Effect of Cage Placement on Health Status of Laying Hens

Hind E. Osman and Hisham Eltegani Makey Elshreef

ABSTRACT

Evaluation of cage placement on bird’s health was done to access the efficiency of the conventional battery cages as a housing system for laying hens in the highly demanding industry in tropical countries. Experimental birds were placed in House A in the lateral sixth northern battery cage (AN6L) beside cooling pads and medial northern battery cage (ANM) horizontally at the middle lower row in both sides-left and right. Each battery raw was divided into: first third beside pad (1W) consists of 130 cages; second third in middle (2W) which also consists of 130 cages and last third beside fans (3W) consists of 128 cages. The total birds in the two batteries were about four thousand and five hundred birds. In house B, experimental birds were placed in the lateral first northern battery cage (BN1L) beside northern pad, medial northern battery cage (BNM) in middle and lateral sixth northern battery cage (BN6L) beside southern pad vertically and horizontally from bottom in both sides (left and right). Each battery raw was divided into: first third beside pad (1W) consists of 520 cages; second third in middle (2W) consists also of 520 cages and last third beside fans (3W) beside fans consists of 512 cages, the total birds in the three batteries were about thirty thousand birds. Mortality and pathological changes were used in this study to evaluate the health status and welfare of Lohmann LSL Lite laying hens at different ages. Mortality of 4500 Lohmann LSL Lite laying hens at age 80 wks was recorded for twenty days in one lateral and one medial battery in House A; and it was recorded for 30000 Lohmann LSL Lite laying hens at age 57 wks for forty three days in two lateral and one medial battery in House B. The mortality in the two laying flocks at age 80 wks and 57 wks, in the first 20 days, was found to be 7.4% and 1.6% respectively. In the next 23 days in House B, it was found to be 1.7%. The mortality of the two flocks was significantly different. In the three positions- 1W, 2W, 3W- the mortality at a lateral (AN6L) and a medial (ANM) batteries in showed significant difference in the lateral ones of House A. The mortality in the three positions 1W, 2W, 3W of two laterals (BN1L and BN6L) and one medial (BNM) battery showed significant difference between the different positions of both lateral and medial batteries. Comparing house A and house B lateral and medial batteries for the mortality in the same position, 1W, 2W or 3W, revealed significant difference in 1W and 2W, whereas position 3W was found to be insignificantly different, and no significant difference between the lateral or medial batteries as a whole was detected when comparing them in the two houses. Post mortem examination of nine birds at age 80wks and fourteen birds at age 57wks revealed that the only possible effect of cage placement on the internal infection may be exerted by the direction of air current caused by the working exhaust fans.

Keywords: Cage placement, mortality, pathological changes, poultry.

I. INTRODUCTION

The production of eggs for human consumption is based on several technologies that are in turn based on the knowledge and experience gathered over more than a century [1]. One of these technologies is the battery cage production system. It was believed to be the most intensive, most efficient and most appropriate for rearing laying hens [1]. They are a worldwide housing system in modern poultry egg production.

An initial census of poultry farms in Khartoum State, Sudan, was carried out in late 2007 and early 2008. It was reported that there were 527 broiler and layer poultry farm in Khartoum state, 252 layer farms with a total population of 2221800 hens [2]. The state is responsible for almost 90% of Sudan’s poultry production [3]. Most of the recently established poultry farms for egg production in Khartoum state are of closed system with battery cages type.

The efficiency of the cooling system in tropical countries...
is faced with the high ambient temperature and differences in humidity leading to different production environment in the same house and higher temperature than the targeted one.

In tropical countries, there is paucity of information regarding closed system with battery cages and the birds positioning. The present study aimed to evaluate the effect of cage placement, in relation to the cooling system, on the bird’s tissues and mortality of two different ages of Lohmann LSL Lite breed laying hens at age 80 wks- and 57 wks. This will help to understand the effect of cage placement on the health status of the housed birds, raise the awareness of bird welfare in the industry and draw the attention of policy makers to improve the designs of poultry house along with the battle of disease control and diagnosis.

**Literature Review**

The battery system seems to be more advantageous than the other systems, yielding a significantly higher hen day egg production than the free-range system and significantly less mortalities than both the free-range system and the floor house system [4]. Today’s laying hen, selectively bred for high egg production, will produce more than 250 eggs annually [5] compared to 100 eggs per year a century ago [6].

Keeping hens in cages has permitted a dramatic reduction in labor requirements and improved both barn hygiene and the health of the laying hens [7]. Cages were also introduced to improve flock health, reduce labor requirements and allow producers to house many more birds together under one roof [8].

Evaluation of the effect of the laying house, with Easel open sheds or Easel closed sheds and cage placement over body weight, mortality and food conversion in laying hens indicates that cage placement in house ends and external lateral rows are favorable; It is also recommended to use laying houses of less width and with open sheds in tropical climates [9]. Cage position effect on mortality was not significant, the highest mortality was observed on corridor side [10].

A study investigated the effects of cage tier and age on performance characteristics of layer hybrids, egg quality and some stress parameters. The authors [11] concluded that, cage tier is an indicator of stress parameters studied in the experiment. However, these parameters were affected by the age of the hens at the beginning of the laying period.

Housing layer chicks according to their known responses to cage density and position, improves pullet welfare, resulting in better performance [12]. Cage position influence titer of diseases differently [13].

According to [14], poultry producers in Sudan, were not only facing difficult times with rising costs of production and decreasing profit margins, but also increased mortality rates due to infectious diseases, with a significantly higher occurrence of bacterial and parasitic diseases and cannibalism. The occurrence of viral diseases was significantly higher in indoor litter-based housing systems than in cages (P < 0.001) [15]. Such mortality plays a major role in determining profit from egg type layer. Housing systems differ regarding their mortality rate [16]. Mortality can reach unacceptable high levels in non-cage systems; It was lower in furnished cages compared to conventional ones [17]. Mortality is significantly lower in a battery system therefore, the laying stock is being preserved as well as the production obtained from them [4]. Age may affect the mortality rate of flocks. In a previous study, the mortality was found to be 0.8% in the youngest flock, 18-31 wks, to 11.6%, 18 to73 wks, in the oldest flock of the three flocks studied [18]. Mortality of Lohmann selected leghorn laying hen reared in floor and half in conventional cages from 18 to 57 wks was greater in floor-reared Lohmann selected leghorn laying than in the Lohmann selected leghorn laying hens reared in conventional cages. Enteritis (12.9%) was observed to be the second major causes of mortality followed by nephrosis (10.48%) [19].

Other major causes of mortality are metabolic disorders. One of the conditions that affect both layers and broilers is the fatty liver hemorrhagic syndrome which is a metabolic condition of chicken caused by diverse nutritional, hormonal, environmental, and metabolic factors [20]. In laying hens this condition is caused by altered energy balance induced by high-energy and low-protein diets [21]. Caged laying hens on high-energy diets are the most frequently affected by FLHS [22]. Multiple factors like high dietary energy, stress of production and high ambient temperature may have precipitated the fatty hemorrhagic syndrome in broiler breeder hens [18], [23] however, the heavier birds in a flock were more likely to have the condition than lighter birds [24]. Older layers were more susceptible to FLHS than young layers after oestradiol treatment [25].

Ascites in poultry is a cardiovascular metabolic disease characterized by accumulation of fluid around the heart and in the abdominal cavity that eventually leads to death [26]. Respiratory capacity is the most probable factor predisposing the birds to ascites [27]. Ascites constituents 30% of all mortality caused as a consequence of metabolic diseases [28].

**II. METHODOLOGY**

A cross-sectional experimental study was conducted in a cage-rearing closed system production farm in the north of Omdurman in Khartoum State.

Forty eight thousand five hundred experimental birds were used. Eighteen thousand five hundred layers at the age of 80 wks of production were randomly allocated to two battery cages in House A. Thirty thousand layers at the age of 57 wks of production were randomly allocated to three conventional four-row battery cages in House B.

All birds housed in those cages were used to study the mortality rate. Five and four birds from each part in house A and house B respectively were labeled using a pen and a duct-tape. Those labeled birds were used to study the post-mortem lesions (if any). These parameters were used as main criteria for evaluation of the birds’ health status. Duration of the experiment was forty three days. Duration of detection of mortality was affected by a previously scheduled culling of birds at age 80 wks.

To assure that the birds are consistently in appropriate temperatures, efforts were made to maintain the house temperature at 26°C to 28°C as much as possible. The housing system provides access to Ad libitum (ad-lib) balanced ration and water and droppings fall through the wire cage floor onto a belt or into a pit for disposal. The space provided for hens/cage was 60x34x42 cm. According to the

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manufacturer; seven birds were housed in each cage. Vertically, four rows of cages stacked on top of each other with four row-top, middle upper, middle lower and bottom. Those batteries in rows were divided into three parts starting from beside the cooling pads (1W), the middle (2W) and the last beside the fans (3W).

In house A, experimental birds were placed in the lateral sixth northern battery cage (AN6L) beside cooling pads and medial northern battery cage (ANM) horizontally at the middle upper row in both sides-left and right. Each battery raw was divided into: first third beside pad (1W) consists of 130 cages; second third in middle (2W) also consists of 130 cages and last third beside fans (3W) consists of 124 cages. The total birds in the two batteries were about four thousand and five hundred birds.

In house B, experimental birds were placed in the lateral first northern battery cage (BN1L) beside northern pad, medial northern battery cage (BNM) in middle and lateral sixth northern battery cage (BN6L) beside southern pad vertically and horizontally from bottom in both sides (left and right). Each battery raw was divided into: First third beside pad (1W) consists of 520 cages; second third in middle (2W) consists also of 520 cages and last third beside fans (3W) beside fans consists of 512 cages, the total birds in the three batteries were about thirty thousand birds.

Mortality rate of thirty thousand birds of Lohmann LSL Lite breed at 57 wks was detected for forty three days. Those birds were housed in the left and right side of the top, middle upper, middle lower and bottom row of each battery. Mortality rate of four thousand fifty hundred Lohmann LSL Lite birds of 80 wks was detected for twenty days. After which the birds were depopulated. Mortality was detected horizontally in left and right side of bottom second row (middle lower) in all experimental parts of the batteries.

Post-mortem examination was performed for nine hens in house A. Three hens from each of the three different cages were examined. The cages were at the first third (1W) beside the cooling pads, middle third (2W) and last third (3W) beside the fans. In house B, post-mortem examination was performed for 14 hens: three hens from the cages in the first third (1W) beside the cooling pads, four hens from the cage in the middle third (2W) 7 hens from the last third (3W) beside the fans.

III. RESULTS

A. Detection of Mortality

Mortality of 4500 Lohmann LSL Lite laying hens at age 80 wks was recorded for twenty days in one lateral and one medial battery in House C; and it was recorded for 30000 Lohmann LSL Lite laying hens at age 57 wks for forty three days in two lateral and one medial battery in House B. The mortality in the two laying flocks at age 80 wks and 57 wks, in the first 20 days, was found to be 7.4% and 1.6% respectively. In the next 23 days in House B, it was found to be 1.7%.

Mortality mean values and standard deviations of Lohmann LSL laying hens were examined in cages at the three different positions, 1W, 2W, 3W for age 80 wks in a lateral and a medial battery and age 57 wks in two laterals and one medial battery were shown in Table I and Table II respectively. The mortality in the different positions of the AN6L, BN1L, BNM, BN6L battery shows significant difference. Table III shows the mortality mean values of Lohmann LSL laying hens at age 57 and 80 wks placed in the lateral (AN6L, BN6L) and medial (ANM, BNM) batteries that were found to be insignificantly different; while the total mortality of the two houses showed significant difference.

### Table I: Mortality Mean Values of Lohmann LSL Lite Laying Hen at Age 80 Wks Placed in Cages at the Three Different Positions, 1W, 2W, 3W of a Lateral and Medial Batteries

| Variables | Number | Mortality | P value |
|-----------|--------|-----------|---------|
|           | Mean   | Standard deviation | Standard error |   |
| AN6L-1W   | 20     | 2.25      | 1.585   | 0.354   |
| AN6L-2W   | 20     | 2.15      | 1.531   | 0.342   |
| AN6L-3W   | 20     | 3.35      | 1.872   | 0.418   |
| ANM-1W    | 20     | 2.85      | 2.368   | 0.53    |
| ANM-2W    | 20     | 3.3      | 3.404   | 0.761   |
| ANM-3W    | 20     | 2.8      | 2.331   | 0.521   |

**significant, *nonsignificant**

### Table II: Mortality Mean Values of Lohmann LSL Lite Laying Hens at Age 57 Wks Placed in Cages at the Three Different Positions 1W, 2W, 3W of Two Laterals and One Medial Batteries

| Variables | Number | Mortality | P value |
|-----------|--------|-----------|---------|
|           | Mean   | Standard Deviation | Standard Error |   |
| BN1L-1W   | 43     | 2.7442    | 1.41578 | 0.2159 |
| BN1L-2W   | 43     | 2.1395    | 1.44059 | 0.21969 |
| BN1L-3W   | 43     | 3.186     | 2.45198 | 0.37392 |
| BNM-1W    | 43     | 2.1628    | 1.39609 | 0.2129 |
| BNM-2W    | 43     | 2.2791    | 1.69489 | 0.25847 |
| BNM-3W    | 43     | 3.0698    | 1.9088  | 0.30207 |
| BN6L-1W   | 43     | 3.186     | 2.22813 | 0.33979 |
| BN6L-2W   | 43     | 2.4186    | 1.93012 | 0.29434 |
| BN6L-3W   | 43     | 4.7209    | 2.6844  | 0.40937 |

**significant, *nonsignificant**
TABLE III: MORTALITY MEAN VALUES OF LOHMANN LSL LITE LAYING HENS AT AGE 57 AND 80 WKS PLACED IN THE LATERAL AND MEDIAL BATTERIES.

| Housing | Number of birds | Mean Rank | Sum of Ranks | P value |
|---------|----------------|-----------|--------------|---------|
| House A | AN6L           | 20        | 17.93        | 358.5   |
| House B | BN6L           | 20        | 23.08        | 461.5   |
| House A | CNM            | 20        | 21.63        | 432.5   |
| House B | BNM            | 20        | 19.38        | 387.5   |
| House A |               | 20        | 15.33        | 306.5   |
| House B |               | 20        | 25.68        | 513.5   |

Mann-Whitney U Test

**significant  * nonsignificant

Fig. 1. Mortality of Lohmann LSL laying hens at age 57 wks placed in position 1W of lateral BN1L and medial BNM batteries.

Fig. 2. Mortality of Lohmann LSL Lite laying hens at age 57 wks placed in position 2W of lateral BN1L and medial BNM batteries.

Fig. 3. Mortality of Lohmann LSL Lite laying hens at age 57 wks placed in position 3W of lateral BN1L and medial BNM batteries.

Fig. 4. Mortality of Lohmann LSL Lite laying hens at age 57 wks placed in position 1W of lateral BN6L and medial BNM batteries.
Mortality of 57 wks Lohmann LSL laying hens at position 1W, 2W and 3W of lateral northern (BN1L) and medial (BNM) battery is shown in Fig. 1, 2, 3 and the mortality of the same age positioned at the lateral southern (BN6L) and medial (BNM) battery is shown in Fig. 4, 5, 6. The mortality in position 3W of lateral and medial batteries was significant.

Comparing the mortality at similar position in lateral and medial batteries in house A and B and at northern and southern lateral batteries in house B showed insignificant difference between the compared positions except 3W in BN1L and BNM and 3W in BN1L and BN6L.

Comparing the mortality in position 1W, 2W and 3W in the lateral northern batteries, AN6L and BN6L, of House A and House B showed significant difference whereas position 3W was insignificantly different. The mortality in the medial batteries of House A and House B, ANM and BNM, at position 1W, 2W and 3W was found insignificantly different.

B. External Examination

The external examination of seven organs namely: eyes, ears, legs, feet, feather, skin and vent of the hens in House A revealed no morphological changes. In House B pasty vent area was detected in two birds.

C. Post-mortem

Post-mortem examination was performed for recently died bird and apparently healthy for nine hens from AN6L in House A, and House B.

In house A, increased in adipose tissue was obvious around the heart, spleen and subcutaneous layer of abdominal wall. The thickness of the fat layer in the subcutaneous layer was up to ten millimeter. Fat droplets are manifested on the surface of the visceral organs. Ascites appeared in 30% of the examined hens with accumulation of fluids in cysts.

The lesions on the liver differ from one hen to another but most of those livers were enlarged, pale, hemorrhagic and hyperemic (Fig. 7). Kidneys of the examined hens showed enlargement, large areas of cloudy discoloration and presence of pale foci. Oviducts were swollen, hard in consistency, with caseated material and calcification inside some of them (Fig. 8). Individual cases of adhesion between the capsule and muscles of the gizzard and hyperaemia and haemorrhages in the ovarian follicles. Spleen showed pale foci (Fig. 9)

In house B, hyperaemia and haemorrhage were the pathological changes that were detected in the trachea. Examined hens showed lesions in lung such as pale foci (Fig. 10), hyperemia and hemorrhage. Some hens showed increase in adipose tissue around the heart (Fig. 11) and almost all examined hens showed excessive accumulation of fats subcutaneously in abdominal cavity (Fig. 12). Inside the abdominal cavity there was accumulation of fluid in cysts. Those cysts were of different shape and size and some of them were opaque, (Fig. 13) while the majority were translucent (Fig. 14). Examination of the intestine revealed swelling, excessive mucous in the small intestine and presence of gases. Pathological changes detected in the livers were hypertrophy, diffuse or focal pale foci, hyperemia, hemorrhage and fragility. A spleen showed focal pale areas. Lesion detected in kidneys were hypertrophy (Fig 15), edematous pale areas and hemorrhagic foci (Fig. 16).

Fig. 7. House A: CN6L, 1W; 80 wks hen liver: pale with few hemorrhagic foci.
Fig. 7. House A: CN6L, 1W; 80 wks hen, oviduct: swelled with content hard in consistency.

Fig. 8. House B: BN1L, 3W; 57 wks hen lungs: pale focal lesions.

Fig. 9. House A: CN6L, 1W; 80 wks hen, spleen: white foci.

Fig. 10. House B: BNM, 2W; 57 wks hen abdominal cavity: increased deposition of fats.

Fig. 11. House B: BN6L, 1W; 57 wks hen abdominal cysts: translucent (left) and semitransluecent (right).

Fig. 12. House B: BN6L, 1W; 57 wks hen, kidneys: hypertrophy and urates deposition.

Fig. 13. House B: BNM, 3W; 57 wks hen abdominal cysts: opaque.
IV. DISCUSSION

The battery system seems to be the most frequently used housing system in intensive poultry production in Khartoum. It was believed to be the most intensive, efficient and appropriate for rearing laying hens [1]. Housing layer chicks according to their known responses to cage density and position, improves pullet welfare and results in a better performance [12], [13].

The difference in mortality between the three positions-1W, 2W and 3W- in all medial and lateral batteries is significant, except the ANM in House A. The difference increases towards the southern side; this may be attributed to the direction of wind in Sudan, which is northern. Higher mortality was manifested beside fans (3W) to where the air current is directed. This difference in mortality indicates that the cage placement within the battery and inside the house has a role in the bird’s health.

In general, when comparing the same cage position- 1W, 2W or 3W- at successive batteries, the difference in mortality was insignificant except for position 3W of BN6L with BNM and BN6L with BN1L.

The effect of cage placement on the flocks of birds of two ages (80 wks and 57 wks) was insignificantly different when the mortality in the two different lateral and two different medial batteries of the two houses was compared in the whole battery. The mortality in the cages positioned as 1W, 2W and 3W in AN6L and BN6L and ANM and BNM showed different effect in the positions at the lateral batteries and was insignificantly different in the medial batteries. This suggests different effect of the cage placement on different ages of birds.

The total mortality for twenty days in each of the two laying flocks was 7.4% at age 80wks and 1.6% at age 57wks. It is significantly different and obviously higher in the older age. This may be due to cumulative causes such as metabolic disorders, increase of bacterial load inside the house and environmental stresses. The metabolic disorders were an obvious finding in the post-mortem of the birds from the two flocks. Environmental stresses should not be overlooked as it was found impossible with the design and constructive material used, to maintain the temperature less than 28 °C during the dry and wet summer. It is not uncommon for the temperature to exceed 30 °C.

In this study, mortality is higher in older hens than younger ones. Similar results were reported by [10] who showed significant difference in mortality between hens at different ages. The cage placement differs in its effect on the two groups of age, where the older flock (80wks) was not affected by the medial positioning of the battery.

It could be concluded that cage placement affects both ages. The effect is directed longitudinally from cooling pads to fans with a tendency to increase towards the southern part of the house. Similar findings on the effect of cage positioning on birds’ health were reported by [9], [11], [29].

There is a contradiction between the results of this study and that of [10] who found that the cage position effect on mortality was not significant.

Surprisingly, the birds in House B (57wks) were less healthy than those in House C, as indicated by the affection of the internal organs in general, and the liver, abdominal fats, kidney and intestine in specific. This may be due to the difference in management, feed formulation and/or the additional stress of infections. Although the mortality is higher in the older flock (80 wks), it should not be unexpected for the mortality in the younger flock (57 wks) to flare up after the study period.

Birds kept in House B showed obvious pathological changes in some organs- such as the lung and heart- that did not show similar changes in the second flock at House C. Those changes were found to be more intense towards the fans, suggesting infection rather than environmental stress.

The most prevalent lesions were liver hypertrophy, fatty change, hyperaemia and haemorrhages, together with the increased deposition of abdominal fats and ascites. The lesions indicate fatty liver hemorrhagic syndrome, which is a metabolic disorder.

Ascites is one of the important hazards in poultry production. In the current study, ascites was detected in 33% of the examined birds at age 80 wks and 71.4% of the examined birds at age 57 wks. Higher occurrence of ascites compared to that reported by [28] which was 30% and higher rate of mortality of the two flocks collectively than that recorded by [28] may be due to the difference in climate or feed.

Eighty nine percent of hen’s livers at age 80 wks and 100% of them at age 57 wks were found to contain lesions similar to fatty liver hemorrhagic syndrome (FLHS). Caged laying hens on high-energy diets are the most frequently affected by FLHS [22]. The environmental factor and management ones, such as housing in cage system, restrict the movement of hen and predispose them to FLHS beside nutritional, hormonal and metabolic factors [20], [21]. Percentage of the affected birds’ livers is suggestive for a negative role for this type of housing although there is no difference between different ages or bird positioning in occurrence of FLHS.

Pathological changes in oviduct were obvious in two of the nine examined birds at age eighty whereas there is no similar changes at age 57 wks. These results suggest that the reproductive system is affected by age.

Although several studies demonstrated superiority of conventional cages over other different systems in reduced infection, morbidity and mortality of the housed birds [4], [7], [30], [31], special designs for laying houses in tropical climates should be considered.

Hens rearing in conventional cages in tropical countries need more attention of policy makers to improve battery designs along with the battle of diseases misdiagnosis to reduce mortality and to decrease the impact of faulty management.
Further investigations regarding housing in conventional cages housing their placement’s impact would be necessary to obtain. Sufficient and accurate information on the effect on other parameters such as quality of feed, microbial load and blood profile of the housed birds are needed.

REFERENCES
[1] Kabakchiev M. From cage batteries to alternative technologies. Ptcieredvstro. 2000; 6: 15-18.
[2] Sirdar MM, Picard J, Bisschop S, Gumbow B. A questionnaire survey of poultry layer farmers in Khartoum State, Sudan, to study their antimicrobial awareness and usage patterns. Understrespoort Journal of Veterinary Research. 2012; 79(1): 1-8.
[3] Anone. Ministry of Agriculture, Animal resources and Irrigation, Khartoum State, Sudan. 2005.
[4] Mostert BE, Bowes EH, Van der Walt JC. Influence of different housing systems on the performance of hens of four laying strains. South African Journal of Animal Science. 1995; 25(3): 80-86.
[5] Anone. U.S. Department of Agriculture National Agricultural Statistics Service. 2008.
[6] Ensminger ME. “Poultry Science” 3rd ed. Danville, IL: Interstate Publishers. Minnesota: USA. 1992.
[7] Singh R, Cheng MK, Silversides GF. Production performance and egg quality of four strains of laying hens kept in conventional cages and floor pens. Poultry Science. 2009; 88(2): 256-264.
[8] Bell DD, Weaver WD. Commercial chicken meat and egg production, 5th Edition Norwell MA: Kluwer Academic Publishers. 2002: 1007-1008.
[9] Sánchez C, Montilla JJ, Angulo I, León YA. Effect of laying house design and cage placement on body weight, mortality and food conversion in laying hens. Rev. Fac. Agron. (LUZ). 2003; 20: 195.
[10] Simsek E, Kılıc L. Building Environment and interaction of population density and position and their relationship to layer performance. International Journal of Poultry Science. 2006; 5 (9): 856-862.
[11] Şekeröglu A, Duman M, Tahtalı Y, Yıldırım A, Eleroğlu H. Effect of cage tier and age on performance, egg quality and stress parameters of laying hens. South African Journal of Animal Science. 2014; 44(3): 289-297.
[12] Bozkurt Z, Bayram I, Turkmenoglu I, Aktepe OC. Effects of cage density and cage position on performance of commercial layer pullets from four genotypes. Turk J Vet Anim Sci. 2006; 30(1): 17-28.
[13] Bozkurt Z, Bayram I, Bülbül A, Aktepe OC. Effects of strain, cage density and position on immune response to vaccines and blood parameters in layer pullets. Lucrări Stiinţifice Zootehnige Biotehnologi. 2009; 42 (1): 191-204.
[14] Babiker MA, Tawfeig A, Yahia IE, Noura KI. Mortality and diseases status in layer chicken flocks reared in traditional farms in Khartoum- Sudan. International Journal of Poultry Science. 2009; 8(3): 264-269.
[15] Bossen O, Jansson DS, Eiteter PE, Vägsholm I. Causes of mortality in laying hens in different housing systems in 2001 to 2004. Acta Veterinaria Scandinavica. 2009; 51(1): 1-9.
[16] Tauson R. Furnished cages and aviaries: production and health. World’s Poultry Science Journal. 2002; 58(1): 49-63.
[17] Lay Jr. DC, Fulton RM, Hester PY, Karcher DM, Kjaer JB, Mench JA, et al. Emerging issues: Social sustainability of egg production symposium hen welfare in different housing systems. Poultry Science. 2011; 1-16.
[18] Shini A. Fatty liver hemorrhagic syndrome in laying hens: field and experimental investigations. Ph.D. Thesis. The University of Queensland, 2014.
[19] Kumar S, Kumar B, Gupta MK, Singh KK, Kumar S. A study on mortality pattern of poultry in and around ranchi. Int. Curr. Microbiol. Appl. Sci. 2018; 7; 3713-3716.
[20] Rozenboim I, Mahato J, Cohen NA, Tirosh O. Low protein and high-energy diet: a possible natural cause of fatty liver hemorrhagic syndrome in caged White Leghorn laying hens. Poultry Science. 2016; 95(3): 612-621.
[21] Gao X, Liu P, Wu C, Wang T, Liu G, Cao H, et al. Effects of fatty liver hemorrhagic syndrome on the AMP-activated protein kinase signaling pathway in laying hens. Poultry Science. 2019; 98(5): 2201-2210.
[22] McMullin P. A pocket guide to poultry health and disease. 5M Enterprises Ltd; 2004.
[23] Dey S, Pakhira MC, Batabyal K, Isore DP, Samanta I. Concurrent occurrence of fatty liver haemorrhagic syndrome (FLHS) and colisepticaemia in a broiler breeder flock. Int. J. Curr. Microbiol. Appl. Sci. 2018; 7(9): 185-189.

Shini A, Shini S, Bryden WL. Fatty liver haemorrhagic syndrome occurrence in laying hens: impact of production system. Avian Pathology. 2019; 48(1): 25-34.
Dong X, Tong J. Different susceptibility to fatty liver-haemorrhagic syndrome in young and older layers and the interaction on blood LDL-C levels between oestradiols and high energy-low protein diets. British Poultry Science. 2019; 60(3): 265-71.
Khodambashi Emami N, Golian A, Danesh Mesgaran M, Anthony NB, Rhoads DD. Mitochondrial biogenesis and PGC-1α gene expression in male broilers from ascites-susceptible and resistant lines. Journal of Animal Physiology and Animal Nutrition. 2019; 88(2): 152-159.
Leeson S, Diaz G, Summers JD. Publication announcement: poultry metabolic disorders and mycotoxins. J Appl. Poult. Res. 1995; 4(2): 216.
Tauson R, Wahilstrom A, Abrahamsson P. Effect of two floor housing systems and cages on health, production, and fear response in layers. Journal of Applied Poultry Research. 1999; 8(2): 152-159.
Weitzerburger D, Vits A, Hamann H, Distl O. Effect of furnished small group housing systems and furnished cages on mortality and causes of death in two layer strains. British Poultry Science. 2005; 46(5): 553-559.
Dikmen BY, Ipек AY, Sahan Ü, Petek ME, Sözcü A. Egg production and welfare of laying hens kept in different housing systems (conventional, enriched cage, and free range). Poultry Science. 2016; 95(7): 1564-72.
Milsavicjevic T. Ascites poultry. J Dairy Vet Anim Res. 2014; 1(2): 18-20.
Lukanov H, Alexieva D. Trends in battery cage husbandry systems for laying hens. Enriched cages for housing laying hens. Agricultural Science & Technology. 2013; 5(2).

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Vol 2 | Issue 5 | September 2022

8