applied sciences

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Investigation of the Plumage Condition of Non-Beak-Trimmed Rhode ISLAND-Type Pedigree Hens in Cages and Alternative Pens

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Abstract: The extent of the feathers covering a bird's body and the condition of the plumage largely determine the bird's well-being and aesthetic condition. This investigation aimed to compare changes in the plumage status of laying hens in dissimilar housing systems in the egg-laying period. The experiment was carried out with 1460 non-beak-trimmed laying hens, provided by Bábolna TETRA Ltd., representing a part of the Rhode-type elite lines (Rhode Island Red (RIR) and Rhode Island White (RIW)) used for breeding brown layer hybrids. Hens were kept in the closed experimental laying house of MATE University (Kaposvár Campus), where the RIR and RIW hens were placed into three types of housing systems: EU standard furnished cage (EU) (7560 cm^2; 10 hens/cage; 756 cm^2/hen); Alternative pen (A) (5.52 m^2, floor and litter combination, 53 hens/pen; 1040 cm^2/hen); and Conventional cage (C) (3780 cm^2; 6 hens/cage; 630 cm^2/hen). The feathering status of the hens was examined at five body parts: neck, breast, wings, back and tail at 33, 45 and 61 weeks of age, which was evaluated on a four-grade scale by the same experienced scorer, and the cumulated plumage point (5–20) was calculated for each hen. The RIW genotype had a better plumage condition than RIR at each of the examined times (at the 33rd week: 19.0, 18.3; at the 45th week: 18.4, 17.4; at the 61st week: 17.2, 15.5). The status of the plumage of the RIR hens had deteriorated to a greater extent. As age progressed, the plumage condition of both genotypes significantly deteriorated in all the three housing technologies. The relatively high level of deterioration can be partly explained by the fact that the animals were non-beak-trimmed. At all test times, the total feather score of the birds in the alternative cage housing was significantly better (at the 33rd week: EU: 18.4, A: 19.1, C: 18.5; at the 45th week: EU: 17.6, A: 18.6, C: 17.4; at the 61st week: EU: 15.9, A: 16.9; C: 16.1). The condition of the neck plumage was better in group RIW than in RIR, and the best in the alternative housing at each test time. At the end, the high decomposition results were striking, since at the beginning there were values close to the maximum (3.98; 3.99). It can be concluded that the reason for the dominantly favorable aviary results is that the hens in this type of housing have to come into contact with fewer mechanical factors, their companions do not jump on their backs when changing places, they do not have to stick their heads out of the grid to collect feed, etc. In addition to all this, they also had a littered scratching area and a nest lined with artificial grass, where they could scratch and take a dust bath.

Keywords: hen; beak trimming; plumage; egg production; mortality; housing system

Citation: Szász, S.; Milisits, G.; Orbán, A.; Farkas, T.P.; Pető, L.; Mezőszentgyörgyi, D.; Garamvölgyi, E.; Horn, P.; Sütő, Z. Investigation of the Plumage Condition of Non-Beak-Trimmed Rhode ISLAND-Type Pedigree Hens in Cages and Alternative Pens. *Appl. Sci.* **2023**, *13*, 4501. https://doi.org/10.3390/app13074501

Academic Editor: Luis Javier Garcia Villalba

Received: 23 February 2023
Revised: 27 March 2023
Accepted: 29 March 2023
Published: 1 April 2023

1. Introduction

A characteristic element of the outer covering of birds and unique to this taxonomic class is the plumage. The extent of the feathers covering a bird's body and the condition of the plumage largely determine the bird's well-being and aesthetic condition. Meanwhile, it also provides clues about the individual's health status [1].

After the feather has developed, it becomes a lifeless formation and begins to wear and tear. This process in poultry farming is carried out by various technological elements; feeders, drinkers, grid elements, etc., are facilitated. They effectively contribute to the wear and tear of feathers and even to the balding of some parts of the body [2]. The damage and loss of function of the plumage can be caused not only by the mentioned technological elements, but also by the species themselves, with their well-intentioned, inquisitive pecking or during escape reactions, by jumping on each other. The group size is also a factor that strongly influences the state of the plumage [3]. At the same time, feather pecking can also become a bad trait, in addition to pulling out feathers, eating feathers, pinching skin areas that have become featherless, injuring other individuals, and finally, cannibalism [4–6]. This process can easily increase during the time spent in production [7,8].

Some of the layer hybrid genotypes on the market today were bred at a time when breeding companies did not have to pay attention to the temperament of the hens or genetically determined harmful traits (e.g., aggressiveness, susceptibility to feather plucking, cannibalism), which are currently not allowed in hen keeping trends [9–11].

These new trends are partly influenced by the "End the cage age" movement and are characterized by cage-free housing, free-range housing and the absence of beak trimming [12]. Beak trimming has already been banned in several European countries [13]. Although beak trimming was originally used to decrease feather pecking and cannibalism [14–17] because in non-beak-trimmed herds, aggression and cannibalism can unfortunately be higher, the consequence of which is a higher mortality rate, and the rate of egg breakage and feed waste may also increase [10,11]. The appearance of bad habits in these husbandry technologies represents a particularly significant animal health and economic risk. In order to mitigate these risks, the world's leading hen breeding companies have successively started to breed layer hybrids with a calm temperament and nature that meet the new expectations, since selection can also help reduce aggression, including the level of feather pecking [18].

The basis of the breeder's work is the selection of purebred maternal and paternal pedigree lines, which are then responsible for the production of a huge number of offspring, which is why it is necessary at this level to filter out individuals carrying traits harmful to the breeder. Temperament can be judged by gene mapping, ethological tests and the examination of the hen's plumage during production. Based on these, it is clear that the examination of the state of the plumage, the so-called feather scoring, can provide an opportunity to monitor the status of the flocks.

This investigation therefore aimed to compare changes in the plumage condition of non-beak-trimmed laying hens in different housing systems during the egg-laying period. The aim of this study was not to make an ethological laboratory study, but model the farm conditions, where plumage condition was considered as an indicator trait for feather pecking.

2. Materials and Methods

2.1. Experimental Animals and Housing Conditions

The experiment was carried out with altogether 1460 non-beak-trimmed laying hens, which all originated from Bábolna TETRA Ltd., representing a part of the Rhode-type pedigree lines (Rhode Island Red (RIR) and Rhode Island White (RIW)) used for breeding brown egg layer hybrids. All genotypes were reared (according to the parent stock management guide of Bábolna TETRA Ltd.) in the same building, under the same conditions, in deep litter until the 18th week of life.

Hens were kept in the closed laying house of the Experimental Poultry Farm of the Hungarian University of Agricultural and Life Sciences, Kaposvár Campus, where both the RIR and RIW hens were placed into three different types of housing systems:

1. EU standard furnished cage (KOVOBEL SKNO-/30-60/ECS, 7560 cm^2 basic area; 10 hens/cage; 756 cm^2/hen);
2. Alternative pen (5.52 m^2 basic area, floor and litter (dust-free softwood shavings) combination, 53 hens/pen; 1040 cm^2/hen);

3. Conventional cage (3780 cm^2; 6 hens/cage; 630 cm^2/hen).†

[† Permissions: MÁB 232.1/00412/0016/2011; SOI/312766-7/2016 (KA-2044)]

The experiment was conducted between the ages of 18 and 72 weeks. For the *ad libitum* feeding of the hens, commercial layer starter diet was supplied until 20 weeks of age, followed by layer feed (Table 1). Drinking water was continuously available from self-drinkers. In the poultry house, the average temperature was 14–18 °C, and humidity was between 65 and 70%. The lighting period was 16L:8D (light: 5:00–21:00 h; 30 lux, warm white).

Table 1. Composition of the diets used in the examined egg-laying period.

Component	Diet	
	Layer Starter (18–19 Weeks)	Layer (20–72 Weeks)
Dry matter (%)	89.0	89.0
ME Poultry (MJ/kg)	11.69	11.40
Crude protein (%)	17.5	17.5
Crude fat (%)	3.44	4.72
Crude fiber (%)	4.84	3.61
Crude ash (%)	10.35	14.00
Nitrogen-free extractives (%)	57.8	54.9
Sodium (%)	0.17	0.17
Lysine (%)	0.80	0.85
Methionine (%)	0.40	0.42
Calcium (%)	2.50	3.80
Phosphorous (%)	0.42	0.40

2.2. Examination of the Condition of the Plumage

The plumage condition of hens was assessed at 33, 45 and 61 weeks of age. It was controlled at five different body parts: neck, breast, wings, back and tail. Based on a reference photo series [19], the plumage condition was evaluated on a four-grade scale, where:

4: Intact plumage;

3: Slightly damaged feathers (the tip of the feather is worn, body covered with plumage overall);

2: Moderately damaged (the feather shows a partial lack of rachis, skin parts visible);

1: Strongly damaged and incomplete plumage (rachis without vane, big skin parts visible).

By summing the plumage scores of the different body parts, a total plumage score was calculated for each hen, which varied between 5 and 20. Plumage condition was scored by the same experienced scorer throughout the study period.

2.3. Statistical Analysis

The effect of type and housing system on the plumage condition of the hens was statistically evaluated by Multivariate Analysis of Variance using the following General Linear Model:

$$Yijk = \mu + Ti + HSj + Ti \times HSj + eijk, \quad (1)$$

where

Yijk = observation k in level i of factor T, and level j of factor KS; μ = overall mean;
Ti = type (RIR or RIW) of the ith hen (i = 1–2); HSj = housing system of the jth hen (j = 1–3);
Ti × HSj = interaction between the type and housing system of the hens; eijk = random error.

All data were evaluated with the SPSS 10.0 software package [20].

3. Results and Discussion

Plumage Condition

A significant difference was found between the Rhode Island Red- and White- genotype hens in all the investigated ages (Table 2). It can be seen that the Rhode Island White genotype had a significantly better plumage condition at each of the examined times. By

carefully examining the plumage of the animals, beyond the scoring, it was noticed that the plumage of the Rhode Island White animals always gave the impression of being richer, denser, cleaner, healthier and longer-lived. Overall, it can also be said that the state of the plumage of the Rhode Island Red hens deteriorated to a greater extent compared to the first examination date than in the case of the Rhode Island White birds. The Rhode Island White hens continued to maintain relatively good feather condition. As age progressed, the plumage status of the hens significantly deteriorated for both genotypes and for the three housing technologies, which corresponds to the literature data [21–23]. The relatively high level of deterioration can be partly explained by the fact that the animals were non-beak-trimmed, as the state of the plumage deteriorates to a greater extent in non-beak-trimmed flocks [24,25].

Table 2. Effect of type and housing system on the total plumage score of non-beak-trimmed Rhode Island hens.

Age (Weeks)	Type		Housing System			Prob.			SE
	Rhode Island Red	Rhode Island White	EU Standard Cage	Alternative Pen	Traditional Cage	Type	Housing System	Interaction	
33	18.3 ^{C}	19.0 ^{C}	18.4 ^{aC}	19.1 ^{bC}	18.5 ^{aC}	<0.001	<0.001	<0.001	0.030
45	17.4 ^{B}	18.4 ^{B}	17.6 ^{aB}	18.6 ^{bB}	17.4 ^{aB}	<0.001	<0.001	<0.001	0.047
61	15.5 ^{A}	17.2 ^{A}	15.9 ^{aA}	16.9 ^{bA}	16.1 ^{aA}	<0.001	<0.001	<0.001	0.082
Prob.	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
SE	0.037	0.057	0.050	0.054	0.092	-	-	-	-

Total plumage score could be ranged from 5 (worst) to 20 (best). ^{ab} Different letters in the same row indicate significant differences ($p \leq 0.05$). ^{ABC} Different letters in the same column indicate significant differences ($p \leq 0.05$).

At all test times, the total feather score of the birds in the alternative pen housing was significantly better. Examining the genotype–environment correlation, similar to previous research [26], it can be concluded that the herds housed in the alternative pen housing technology had the most favorable results. In another very interesting study [27], the state of the hens' plumage was the best where the hens could move freely, vertically and horizontally. Where only one of these was possible, it was worse. It is interesting that in relation to this, there is also an opposite opinion in the literature, according to which environmental enrichment in some husbandry technologies does not affect the state of the plumage of layers [24].

In the alternative housing technology, the base area of the pen was a scratching area littered with wood shavings. It has also been shown in cages that a significant improvement in the plumage and health of the hens can be achieved only by providing litter [28].

The condition of the neck plumage worsened with age in both genotypes included in the study (Table 3). Between weeks 33 and 61, we measured 22.5% lower plumage point values for the Rhode Island Red genotype, and 19.3% lower plumage point values in the Rhode Island White herd. Among the genotypes, the RIW received a higher score than the RIR herd at all test times.

Table 3. Effect of type and housing system on the plumage points on the neck feathers of non-beak-trimmed Rhode Island hens.

Age (Weeks)	Type		Housing System			Prob.			S. E.
	Rhode Island Red	Rhode Island White	EU Standard Cage	Alternative Pen	Traditional Cage	Type	Housing System	Interaction	
33	3.46 ^{C}	3.79 ^{C}	3.51 ^{aC}	3.87 ^{bC}	3.50 ^{aC}	<0.001	<0.001	<0.001	0.013
45	3.24 ^{B}	3.59 ^{B}	3.30 ^{bB}	3.78 ^{cB}	3.16 ^{aB}	<0.001	<0.001	<0.001	0.019
61	2.68 ^{A}	3.06 ^{A}	2.63 ^{aA}	3.23 ^{bA}	2.75 ^{aA}	<0.001	<0.001	<0.001	0.029
Prob.	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
SE	0.017	0.019	0.019	0.017	0.037	-	-	-	-

Plumage point could be ranged from 1 (worst) to 4 (best). ^{abc} Different letters in the same row indicate significant differences ($p \leq 0.05$). ^{ABC} Different letters in the same column indicate significant differences ($p \leq 0.05$).

The condition of the neck feathers deteriorated with age in all the tested housing technologies.

The most favorable neck feathering results were determined in the alternative posture at each test time. The use of a different type of feeder in cage housing, where the allocation of the anti-scratch grid was different than in the troughs of cage housing, may have played a role in this. In the 33rd and 61st weeks, the results measured in the furnished and traditional cages did not vary statistically. At the same time, in the middle of the study, all postures differed significantly from the others.

Examining the feather area of the back (Table 4), the high decomposition results are striking, since at the beginning of the measurements there were values close to the maximum (3.98; 3.99) and at the end of the test period, we did not receive ratings falling below the average of 3.0. This means that the wear and tear of this pen area was remarkably small.

Table 4. Effect of type and housing system on the plumage points on the back feathers of non-beak-trimmed Rhode Island hens.

Age (Weeks)	Type		Housing System			Prob.			SE
	Rhode Island Red	Rhode Island White	EU Standard Cage	Alternative Pen	Traditional Cage	Type	Housing System	Interaction	
33	3.93 ^{C}	3.98 ^{B}	3.95 ^{bC}	3.99 ^{cC}	3.91 ^{aB}	<0.001	<0.001	<0.001	0.006
45	3.81 ^{B}	3.94 ^{B}	3.84 ^{aB}	3.94 ^{bB}	3.86 ^{aB}	<0.001	<0.001	<0.001	0.012
61	3.33 ^{A}	3.76 ^{A}	3.55 ^{A}	3.51 ^{A}	3.57 ^{A}	<0.001	0.548	<0.001	0.024
Prob.	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
SE	0.021	0.016	0.013	0.014	0.023	-	-	-	-

Plumage point could be ranged from 1 (worst) to 4 (best). ^{abc} Different letters in the same row indicate significant differences ($p \leq 0.05$). ^{ABC} Different letters in the same column indicate significant differences ($p \leq 0.05$).

Evaluating the genotypes, it can be concluded that the RIW flocks received higher values than the RIR birds at all test times. Their plumage was in better condition, and wear was less typical, even at the end of the test. The effect of the housing methods on the plumage of the back was less pronounced, since, while in the 33rd week every system was different from the others, at the second examination date only the alternative system diverged verifiably from the two cage systems, and finally, in the 61st week, there was no verifiable difference between the housing technologies, so all of them remained above 3.5 points, i.e., less than 12.5% pen wear and tear could be measured on the back.

At 33 weeks, the condition of the hens' back plumage was significantly better in the furnished cage with perches and in the alternative pen with even more perches. This result is consistent with a previous literature finding that the condition of the back plumage of layers is better in cages containing perching bars [29].

The favorable results of the back area were not reflected in the rectrices (Table 5).

Table 5. Effect of type and housing system on the plumage score on the rectrices of non-beak-trimmed Rhode Island hens.

Age (Weeks)	Type		Housing System			Prob.			SE
	Rhode Island Red	Rhode Island White	EU Standard Cage	Alternative Pen	Traditional Cage	Type	Housing System	Interaction	
33	3.27 ^{C}	3.38 ^{C}	3.24 ^{aC}	3.51 ^{bC}	3.23 ^{aB}	0.001	<0.001	0.004	0.014
45	2.98 ^{B}	3.12 ^{B}	3.01 ^{bB}	3.26 ^{cB}	2.88 ^{aA}	<0.001	<0.001	<0.001	0.017
61	2.55 ^{A}	3.07 ^{A}	2.74 ^{A}	2.80 ^{A}	2.88 ^{A}	<0.001	0.152	<0.001	0.027
Prob.	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
SE	0.014	0.017	0.016	0.020	0.029	-	-	-	-

Plumage point could be ranged from 1 (worst) to 4 (best). ^{abc} Different letters in the same row indicate significant differences ($p \leq 0.05$). ^{ABC} Different letters in the same column indicate significant differences ($p \leq 0.05$).

At the time of the first scoring, 15–18% feather wear and tear could be recorded in this pen area. The obvious reason for this is the large size of these feathers, and thus their relative

"hanging out" from the streamlined bird's body—compared to contour feathers—which makes these feathers more vulnerable in contrast to their stable structure.

For each of the two Rhode genotypes, decreasing measurement values appeared with advancing age. The white birds behaved better here as well, compared to the RIR type.

In the case of housing systems, we recorded for the first time a situation where the alternative system was preceded by the result of a cage technology. This occurred at week 61, when the conventional cage, which was said to be the least gentle, had the highest tail feather scoring points. In the previous tests, the usual results were obtained, and the highest points were given by the hens living in the alternative system. The difference in the two cases is that in the 45th week the two cage systems were also statistically proven to be separated from each other; in the 33rd week this was not the case.

The breast was the examined area where the plumage was least damaged (Table 6). Here, it was possible to record 100% intact plumage, in traditional cage housing. This is an interesting result because, on the one hand, in other studies, the greatest degree of damage was specifically measured in the case of the breast plumage, and also, as the age advances, the breast plumage deteriorates the most [30]. In our case, the opposite happened.

Table 6. Effect of type and housing system on the plumage points on the breast feathers of non-beak-trimmed Rhode Island hens.

Age (Weeks)	Type		Housing System			Prob.			SE
	Rhode Island Red	Rhode Island White	EU Standard Cage	Alternative Pen	Traditional Cage	Type	Housing System	Interaction	
33	3.95 ^{A}	3.99	3.99 ^{bB}	3.98 ^{b}	3.94 ^{aA}	<0.001	0.001	<0.001	0.004
45	3.99 ^{B}	3.99	3.95 ^{aA}	3.97 ^{ab}	4.00 ^{bB}	0.004	0.007	0.212	0.005
61	3.97 ^{AB}	3.98	3.97 ^{A}	3.99	3.99 ^{B}	0.755	0.302	0.108	0.006
Prob.	0.010	0.090	0.001	0.325	0.013	-	-	-	-
SE	0.003	0.012	0.005	0.004	0.009	-	-	-	-

Plumage point could be ranged from 1 (worst) to 4 (best). ^{ab} Different letters in the same row indicate significant differences ($p \leq 0.05$). ^{AB} Different letters in the same column indicate significant differences ($p \leq 0.05$).

In this plumage area, we received several surprising measurement results. Here, the highest damage rate (10%) was experienced in the 33rd week in the traditional cage, while completely intact plumage was formed by the next test time and the highest values were also measured at the last test time.

In the other investigated feather areas, the quality of the plumage regularly deteriorated with advancing age, while in the breast area we obtained small but continuously improving values for the RIR type. However, in the case of the housing technologies, in the furnished cage and the alternative pen, by the second examination date we found a deterioration, which then improved at the last examination date, which was better than the 33rd week findings in the alternative pen.

In addition to rectrices, remiges were examined from the feathers used for flight (Table 7).

Table 7. Effect of type and housing system on the plumage points on the remiges of non-beak-trimmed Rhode Island hens.

Age (Weeks)	Type		Housing System			Prob.			SE
	Rhode Island Red	Rhode Island White	EU Standard Cage	Alternative Pen	Traditional Cage	Type	Housing System	Interaction	
33	3.69 ^{C}	3.91 ^{C}	3.70 ^{aC}	3.79 ^{bC}	3.91 ^{cC}	<0.001	<0.001	<0.001	0.012
45	3.38 ^{B}	3.72 ^{B}	3.48 ^{aB}	3.66 ^{bB}	3.51 ^{aB}	<0.001	<0.001	<0.001	0.017
61	2.92 ^{A}	3.33 ^{A}	3.05 ^{aA}	3.39 ^{bA}	2.95 ^{aA}	<0.001	<0.001	<0.001	0.025
Prob.	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
SE	0.012	0.017	0.016	0.017	0.033	-	-	-	-

Plumage point could be ranged from 1 (worst) to 4 (best). ^{abc} Different letters in the same row indicate significant differences ($p \leq 0.05$). ^{ABC} Different letters in the same column indicate significant differences ($p \leq 0.05$).

We detected a continuous deterioration of plumage quality with advancing age for all genotypes and husbandry technologies in this body area as well. The RIW genotype started with 0.22-point (6%) higher values in the 33rd week and almost doubled this difference by the end of the measurement period, when the difference was 0.41 points.

Of the housing technologies, at the beginning of the measurement, the remiges were statistically in the best condition in the traditional cage, while at the end of the measurement period, the lowest values were here and the alternative housing was the most effective, which was also significant. In cage housing, the narrower space, the higher density of animals and the wire grid present on all sides may have caused technological and mechanical damage to the remiges, as has been proven by others long before [31,32]. Such a problem did not exist in the alternative husbandry technology.

4. Conclusions

In the examined non-beak-trimmed Rhode Island Red and Rhode Island White pure lines, the condition of the plumage deteriorated as the age progressed, and wear and tear could be measured on the examined body areas, except for the breast area.

We measured the best feather conditions in the aviary alternative housing. The only exception to this was the 61st week of life and the area of the back, where, unexpectedly, in both cage treatments we established better feather classification points than in the aviary.

Regarding the genotype–environment interaction, we can state that the flocks housed in the alternative pen housing technology had the most favorable plumage condition for both the RIR and RIW genotypes, with the exception of the results of the back and tail at week 61, where the traditional cage was six and eight percentage points better, respectively showed quality values. In the background of these surprising jumps, the change of feathers that starts here earlier and the newly grown intact plumage that appears can be recognized as an average improvement effect. We recorded the lowest feather quality values for both genotypes in traditional cage housing, with exceptions discussed above.

In our opinion, the reason for the dominantly favorable aviary results is that the hens in this type of housing have to come into contact with fewer mechanical factors, their companions do not jump on their backs when changing places, they do not have to stick their heads out of the grid to collect feed, etc. In addition to all this, they also had a littered scratching area and a nest lined with artificial grass, where they could scratch and take a dust bath. In the nest, the birds were able to separate themselves from their peers not only during egg laying, but also simply for peace and rest. Thus, they were exposed to less stress, and the related restlessness and increased activity, than their peers living in cages. This resulted in better plumage status and a calmer flock.

In our study, most feather injuries and feather wear occurred on the rectrices in the case of animals kept in traditional cages, followed by the neck feathers and then the remiges.

The abrasive effect of the cage lattice has a significant role in the damage to the remiges, rectrices and neck feathers. It has also been statistically proven that in aviary housing, where it is not necessary for the plumage to collide with the lattice during the wing beat, the rectrices are less in contact with the side of the pen and the hens do not have to stick their heads between the grating to take in the feed, there were significantly fewer feather injuries than in a two-cage system.

Author Contributions: Data curation, S.S., G.M. and T.P.F.; Formal analysis, S.S., T.P.F., G.M. and Z.S.; Investigation, S.S., T.P.F., G.M., L.P., E.G. and Z.S.; Resources, A.O. and G.M.; Supervision, T.P.F., D.M., P.H. and Z.S.; Validation, T.P.F. and G.M.; Visualization, T.P.F. and G.M.; Writing—original draft, S.S., T.P.F. and Z.S.; Writing—review and editing, S.S., T.P.F. and Z.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Hungarian State, grant number 2018-1.3.1-VKE-2018-00042.

Institutional Review Board Statement: All animals were handled according to the principles stated in the Directive 2010/63/EU regarding the protection of animals used for experimental and other scientific purposes [33].

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to sensitive data about some pedigree lines.

Acknowledgments: The genotypes required for the research were provided by Bábolna TETRA Ltd.

Conflicts of Interest: A.O. and G.M. are employees of the Bábolna TETRA Ltd., which is the owner of the examined hens. The remaining authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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