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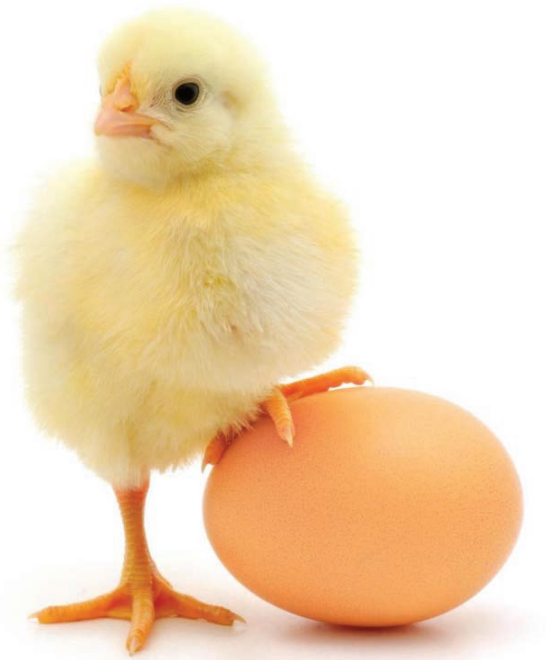

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# Research Article
# Assessment of Normal Mortalities, Biosecurity and Welfare of Lohmann Brown Layers at a Farm in Central Namibia

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## Abstract
**Objective:** The current study investigated the causes of mortality and evaluated the biosecurity situation and welfare conditions of Lohmann Brown layer chickens reared for 12 months, from point-of-lay, at farm A in central Namibia. **Materials and Methods:** Necropsies, standard biosecurity appraisal and on-farm welfare assessment tools were used. A standard protocol was used for post-mortem examinations of dead birds. The Chi-square test was used for analysis of causes of mortality whilst linear regression was used for analysis of the temporal distribution of mortality. **Results:** The overall mortality rate throughout the study period was 18.7% (N = 1000). There was a very strong negative correlation between duration of birds in lay and proportion of live birds [r (162) = 0.97, p<0.05]. The proportion of live birds decreased by an average of 2.98% for every 50 days of the laying period. Overall, the proportional mortalities due to undetermined causes (31.6%) were greater than those due to inflammatory conditions, trauma, cannibalism and retained eggs (20.9, 19.3,16.6 and 11.8% respectively, p<0.05). **Conclusion:** The high mortality rates reported in this study have an obvious negative impact on productivity and thus there is a need to improve the biosecurity and welfare conditions for these layers in order to improve profitability.

Key words: Lohmann brown layers, layer mortality, biosecurity, welfare, Namibia

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

The profitability of a poultry layer enterprise depends on the productivity of individual hens and hence the number of hens that survive and lay eggs in that particular laying cycle ultimately determines the economic performance of the enterprise. In addition, recent years have witnessed the emergence of a quality dimension related to the consumer demand for transparency on the welfare conditions of the laying hens producing the eggs they consume[1-4].

Causes of layer mortality can be classified into infectious and non-infectious causes[5-8]. Infectious causes include various bacterial, viral, parasitic and fungal pathogens, as well as diseases caused by *Mycoplasma* spp.[9]. Viral diseases of economic importance affecting layers include Newcastle disease[10-12], infectious bursal disease (Gumboro disease)[13], infectious bronchitis, avian influenza and Marek's disease[12,14,15]. Bacterial pathogens which cause layer mortalities include *Salmonella* spp.[6,16,17], *Pasteurella multocida* (fowl cholera), *Escherichia coli*[7,8,18,19], *Avibacterium paragallinarum* (infectious coryza)[5], *Mycoplasma* spp.[20,21], *Erysipelas*[19], *Enterococcus* spp. and *Clostridium* spp.[12,13]. According to Gordis[22], mortalities in layers can serve as indicators of the impact of poultry diseases and the effectiveness of the instituted control measures[22].

Internal parasites such as helminths (mostly cestodes and nematodes)[23,24], protozoa (coccidia)[17,20,25,26] and external parasites (especially *Dermanyssus gallinae*) are reportedly the major causes of mortality[18,25]. Leading fungal diseases of poultry include aspergillosis and aflatoxicosis[12,17].

In a large population of layers, it is normal for mortalities to occur due to natural causes in the absence of a major disease outbreak, a phenomenon called normal daily layer mortality[27,28]. Major disease outbreaks, whenever they occur, almost always, wipe out the whole flock or force farmers to depopulate due to their biosecurity, legal and public health implications. In the absence of major disease outbreaks, mortalities can be visited upon layer flocks by various noninfectious conditions which, though not catastrophic, still result in revenue losses. Developmental, degenerative, physical, traumatic, environmental, nutritional, chemical (including toxins), metabolic, genetic, neoplastic and management-related factors (production system and biosecurity measures including vaccination) have been frequently blamed for causing mortality in layers[17,25].

Intensification of production in layers has pushed the normal physiological processes of layers to extremes, inadvertently predisposing the birds to a number of production or metabolic diseases such as hypocalcemia, gout, fatty liver syndrome, urolithiasis and cardiomyopathy[27-29]. In addition, the rigours of egg-laying and constant feeding, over time, also compromise the normal anatomical integrity of the body systems of the laying hen resulting in degenerative conditions such as vent prolapse, volvulus and/or intussusception. Moreover, management factors such as housing (including ventilation)[18,30,31], production system[19], nutritional deficiency[6] and hygiene/biosecurity practices[17] have been found to significantly contribute to layer mortality. According to Vieira *et al.*[32], mortality also increases as the number of birds per cage increase.

Furthermore, the confinement of layers in the same housing environment may lead to stress which may trigger abnormal behaviours such as persecution, self-induced moulting, feather pecking and cannibalism[19,33]. Such abnormal behaviours may also lead to traumatic injuries including getting trapped in the battery cage structure, leg fractures and wing fractures which could ultimately lead to deaths. In addition, stress may compromise the layers' immune system resulting in susceptibility to conditions such as scepticaemia and neoplastic conditions[27]. Sherwin *et al.*[34] demonstrated the relationship between housing system, welfare and mortality in four different housing systems in the United Kingdom[34]. A number of studies, however, have also identified bird-related factors such as age[6], hatchery-related problems[7,11], breed[5], strain of bird[17,35] and extreme seasonal weather conditions[7,11,12,36,37] predisposing birds to mortality. Reports from other studies show high layer mortality in hot dry seasons and even higher mortality in rainy hot seasons[13]. According to Fulton[27], many of the causes of mortality in layers are directly related to the processes of egg laying. Thus, the diseases of the reproductive system such as egg yolk peritonitis, salpingitis, oviduct impaction, ovarian neoplasia and egg bound, which may be caused by bacterial infection, play a major role in the mortality of layers[5,38-41]. The term retained egg disorder or internal laying has been used to loosely define a number of pathological conditions of the reproductive system including egg yolk peritonitis, oviduct impaction, and egg bound[17,27,40,41].

Studies have apportioned more blame on poor animal welfare as a cause for reduced productivity, poor quality eggs and reduced profitability of layer enterprises, thus motivating farmers to take better care of their birds[1,2]. Some studies have also established that low layer mortality is an indicator of good animal welfare[42,43]. An inverse relationship reportedly exists between the level of mortality and animal welfare standards of a livestock production enterprise[44] and thus welfare standards may partially explain the level of mortality in any given enterprise. In addition, there is empirical evidence showing that biosecurity standards of a livestock enterprise are directly related to welfare standards but inversely related to mortality levels in a livestock enterprise.

The objectives of this study were therefore to investigate the magnitude, patterns and causes of layer mortality, perform a parallel biosecurity appraisal and an on-farm welfare assessment on a flock of Lohmann Brown layer chickens reared from point-of-lay, in a battery cage system, over a one-year period, at farm A, in central Namibia. In essence, the overarching aim of the study was to triangulate the relationship between poultry mortality, biosecurity and welfare.

## MATERIALS AND METHODS

**Study area:** The study was carried out at farm A (coordinates: 22°31 0" S and 17°15 0"E) approximately 40 km east of Windhoek in the Khomas region of Namibia; the farm receives an average annual rainfall of 300-400 mm and experiences temperatures ranging from 7-33°C[45,46]. However, the winter temperatures at this farm sometimes drop as low as -2°C[47].

**Study birds:** The study birds comprised of 1000 point-of-lay Lohmann Brown chickens imported from a commercial breeder in South Africa, at point-of-lay (18 weeks of age). The chickens had been vaccinated against the major poultry diseases, including Newcastle disease. The chickens were exposed to 17.5 h of both natural and artificial light per day and fed a balanced commercial layer mash supplied by a local animal feed manufacturer (Feedmaster Pty Ltd) and water was provided *ad libitum* through nipple drinkers. The layers were housed in battery cages, with up to five birds per cage. The cleanliness of the cages and conditions in the bird house were monitored on a daily basis.

**Study design:** The study was carried out at a small-scale layer chicken production unit at a farm designated farm A. A single batch of 1000 pullets were followed from their time of arrival at point-of-lay in June 2017 until they were disposed of, as spent birds, in June 2018. Mortalities, biosecurity measures and welfare were assessed during the 12-month period during which the birds were in lay.

**Bird mortalities:** Mortalities were recorded and necropsies performed on dead birds. Necropsies were performed according to the method described previously[48,49]. Appropriate samples were collected whenever further investigations were required. An initial external examination of the body condition, condition of the feathers, evidence of external parasites, any discharges, joint lesions, weight and muscle mass assessments, and any visible lesions such as injuries, tumours, pox lesions was performed, prior to examination of the internal organs. Body condition was scored on a scale of 0 to 3 following the procedure described by Gregory and Robins[50].

**Biosecurity appraisal:** A biosecurity appraisal was performed on the poultry unit using an assessment tool modified from Madhuka *et al.*[51]. Each criterion was assessed as either having a positive or negative impact on biosecurity. The total number of positive and negative responses were added up and scored out of a total of 37 parameters measured and expressed as a percentage.

**Welfare assessment:** An outcome-based or animal-based on-farm animal welfare assessment of the flock was performed at random times once a month throughout the study period, following a modified version of methods used in previous studies[1-4]. The assessment was based on the five freedoms of animal welfare. A qualitative score, ranging from poor to good welfare was assigned to each parameter assessed.

**Statistical analysis:** The Shapiro-Wilk test was used to test for normality in the overall distribution of the data collected in this study (W = 0.98 and $R^2$ = 0.96). A summary of the descriptive statistics of the mortalities of laying birds due to various causes over 12 months was calculated using Microsoft Excel (2013). A Pearson correlation coefficient was computed to assess the relationship between the duration of lay and the proportional mortality of laying birds. The inferences on strength of correlations were made based on the descriptions shown in Table 1.

The Chi-square test was used for statistical analysis of the proportional quarterly distribution of bird mortalities and causes of mortality. Causes of mortalities were categorized into cannibalism (death due to vent-pecking and fight-inflicted wounds), trauma (death from cage-hardware

Table 1: Descriptions assigned to the ranges of the values of correlation coefficients (r)

| r-value | Description |
|---|---|
| 0-0.19 | Very weak |
| 0.2-0.39 | Weak |
| 0.4-0.59 | Moderate |
| 0.6-0.79 | Strong |
| 0.8-1.0 | Very strong |

inflicted lesions), egg bound (death due to egg retention), inflammatory conditions (death from peritonitis and/or enteritis) and undetermined (necropsies not performed, autolyzed carcasses or failure to identify the probable cause of death). Scatter plots correlating the proportion of live birds (%) to duration in lay (days) were drawn in Microsoft Excel (2013). The expected change in the Y variables (% birds alive) per unit change in the X variables (days in lay) was determined from the linear equation of the trend line modelled within the scatter plot. The Statistical Package for Social Sciences (SPSS) version 25 was used for regression analysis and Chi-square analysis where $p \leq 0.05$ was considered significant.

## RESULTS

The overall mortality of layer chickens at farm A during the study period was 18.7% (187/1000) giving a livability of 81.3%. Undetermined causes (31.6%), inflammatory conditions (20.9%), trauma (19.3%), cannibalism (16.6%) and retained eggs (11.8%) were responsible for chicken mortalities.

As shown in Fig. 1, there was a very strong negative correlation between the duration of birds in lay and the proportion of live birds [r (162) = 0.97, p<0.05]. The proportion of live birds decreased by an average of 2.98% for every 50 days of the laying period. The duration of the laying period explained 95% of the variation in the proportion of live birds.

The overall quarterly proportional mortalities of layers from the 2nd and 3rd quarters (4.7 and 5.4%, respectively), were significantly greater than those of the 1st quarter (2.2%, p<0.05) (Fig. 2). The proportional quarterly mortality of the 4$^{th}$ quarter (6.4%) was significantly greater than those of the 1st and 2nd quarters (2.2 and 4.7%, respectively; p<0.05). There was, however, no significant difference in the proportional quarterly mortalities of the 3rd and 4th quarters (p>0.05).

Overall, mortalities due to undetermined causes (31.6%) were greater than those due to cannibalism, inflammatory conditions, retained eggs and trauma (16.6, 20.9, 11.8 and 19.3%; respectively, p<0.05) (Table 2). Mortalities due to inflammatory conditions were significantly greater than those due to retained eggs (20.9 and 11.8%; respectively, p<0.05). Overall, mortalities due to cannibalism, inflammatory conditions, retained eggs, trauma and undetermined causes were independent of the duration of lay [$X^2(12) = 19.91$;

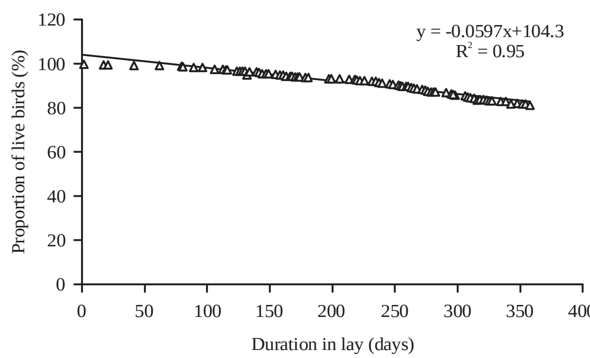


Fig. 1: The correlation between duration of lay and survival of laying birds at the farm between June 2017 and May 2018

Table 2: Quarterly and monthly distribution of hen mortalities from June 2017 and May 2018

| | Cannibalism | | Inflammatory conditions | | Retained eggs | | Trauma | | Undetermined | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Category | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| **Laying period** | | | | | | | | | | | | |
| 0 to≤89 days | 2 | 1.1 | 7 | 3.7 | 1 | 0.5 | 7 | 3.7 | 5 | 2.7 | 22 | 11.8 |
| 90 to≤179 days | 11 | 5.9 | 3 | 1.6 | 8 | 4.3 | 7 | 3.7 | 18 | 9.6 | 47 | 25.1 |
| 180 to ≤269 days | 7 | 3.7 | 11 | 5.9 | 4 | 2.1 | 14 | 7.5 | 18 | 9.6 | 54 | 28.9 |
| 270 to ≤360 days | 11 | 5.9 | 18 | 9.6 | 9 | 4.8 | 8 | 4.3 | 18 | 9.6 | 64 | 34.2 |
| **Month** | | | | | | | | | | | | |
| January | 0 | 0.0 | 4 | 2.1 | 2 | 1.1 | 5 | 2.7 | 9 | 4.8 | 20 | 10.7[c] |
| February | 6 | 3.2 | 9 | 4.8 | 2 | 1.1 | 6 | 3.2 | 3 | 1.6 | 26 | 13.9 |
| March | 8 | 4.3 | 10 | 5.3 | 3 | 1.6 | 6 | 3.2 | 2 | 1.1 | 29 | 15.5 |
| April | 2 | 1.1 | 7 | 3.7 | 4 | 2.1 | 1 | 0.5 | 12 | 6.4 | 26 | 13.9 |
| May | 2 | 1.1 | 4 | 2.1 | 3 | 1.6 | 5 | 2.7 | 5 | 2.7 | 19 | 10.2[c] |
| June | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 3 | 1.6 | 1 | 0.5 | 4 | 2.1[d] |
| July | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 | 1 | 0.5[d] |
| August | 2 | 1.1 | 4 | 2.1 | 0 | 0.0 | 3 | 1.6 | 2 | 1.1 | 11 | 5.9[b] |
| September | 2 | 1.1 | 1 | 0.5 | 4 | 2.1 | 5 | 2.7 | 0 | 0.0 | 12 | 6.4[b] |
| October | 6 | 3.2 | 0 | 0.0 | 4 | 2.1 | 2 | 1.1 | 6 | 3.2 | 18 | 9.6[a] |
| November | 3 | 1.6 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 12 | 6.4 | 15 | 8.0[a] |
| December | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 6 | 3.2 | 6 | 3.2[d] |
| Total | 31 | 16.6[ab] | 39 | 20.9[a] | 22 | 11.8[b] | 36 | 19.3[ab] | 59 | 31.6 | 187 | 100.0 |

There was no significant difference in values with same superscript[ab] within the same row or column since p>0.05

Table 3: Qualitative biosecurity appraisal of the poultry farm (Modified after Maduka *et al.*[51])

| No. | Biosecurity Risk factor | Status on farm A Poultry House | Comment | Implications on Biosecurity Positive | Implications on Biosecurity Negative |
|---|---|---|---|---|---|
| 1 | Number of birds/Stocking density | 1000 | Low | Positive | |
| 2 | Housing system | Battery Cage | Poor biosecurity | | Negative |
| 3 | Renowned Source of day-old chicks | Yes | Lohmann Brown | Positive | |
| 4 | Awareness of biosecurity practices | Yes | Staff and student parking nearby | Positive | |
| 5 | Density of (>5) farmers in neighbourhood | Chickens in worker's compound | Other poultry and chicken close by in farm worker compound | | Negative |
| 6 | Water bodies with migratory birds in neighbourhood | Yes | farm A | | Negative |
| 7 | Certified sources of quality chicks | Yes | Lohmann Brown | Positive | |
| 8 | Parking lot outside the farm premises | No | Parking all over campus for staff/students | | Negative |
| 9 | Acquisition of second-hand equipment | No | Only new equipment used | Positive | |
| 10 | Fencing with gates | Yes | | Positive | |
| 11 | Washing/disinfection of vehicles | No | Not practised | | Negative |
| 12 | Functional footbath at entry point | Yes | Not functional | | Negative |
| 13 | Visitors allowed into premises | Yes | Gate not always locked | | Negative |
| 14 | Presence of good feed storage facility | Yes | Good facility | Positive | |
| 15 | Appropriate carcass disposal | Yes | Carcasses incinerated | Positive | |
| 16 | On-farm necropsy | Yes | In a post mortem hall | Positive | |
| 17 | Certified commercial feed sources only | Yes | Feedmaster (Pty) Ltd | Positive | |
| 18 | On-farm carnivores (dogs and cats) | Yes | Free roaming dogs and feral cats on campus | | Negative |
| 19 | Hand washing/shower before and after handling birds | Yes | Showers installed but not used | | Negative |
| 20 | Rodent-proof | Yes | | Positive | |
| 21 | Residence of farm workers within premises | No | Farm workers do not live inside Poultry Unit fence | Positive | |
| 22 | Functional † footbath at entrance of poultry house | Yes | Not functional | | Negative |
| 23 | Separation of poultry types | Yes | Only layers inside poultry house | Positive | |
| 24 | Separation of birds according to age | Yes | Only one group | Positive | |
| 25 | Proper ventilation | Yes | Mechanical ventilators installed | Positive | |
| 26 | Availability of clean water | Yes | Automatic drinkers | Positive | |
| 27 | Appropriate bedding material | Yes | At all times | Positive | |
| 28 | Dry bedding | Yes | At all times | Positive | |
| 29 | Frequent changing of bedding | Yes | Changed every 24hours | Positive | |
| 30 | Birds occasionally allowed to move out of the poultry house | No | separated from other poultry | Positive | |
| 31 | Washing/disinfecting poultry house prior to restocking | Yes | All the time | Positive | |
| 32 | Practice of all-in all-out management system | Yes | All the time | Positive | |
| 33 | Washing feeders/drinkers regularly | Yes | Workers | Positive | |
| 34 | Disinfecting feeders/drinkers regularly | Yes | Workers | Positive | |
| 35 | Isolation of apparently sick birds | Yes | Sick bay | Positive | |
| 36 | Prophylactic chemotherapy to apparently healthy birds | Yes | | Positive | |
| 37 | Consultation of veterinarians only in the event of problems | Yes | Veterinarians on campus | Positive | |
| Total | | - | - | 27 (73%) | 10 (27%) |

p>0.05]. The months of February, March and April, however, had the greatest mortalities than the rest of the other months of the year (13.9, 15.5 and 13.9%, respectively; $p<0.05$).

An overall, biosecurity appraisal score of 73% was attained by the farm (Table 3). The environmental location of the chicken houses near other farms, water bodies with wild fowl, high human and carnivore traffic, and the absence of control and implementation of disinfection at the farm entrance gate and chicken houses are factors that were identified as compromising biosecurity.

The welfare assessment revealed that feeding and watering of birds was good (Fig. 3). However, the birds were

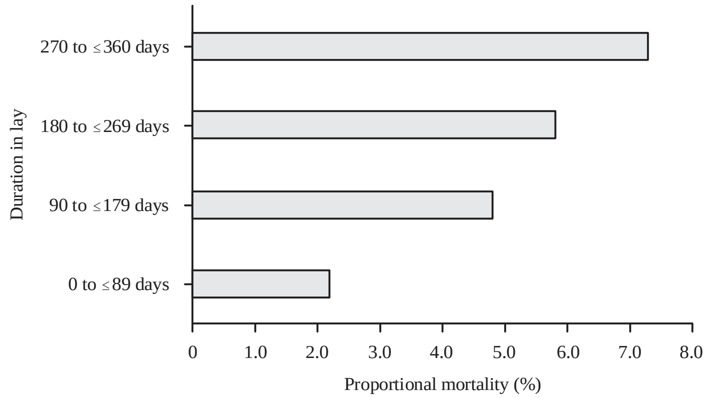


Fig. 2: Quarterly mortality of layers at farm A from June 2017 to May 2018

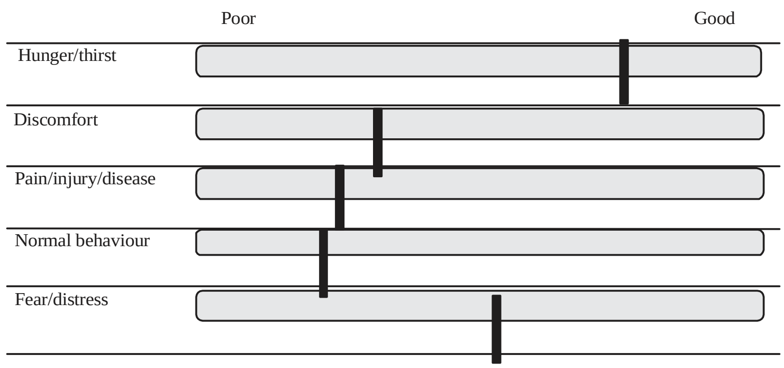


Fig. 3: An animal based on-farm animal welfare assessment as modified from other studies[1,3,4]

exposed to situations of fear/distress, discomfort, pain, injury and disease and their ability to perform natural behaviours was compromised because of the battery cage system of housing.

## DISCUSSION

The overall mortality recorded in the current study (18.7%) is higher than those of several previous studies which showed 6-12% mortality rate for layers and 6-10% mortality rate for Lohmann Tierzucht[12,16,19,20,29]. According to Pereira *et al*.[37], international breeders (Hy-line, Dekalb and Lohmann) regard mortality rates of 0.8-1.5% as acceptable for laying hens. Some reports flag a mortality rate of 2-5% as the mortality rate beyond which profitability becomes compromised[20] while others contend that a layer enterprise can lose as much as 10% and still make a profit[52]. Our result is closer to a previous study which reported a mortality rate of 20.8% in birds of the same breed reared under a free ranging system in Denmark[19] and studies elsewhere that reported mortalities of 14.48[11] and 21.3%[17]. There is no general acceptable level of normal mortality rate in laying hens, however, these mortalities negatively impact egg production and net profit[11,12,20]. The authors concluded that the mortality rate of Lohmann Brown hens in this study was high. The contribution of the sub-optimal biosecurity practices and welfare standards to mortalities on the farm could have been the major underlying factor, especially considering that the birds were not housed in environmentally controlled facilities.

Undetermined causes accounted for the highest proportion of all the causes of deaths. These were cases where the carcasses were either not presented for necropsy or were autolyzed, or instances where the post-mortems were done, but the cause of death could not be established.

Inflammatory conditions were the second highest cause of layer mortality, presenting higher figures than those in literature. In this study, the inflammatory conditions category is too broad and includes causes of mortality such as septicaemia[28] and infectious diseases as well as non-infectious causes[5–8]. The broadness of the category may be responsible for it becoming the second highest cause of mortality.

Mortalities due to trauma were unacceptably high (19.3%) and no other studies have reported such high rates except a few in which, however, the actual percentage contribution was not quoted[27]. The reason for lower rates of deaths due to trauma in literature may simply be due to the fragmentation of trauma into different types such as leg fracture, caught in the structure, exsanguination, caught by spur and wing fracture being reported in separate categories[27].

The observation of high mortality rates due to cannibalism (16.6%) further confirms the need for farm A to improve its welfare standards. This observation, as expected, is contradictory to other studies which reported that cannibalism was a minor cause of mortality in layers[17,23]. This contradiction is less pronounced when findings by Usman and Diarra[12] are taken into consideration. In fact, some studies insist that cannibalism is lower in cage systems than in litter-based and free-range systems[18,19]. However, some studies have shown that in non-cage systems cannibalism can be controlled without beak trimming, through selective breeding, good design of non-cage systems and the use of a variety of preventive management measures[53]. Deficiency of fiber in feed[54], overcrowding, large group sizes[33] and increasing light intensity[55] have been implicated as causes of cannibalism. Reducing the metabolizable energy (ME)[56] or increasing the crude fiber content[57] of the diet has been reported to reduce the level of cannibalism in layer flocks. The layer hens at farm A were not beak trimmed and were thus able to peck normally, which promoted their welfare[58].

The incidence of mortality caused by retained egg disorder in this study was relatively high (11.8%). This high mortality figure was not unexpected as previous studies have shown that causes of mortality in layers are closely related to processes of egg laying[27] or the strain brought onto the normal homeostatic process by the process of egg laying[28,29].

There was a very strong negative correlation between duration of birds in lay and proportion of live birds, whereby live birds decreased by 2.98% for every 50 days in lay and the duration in lay was responsible for 95% of the variation in proportion of live birds. This rise in rate of mortality could be explained by a lack of adaptability to the harsh husbandry conditions, especially when the productive stress becomes higher as the birds approach their peak laying period[59].

There are conflicting reports about the age group at which there is higher mortality[9,11,17,20,30,31,39]. Some authors have reported more deaths during the growth phase[11,13,20,31], while the majority reported more deaths during the laying phase[9,17,31,39] and one study found no relationship between the phase of production and mortality[30]. Even though the majority of studies concur that higher mortalities occur during the laying phase, there is still controversy over which quarter of the laying period has the highest mortalities. Although Farooq[20] reported a negative association between mortality and peak laying period, Yakubu *et al.*[59] found that the highest mortalities occurred in the 1st and 2nd quarters of laying, a period that include the peak phase of egg laying.

It was surprising that such a high level of mortality occurred in a battery cage system. It has previously been demonstrated that the unfurnished battery cage system such as was used at farm A in this study has serious challenges when it comes to both welfare and biosecurity[18,60]. In spite of their purported containment of disease spread in comparison to the litter-based and free-range housing systems[18], conventional (unfurnished) cage systems are notorious for restricting "the freedom of movement, freedom from fear, comfort and shelter, suitable flooring and freedom to display most normal patterns of behavior"[60]. Due to lack of perches, conventional cages have been reported to cause more fractures[3,34]. In fact, as of 2012, conventional cage housing systems were banned in the European Union due to serious welfare concerns[34,61]. The animal welfare assessment report of the current study showed a considerably high number of birds (about five) per cage. There is a serious need for farm A to adopt the use of furnished cages.

Results of the current study showed that mortalities were the highest in summer and the lowest in winter. High mortalities were recorded during high temperatures and humidity in mid to late summer[44]. It was also observed that high temperatures and humidity negatively affect thermoregulation and result in a decrease in feed consumption[62] and feed efficiency resulting in mortality[7,11,36,37]. It has been previously reported that temperatures at farm A can soar up to 36°C in summer resulting in mortality due to heat stroke and dehydration. Some studies have, however, also reported higher mortality in winter[5,13]. Although farm A is located in a semi-arid region which is reputable for harsh winters, winter mortalities in this study were quite low, possibly because this coincided with the growth phase of the birds.

## CONCLUSION

The level of mortalities were much higher than most levels cited in literature and this has a serious impact on the productivity and profitability of the enterprise. Improving the biosecurity and welfare conditions of the flock could go a long way in reducing mortalities and therefore improve productivity.

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