investigated. This way a number of scenarios of how KBD affects PC and *vice versa* could be clarified. Finally, further research is needed to determine the effect of KBD on the PC of laying hens at the end of the production cycle.

Ethics statement

The study was conducted according to the guidelines of the Declaration of Helsinki. No invasive procedures were performed on the animals. Birds were handled in accordance with the rules and practices of poultry welfare during the evaluations.

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Declaration of competing interest

The authors declare no conflict of interest.

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DEDOUSI, A., M. ĐUKIĆ STOJČIĆ, E. N. SOSSIDOU: Utjecaj oštećenja prsne kosti, sustava držanja, hibridne linije i faze proizvodnog ciklusa na stanje perja kokoši nesilica. Vet. arhiv 95, 457-467, 2025.

SAŽETAK

Cilj rada bio je istražiti utjecaj oštećenja prsne kosti, sustava držanja, hibridne linije i faze proizvodnog ciklusa na stanje perja kokoši nesilica. Pokusi su provedeni na pet industrijskih farmi primjenom različitih sustava držanja: obogaćeni kavezni sustav držanja, podni sustav držanja, sustav slobodnog uzgoja i sustav volijera. Istraživanje je obuhvatilo hibride *Isa Brown*, *Hy-Line Brown*, *Hy-Line Silver Brown* i *Lohmann Brown*. Za utvrđivanje oštećenja prsne kosti i stanja perja nasumično je odabrano 50 kokoši nesilica po farmi. S obzirom na fazu pernaćenja i procjenu oštećenosti prsne kosti, jedinke su razvrstane u skupine, i to u skupinu koja je na početku proizvodnog ciklusa (22-38 tjedana) i skupinu jedinki koje su u sredini proizvodnog ciklusa (43-56 tjedana). Procijenjen je ukupni rezultat stanja perja kao i stanje perja na sedam pojedinačnih dijelova tijela. Pokazalo se da oštećenje prsne kosti nije znakovito utjecalo na stanje perja. Sustav držanja i hibridna linija utjecali su znakovito ($P<0,05$) na ukupni rezultat u pogledu stanja perja i na rezultate za pojedine dijelove tijela. Kokoši držane u sustavu volijera i držane na podu imale su znakovito veći ($P<0,05$) ukupni rezultat u odnosu na kokoši u obogaćenim kavezima i sustavu slobodnog držanja, uz znakovito manji ($P<0,05$) broj bodova za kokoši u sustavu slobodnog držanja u odnosu na kokoši u obogaćenim kavezima. *Hy-Line Silver Brown* i *Isa Brown* imale su znakovito manji ($P<0,05$) broj bodova za ukupno stanje perja u odnosu na hibridnu liniju *Lohmann Brown*. Faza proizvodnog ciklusa nije znakovito utjecala na stanje perja, premda su uočene znakovite razlike ($P<0,05$) u rezultatima za pojedine dijelove tijela među kokošima u različitim fazama proizvodnog ciklusa. Istraživanje je pokazalo da na perje kokoši nesilica utječu sustav držanja, genotip-hibridna linija i faza proizvodnog ciklusa, dok oštećenje prsne kosti nema utjecaja.

Ključne riječi: kokoši nesilice; izgled perja; oštećenje prsne kosti; sustav držanja; hibridi; proizvodni ciklus