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Proceeding Paper

Study of the Physiological Responses of Two Strains of Laying Hens under Thermal Challenge †

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Abstract: The breeding of laying hens has been profoundly transformed by various factors from genetic selection to the development of infrastructure, including nutritional and health management, making this activity a pillar of the food chain. However, temperature fluctuations, which are increasingly frequent due to climatic upheavals, pose significant challenges to production systems. Thermal challenges could have harmful consequences for physiological responses, thus impacting the ability to produce eggs optimally. In this general context, the work presented aims to study specific aspects of the physiological responses in two strains of laying hens, Novogen Brown and Isa Brown. The birds were maintained under thermal challenge, and measurements of the blood lipid profile and laying performance were carried out from the 26th to the 36th week of age at the rate of a sample every 15 days. The results revealed that the Novogen Brown strain presents significantly lower cholesterol levels than the Isa Brown strain when considering all samples (2.02 ± 0.09 vs. 2.45 ± 0.04 g/L; $p = 0.0098$). This general trend in the results was also observed for triglyceride levels, with respective means of 1.99 ± 0.02 vs. 2.12 ± 0.08 g/L; $p = 0.034$. The production indicators were in favor of the Novogen Brown strain, where significant increases in the laying rate were recorded (82.33 ± 3.32 vs. 79.82 ± 4.21%; $p = 0.0041$), of egg weight (59.98 ± 1.33 vs. 57.23 ± 2.32; $p = 0.00097$), as well as a reduction in the breakage rate (4.99 ± 0.23 vs. 6.02 ± 0.58%; $p = 0.021$) and mortality rate (6.41 ± 1.11 vs. 8.23 ± 2.22; $p = 0.016$). All the results also highlighted physiological responses that materialized due toa disturbance in the lipid balance, which impacted the entire production process.

Keywords: strains; laying hens; physiological responses; thermal challenge

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1. Introduction

Raising laying hens is paramount in practices ranging from food security to economics and environmental sustainability. By providing eggs for regular consumption, these birds provide consumers with a highly nutritional protein source, which is essential for a balanced diet. Beyond these contributions, the breeding of laying hens has been profoundly transformed, from genetic selection to the development of infrastructure, including nutritional and health management, making this activity a pillar of the food chain in the face of a constantly expanding global population, generating intense demand for animal proteins. In addition, this activity offers considerable economic opportunities for farmers and rural populations while promoting local development. Given all these considerations, breeding laying hens is not just a simple activity but represents a fundamental pillar of the entire food chain of populations. However, the activity remains faced with many challenges, including climate change. The latter generates increasingly frequent temperature fluctuations, which expose production systems to significant difficulties. In this sense, the thermal challenge could have harmful consequences for the physiological responses of these birds. The impacts would be more accentuated given the physiology of these animals, which lack sweat glands and are covered in feathers, which makes heat dissipation difficult and weighs heavily on maintaining thermal balance. These conditions could hurt the ability to produce eggs optimally and even affect the vitality of flocks. The study presented took place within this general context. It aims to study specific aspects of the physiological responses faced with thermal challenges in two strains of laying hens, the Novogen Brown and the Isa Brown, conducted in the summer season in northern Algeria.

2. Material and Methods

2.1. Experimental Apparatus

The experimental work coincided with the summer period, which extended from mid-June to the beginning of September. For this purpose, two separate breeding buildings were used; they were built of bricks and equipped with air extractors and cooling pads to control the atmosphere. These installations remain subject to natural variations in climatic conditions given the construction materials used, and this is what was sought from the start. The experiment concerned laying hens of the Novogen Brown strain who were kept in the first building (lot NB), while the second building housed the Isa Brown strain (lot IB). It was a question of measuring the impact of the thermal challenge, expressed by the ambient temperature and relative humidity, on blood markers, cholesterol and triglycerides, and laying performance. It is important to emphasize that the samples were taken between the 26th and 36th weeks of age, at the rate of one sample every 15 days.

2.2. Measurement Methods

2.2.1. Measurement of Ambient Parameters

Ambient temperature and relative humidity were measured using recording thermo-hygrometers; they were placed in different locations of the facilities, in the middle and at the ends. The device allows data to be recorded every half hour.

2.2.2. Measurement of the Lipid Profile

Ten laying hens per building were selected and fasted for 12 h to test the efficacy of these measures. Blood was punctured from the wing vein and collected in heparinized tubes. Subsequently, the samples were centrifuged for 15 min at 3000 rpm. The plasma was collected with micropipettes fitted with single-use tips and then placed in Eppendorf-type tubes. Cholesterolemia [1] and triglyceridemia [2] were measured by the enzymatic colorimetric method using a Biotecnica instrument, BT 3000 type spectrophotometer (Rome, Italy), and SPINREACT type reagent kits (BIOLEGEND, San Diego, CA, USA). Finally, the reading was carried out at a wavelength of 505 nm.

2.2.3. Measurement of Laying Performance

Egg Weight

Egg weight was obtained using a commercial scale.

Laying Rate

The laying rate was obtained using the following formula:

$$\text{Laying rate} = \frac{\text{Number of eggs laid}}{\text{Number of hens present}} \times 100$$

Breakage Rate

The breakage rate was calculated by this formula:

$$\text{Breakage rate} = \frac{\text{Number of broken and/or cracked eggs}}{\text{Number of eggs laid}} \times 100$$

Mortality Rate

The mortality rate was estimated using the formula:

$$\text{Mortality rate} = \frac{\text{Number of dead chickens}}{\text{Number of hens present}} \times 100$$

2.3. Data Processing

All parameters studied were expressed as means ± standard deviations, and the calculations were carried out using Microsoft Excel software in version 2007. The statistical analysis of the data consisted of a one-way analysis of variance (Anova 1) carried out using the same software and was supplemented by significance tests at three levels. Differences were considered significant when $p < 0.05$, very significant when $p < 0.01$, and highly significant when $p < 0.001$.

3. Results

3.1. Ambience Settings

The ambient parameter readings revealed that batch NB was maintained at an average temperature of 33.03 ± 5.66 °C, while for batch IB, the temperature was raised so that it stood at 32.22 ± 6.32 °C. For their part, the relative humidity levels were established at 61.22 ± 3.98% and 60.59 ± 5.87%, respectively, for the two batches.

3.2. Blood Indicators:

The Figure 1 below illustrates the average levels of cholesterol and triglyceridemia obtained during the experiment.

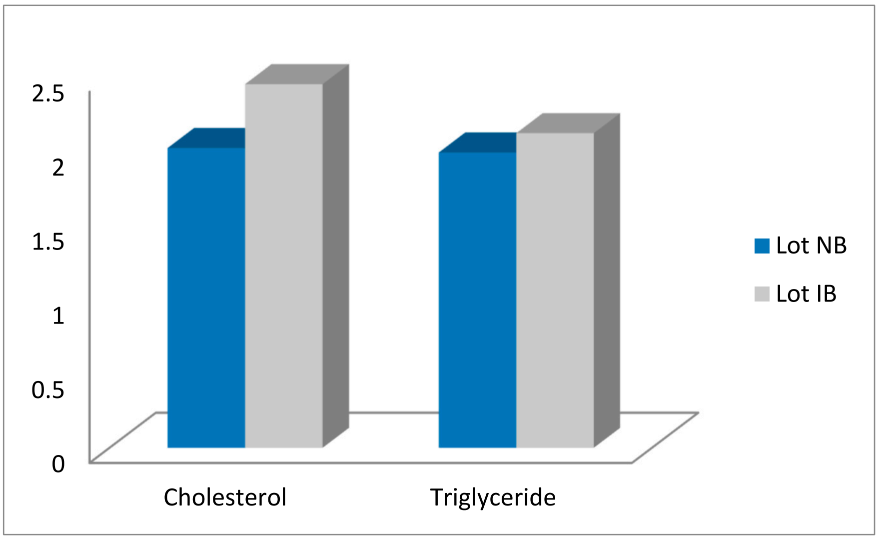

Figure 1. Cholesterol (g/L) and triglyceride (g/L) levels.

The results reveal that the Novogen Brown strain has significantly lower cholesterol levels than the Isa Brown strain. Considering all the samples, the averages were 2.02 ± 0.09 vs. 2.45 ± 0.04 g/L; $p = 0.0098$. This general trend in the results was also observed for triglycerides levels, with respective means of 1.99 ± 0.02 vs. 2.12 ± 0.08 g/L; $p = 0.034$ for all measurements.

3.3. Laying Performance

This Table 1 summarizes the laying performances obtained during the experiment.

Table 1. Laying performance.

Performance	Lot NB	Lot IB	SS
Egg weight (g)	59.98 ± 1.33	57.23 ± 2.32	p = 0.00097
Laying rate (%)	82.33 ± 3.32	79.82 ± 4.21	p = 0.0041
Breakage rate (%)	4.99 ± 0.23	6.02 ± 0.58	p = 0.021
Mortality rate (%)	6.41 ± 1.11	8.23 ± 2.22	p = 0.016

An examination of the results revealed that the production indicators were in favor of the Novogen Brown strain, where significant increases in the laying rate (82.33 ± 3.32 vs. 79.82 ± 4.21%; p = 0.0041) and egg weight (59.98 ± 1.33 vs. 57.23 ± 2.32; p = 0.00097)were recorded, as well as a reduction in the breakage rate (4.99 ± 0.23 vs. 6.02 ± 0.58%; p = 0.021) and mortality rate (6.41 ± 1.11 vs. 8.23 ± 2.22; p = 0.016).

4. Discussion

In light of the results obtained, it can be seen that the ambient parameters led to temperatures that vastly exceeded the recommendations of the breeding guides for the strains studied, which indicates that this parameter should be between 17 and 19 °C from the eighth week of age [1,3–7]. The increase in temperature also impacted the relative humidity levels, indicating a detrimental drying out of the atmosphere since breeding guides advise that humidity in buildings should be around 70%. These observations also suggest that laying hens are subjected to thermal challenges, resulting in chronic thermal stress.

Regarding blood markers, the disruption of the lipid balance could be a reaction to heat stress because the increase in ambient temperature would be accompanied by an increase in cholesterolemia and triglyceridemia [8]. To this end, some authors have reported that cholesterol acts as a precursor to adrenocorticotropic hormones, which increase significantly following hyperstimulation of the adrenal glands [9]. The latter would follow an activation of the HPA (hypothalamic–pituitary–adrenal)axis [5], leading to a reorientation of metabolic energy towards the fight against stress generated by heat [10].

All these reactions would not be without consequences for the laying process and, consequently, for production indicators. To this end, by referring to the breeding guides of the two strains studied, notable depreciations were noted since the standards indicate an average laying rate of 91 and 92% and an egg weight of 62 to 64 g. Regarding breakage and mortality, the accepted breakage rate was 4%, and the mortality rate was 3.5%. A change in these results would be a consequence of the thermal challenge since, under these particular conditions, the first reaction of the birds would be a limitation of food ingestion to fight against the extra heat generated during digestion [6]. According to the same authors, this unavailability of nutrients would alter the shell mineralization process and significantly impact the structural integrity of the eggs [4]. Finally, these reactions could jeopardize the vitality of herds [11], which was observed in the present study.

5. Conclusions

This experiment highlighted the impact of a thermal challenge on laying hens during the summer season. The results showed that the Novogen Brown strain showed more moderate physiological responses than the Isa Brown strain. This was reflected in significantly low levels of cholesterol and triglycerides, which could also be used as stress indicators. This stress reaction also resulted in a significant deterioration in the production indicators in batch IB. However, the results obtained still need to be revised to reflect the recommendations of the breeding guides for the two strains studied. Given all these observations, it is undeniable that the thermal challenge led to cascade reactions, which had repercussions on the blood biochemistry and the egg-laying process and, consequently, on the well-being of these animals. Finally, considering the consequences of high temperatures should become a priority in breeding laying hens through the implementation of measures to strictly control the environment to ensure optimal egg production and thus contribute to food safety.

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References

1. Meiattini, F.; Prencipe, L.; Bardelli, F.; Giannini, G.; Tarli, P. The 4-hydroxybenzoate/4-aminophenazone chromogenic system used in the enzymic determination of serum cholesterol. *Clin. Chem.* **1978**, *24*, 2161–2166. [CrossRef] [PubMed]
2. Fossati, P.; Prencipe, L. Serum triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. *Clin. Chem.* **1982**, *28*, 2077–2080. [CrossRef] [PubMed]
3. ISA Brown. *Product Guide-Cage Production Systems*; Institut de Sélection Animale BV. Hendrix Genetics: Boxmeer, The Netherlands, 2019; p. 36.
4. Kim, D.H.; Lee, Y.K.; Lee, S.D.; Kim, S.H.; Lee, S.R.; Lee, H.G.; Lee, K.W. Changes in production parameters, egg qualities, fecal volatile fatty acids, nutrient digestibility, and plasma parameters in laying hens exposed to ambient temperature. *Front. Vet. Sci.* **2020**, *7*, 412. [CrossRef] [PubMed]
5. Kolesnik, E.; Derkho, M.A. To the problem of physiological adaptive homeostasis in the model of the organism of warm-blooded animals (a review). *Educ. Health* **2020**, *4*, 15–30.
6. Nidamanuri, A.L.; Murugesan, S.; Mahapatra, R. Effect of heat stress on physiological parameters of layers: A review. *Int. J. Livest. Res.* **2017**, *7*, 1–17. [CrossRef]
7. NOVOGEN Brown. *Guide D'élevage des Pondeuses Commerciales*; NOVOGEN Brown: Quintin, France, 2015; p. 39.
8. Hassan, M.S.H.; Mahmoud, H.S.M.; El-Wardany, I.; Ahmed, A.M.H. Effect of heat stress and organic selenium supplementation on some physiological traits in two strains of developed laying hens. *Egypt. J. Agric. Res.* **2015**, *94*, 135–147. [CrossRef]
9. Ihsanullah, I.; Qureshi, M.S.; Suhail, S.M.; Khan, R.U. Postpartum endocrine activities, metabolic attributes and milk yield are influenced by thermal stress in crossbred dairy cows. *Int. J. Biometeorol.* **2017**, *61*, 1561–1569. [CrossRef] [PubMed]
10. Vandana, G.D.; Sejian, V.; Lees, A.M.; Pragna, P.; Silpa, M.V.; Maloney, S.K. Heat stress and poultry production: Impact and amelioration. *Int. J. Biometeorol.* **2021**, *65*, 163–179. [CrossRef] [PubMed]
11. Yan, L.; Hu, M.; Gu, L.; Lei, M.; Chen, Z.; Zhu, H.; Chen, R. Effect of heat stress on egg production, steroid hormone synthesis, and related gene expression in chicken preovulatory follicular granulosa cells. *Animals* **2022**, *12*, 1467. [CrossRef] [PubMed]