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Research Article
Pre-hatch and Post-hatch Egg Breakout and Hatchability Analysis as an Indicator to Increase Layer Breeder Performance and Egg Hatchability

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Abstract

Background and Objective: An experiment was conducted to analyze mating behaviors of layer breeders, time of egg collection and general handling of eggs, days of egg storage and incubation control mechanisms and records of hatchability and chick quality indicators. The study was conducted at the Olympio hatchery, Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. **Materials and Methods:** Four consecutive hatching regimes (from breeding flock through to the hatchery) were observed and monitored. Eggs collected were stored in the cold room at a temperature of 16°C and RH of 70% and pre-warmed for about 6 h interval before setting them in an incubator. Hatchability at the end of incubation was assessed and breakout of hatch debris was done for each regime to measure the impact of incubation parameters on embryo and content of residue left after 21.5 days of incubation. **Results:** Average mating within 3 h of observation between 05:00-08:00 GMT was between 47-50 times. Pen house temperature and egg room temperature which were 27-32°C were high and above physiological zero especially in the afternoons. When eggs were incubated the eggshell temperature (EST) fluctuated between the time of the day. The EST increased steadily at all times of the day from E11-E17 as the experiment progressed due to the increase in metabolic activity of the growing embryo. The incubator air temperature was not the same as EST. **Conclusion:** The study showed that long storage of eggs beyond 7 days increased early embryonic mortality.

Key words: Incubation control mechanisms, egg breakout, eggshell temperature, hatchability, chick quality, chick quality indicators, physiological zero, incubator air temperature, early embryonic mortality

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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

In Ghana, the importation of day-old chicks and chicken meat has greatly increased year after year and records show that in 2013, a total of 4.2 million day-old chicks were reported to have been imported. This further throws light on the need for the production of higher quality day-old chicks[1,2], a requirement Ghanaian hatchery must possess. Presently, there are only a few hatcheries in Ghana and these are also operating below 60% of their installed capacity. A constantly reported poor chick quality and increased importation of day-old chicks give every indication that the local hatchery output is low[3]. However, the reasons for the low production could be traced back to breeder management, also leading to poor chick quality[4], unsuitable pre-incubation treatment and errors in the incubation procedures[5]. These lead to lower chick quality and reduced production of flock post-hatch. For this reason, there is a need for an efficient and well-monitored program to be kept in place to monitor and ensure increased production of healthy chicks to meet the increasing demand, which is over 200,000 Mt of chicken meat annually. Therefore, the hatchery and parent stock management should be optimized for efficiently high-quality output.

The profitability and assessment of a hatchery cannot be evaluated only at the incubation level but both pre and post-hatch incubation levels. It is therefore important to monitor proceedings from the laying house through to when healthy day-old chicks will be ready for the market. Nevertheless, it is a normal phenomenon in every hatchery to record some embryo mortality during incubation but not when total embryonic mortality is high and production of saleable chicks are compromised. The average hatchability performance of a hatchery as stated by Hawken[6] should be around 85%. However, this could be a higher achievement standard for Ghanaian hatcheries because of increased cases of inefficiencies[4,3].

The quality and survivability of a chick during its first weeks of life is highly dependent on the chain of events from the farm till incubated eggs are successfully hatched out as healthy chicks. Therefore, proper analyses of embryo mortality patterns and abnormalities can also help to identify which aspects of the incubation process and breeder management need closer investigation in order to improve hatchability and chick quality. As a result, breeder management indicators such as feed quality, egg collection, egg sanitization, egg storage and incubation techniques need to be at their best for increased chick production and quality[7].

In the hatchery, several factors pertaining to equipment maintenance, incubator cooling, airflow patterns and other conditions may cause embryos to overheat or cool down, to become overhydrated or dehydrated. These may negatively affect hatchability and reduce chick quality. Egg breakout before and after the incubation process is an important tool which can be used to help establish patterns of metabolic and behavioral response, as well as mortality and the development of malformations. All these can potentially be used in monitoring incubating operations and diagnosing problems with faulty equipment[8]. The current experiment was conducted to assess activities occurring in the layer breeder parent pen including health, feeding standards and at the hatchery, machine and air temperature, eggshell temperature, hatchability and egg breakout to determine the focal points of problems in the breeder farm and hatchery that may be affecting hatching performance.

The specific objectives were to monitor the following practices and correlate with hatchability and hatch residue: determine mating frequency in the early hours of the day and effect on egg fertility, impact of time of egg collection, temperature and relative humidity in the pen house, relationship between incubation air temperature and egg eggshell temperature, as well as characteristics of eggs breakout residues after hatch.

MATERIALS AND METHODS

Study area: The study was conducted at the Olympio hatchery, Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. The area is located at altitude 285 m on latitude 06°40' N and on longitude 001°33' W. It is within the semi-deciduous forest zone of Ghana. Temperatures are relatively high throughout the year with the highest average temperature of 35.2°C recorded in March and the lowest of about 20.2°C recorded in January. The average yearly rainfall[9] is 1510.0 mm. The major rainy season occurs from April-July and the minor rainy season from September-October. The dry season is from November-March.

Experimental birds and egg collection: All experimental data were obtained from a total of 550, 56 weeks old Lohmann Brown breeder flocks. These birds were observed in the ratio of 10 hens: 1 cock in a deep litter system with wood shavings as the bedding material. Breeders were fed once a day in the morning within the hours of 8:30-9:00 am and water provided *ad libitum*. A total of 20,160 eggs from 4 different egg collection regimes were monitored through to incubation and hatch out. There were 5,040 eggs in each. Initially, with the first two hatching regimes, eggs were collected 3 times daily without any time interval pattern. Eggs were collected after every 2 h with the first collection starting from 9:00 am

after feeding the flock. Excessively big or small eggs weighing (<48 and >69 g) were exempted from being incubated. Cracked and thin-shelled eggs, elongated, rounded, wrinkled and toe punched eggs were removed.

Storage of eggs and incubation: Eggs were placed in egg crates with the small end pointing up and stored in the cold room under a temperature of 16°C and a relative humidity of 60-70%. The storage duration differed from each other with the least being a day and a maximum of 7 days. Prior to setting, eggs were removed from the cold room and placed in the egg room at room temperature for pre-warming for 6 h prior to incubation. A total of 5,040 eggs in each of the 4 regimes were set in a P5000 Jamesway incubator for 21.5 days. Eggs were kept in setter trays with their small ends pointing downwards at a temperature of 99.5°F, relative humidity of 84.5°F wet and dry bulb temperature (approximately 56%), ventilation set at 50% and turning at 45° angle and turning automatically regulated at every 1 h.

The air temperature inside the machine was monitored 4 times daily by a temperature probe dropped into the middle of the incubator. The eggshell temperature (EST) was measured with handheld ear thermometer which was used to touch the egg surface at regulated time intervals. Three sample points were identified within the trolley which was representative of the average conditions. Measurements were taken in the middle of the egg avoiding readings from the air cell/blunt or pointed end of the egg and the average determined as established by Tullett[10]. Temperature readings were taken 4 times daily usually in the morning (8:00 am), afternoon (1:00 pm) evening (6:00 pm) and sometimes at night (8:00 pm). This measurement started from 4 days till 18 days of incubation to coincide with periods of significant production of heat of metabolism from the embryos[11,12].

Candling and transfer for hatching: All set eggs were candled on the 7th and again at 18th day of incubation in a dark room to remove infertile eggs and early embryonic deaths from fertile eggs. The fertile eggs were seen to be densely clouded and opaque with a network of veins indicating the development of an embryo within the egg while the infertile eggs were translucent under the light. After candling on day 18, fertile eggs were transferred into clean disinfected hatching baskets and placed in a P5000 Jamesway hatcher at a temperature of 98.5°F and a relative humidity of 86°F wet and dry bulb temperature (approximately 60%). Chicks started to hatch from day 20 (early hatch) till day 22 (late hatch). On the 22nd day, all egg hatching trays were pulled out for hatch day breakout to start.

Breakout analysis: Throughout the study hatchery breakouts on residue eggs were performed at 7, 18 and at the end of the incubation period. The 7 day hatchery residue comprised eggs selected as infertile but was broken to remove early dead and clear eggs. The 18 day breakouts were performed on eggs rejected before transfer for early, mid and late dead before transfer of eggs. This was to help monitor the gradual development of the embryos and also ascertain whether optimum conditions for their development was met. On day 23, all trays were pulled out containing hatch debris. Breakout was performed on the eggs which did not hatch. The number of eggs that embryos attempted breaking out with their beaks but were not successful and died in the shell were carefully separated and tagged as external pips. Embryos that were still in the eggs were separated and tagged as dead in shells. These group of eggs were carefully placed on egg crates with the small end pointing downward. The blunt or at the air cell end were carefully opened to determine which stage of their development did embryonic mortality occur. Depending on the maturity of the embryo, they were tagged as early, mid or late mortalities.

Data analysis: Data collected were analyzed using the GLM procedure of SAS and means separated by the student Keul Newman Test at 5% probability.

RESULTS

Mating frequency: The most sexually active period of the day of the birds was observed to be at the early times of the morning. The daily mating frequency during the study period was similar to each other with the highest recorded as 50 times and the least recorded was 47 times within the 3 h' observation period (Fig. 1).

Ambient temperature variation inside poultry house and egg room: The ambient temperature in the egg-laying pens or in the poultry house was high in the afternoon and evening compared to the morning (Fig. 2). The morning temperature was always a little below 27°C while the highest evening and afternoon ambient temperatures were a little below 32°C. As with the pen house, the egg sorting room was also hot especially during the afternoon hours (Fig. 3). The morning

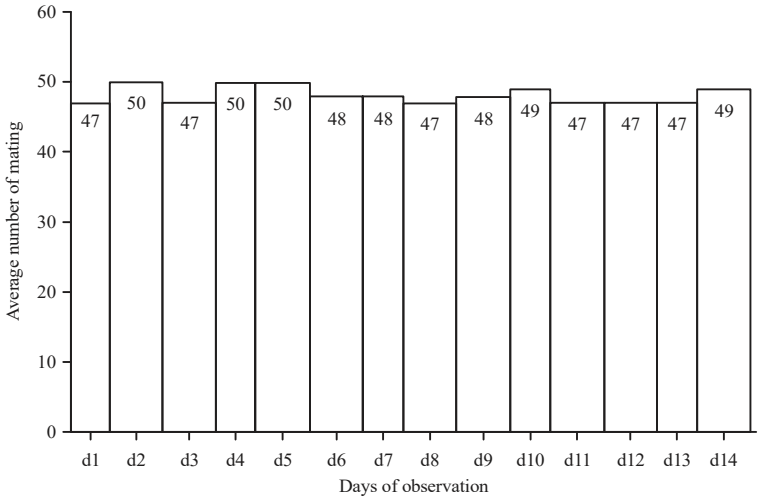

Fig. 1: Mating frequency of Lohmann layer birds measured been 5:30-8:30 am for 14 subsequent days

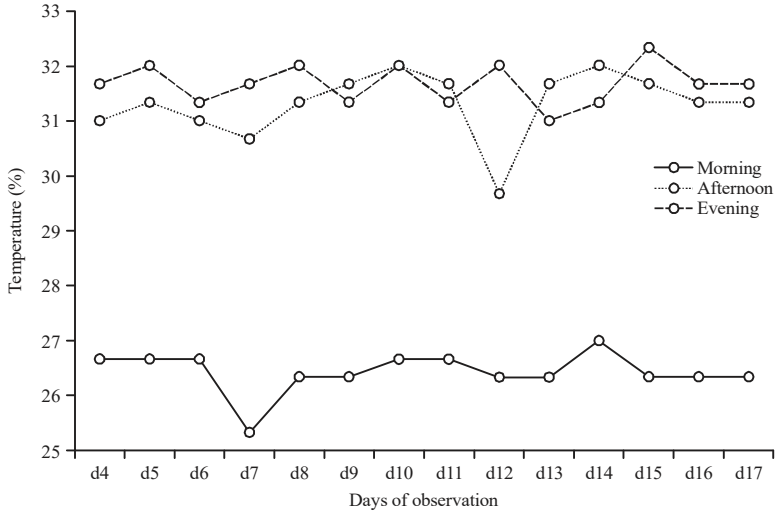

Fig. 2: Temperature variations during the various times of the day in the laying house

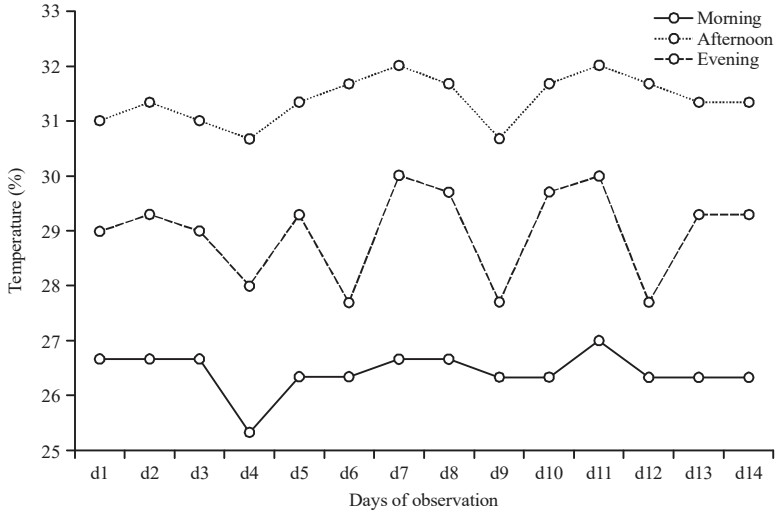

Fig. 3: Temperature variations during the various times of the day in the egg room

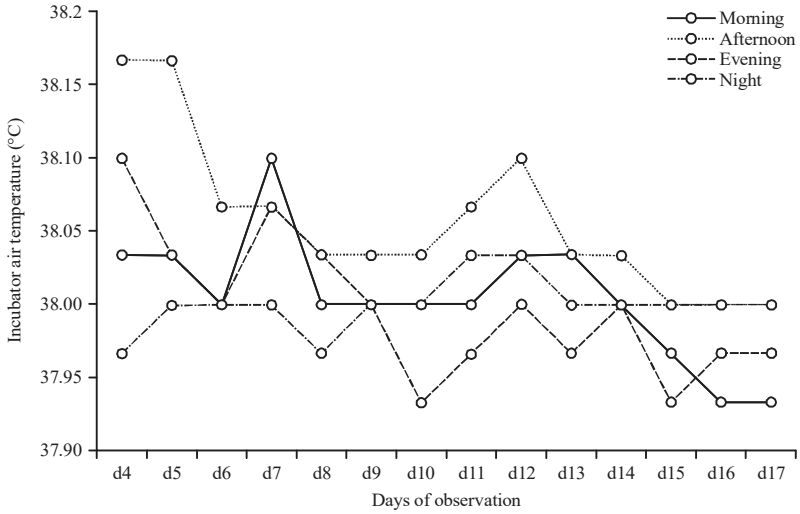

Fig. 4: Average incubator air temperature recorded per time of the day from D4-D17 at a constant machine temperature

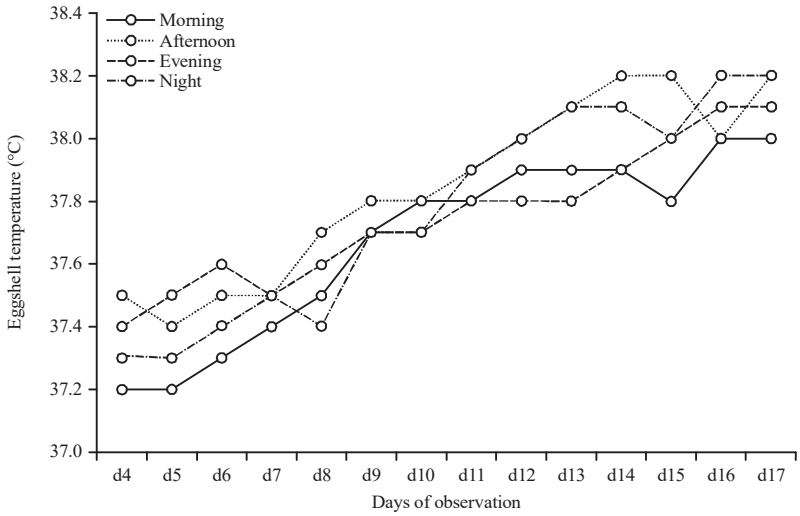

Fig. 5: Average eggshell temperatures measured daily in the morning, afternoon, evening and night using a handheld ear thermometer

hours, as usual, were cooler with temperature averaging between 31 and 32°C. It, however, dropped to around 28 and 30°C in the evening hours.

Incubator air temperature: Figure 4 shows the variation in incubator air temperature at various times of the day. Though there were differences in the temperatures recorded they were marginal. However, the incubator air temperature appeared slightly higher in the afternoon. The eggshell temperature (EST) appeared to be fluctuating depending on the time of the day (Fig. 5). But afternoon EST where higher than morning times which mostly appeared lower. Figure 6 shows that as the incubator air temperature stays at a steady point with small undulating variations, the EST was also rising steadily as the days of incubation increased. The EST became greater than incubator air temperature beginning from day 15-17 (Fig. 7).

Hatchability and egg breakout analysis: The overall hatchability in this present study was 56% (Fig. 8) and could be adjudged as poor already. Egg breakout on unhatched eggs showed that 0.1% of egg infertility was recorded followed by 0.3% being contaminated eggs. Early embryonic deaths (12.9%) turned out to be higher than both mid embryonic death (8%) and that of late embryonic death (10.5%). Eggs that piped and could not hatch also termed as pipping mortality was 3.7% of total eggs set.

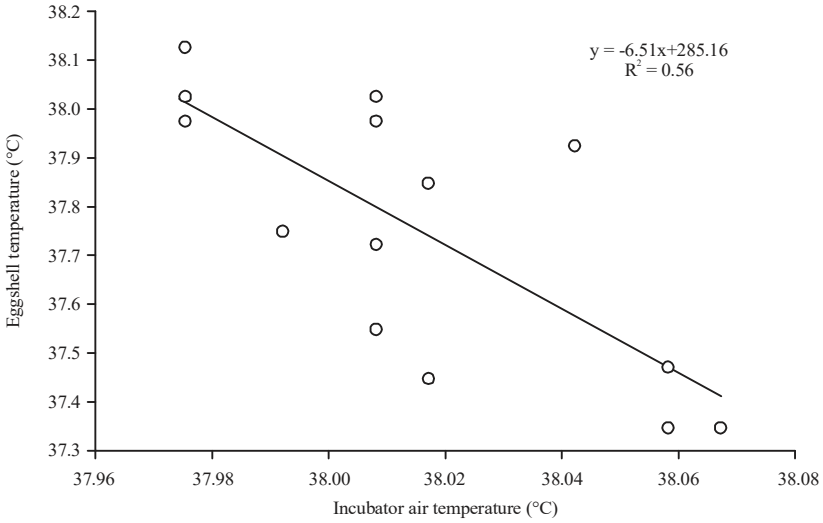

Fig. 6: Relationship between incubator air temperature and eggshell temperature with increasing days of incubation

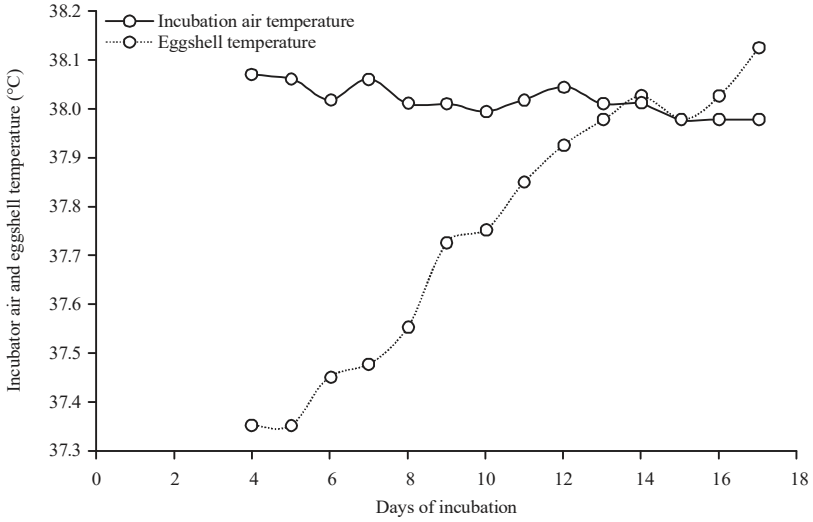

Fig. 7: Impact of increasing days of incubation on trends established by incubator air temperature and eggshell temperature

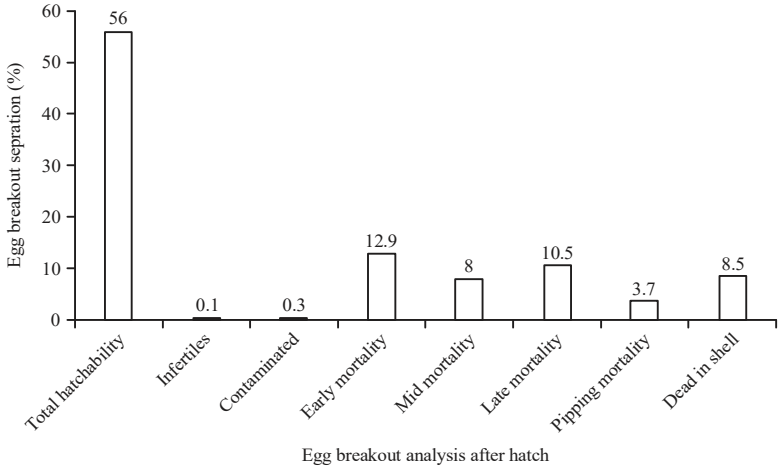

Fig. 8: Breakout analysis of eggs after incubation and hatchability results of incubated eggs

DISCUSSION

Eggs are often laid in the morning the best time for collecting the eggs was in the morning[13]. After lay if the eggs continue to stay in pen temperature above 20°C which, is the egg storage physiological zero the blastoderm begins to develop and this may affect hatchability[14-18]. So there should be a frequent collection of eggs and sent to the cold room. In this study, it was surprising to note that the evening ambient temperatures were most times higher than that of the afternoon temperatures on some days. This could be due to the time of the day in which the data was taken (5:00 pm). The pen house may still be hotter because of radiant heat buildup in the litter. Afternoon and evening temperatures were also in contrast with reports by Bramwell and Martin[19] who recommended a temperature of 25-30°C for the laying house. The higher temperature value recorded in this current study could be due to the high ambient temperature in the environment during the study period and is common with tropical countries.

The egg room in most farms serves as a place for cleaning, sorting and short temporal hold up of eggs until they are transported to the hatchery. The ideal temperature range is between 20-25°C. Bourassa *et al.*[20] did not find any negative effect on hatchability when eggs were held at 19-23°C for 4 days prior to egg transport to the hatchery. From the results obtained in this experiment, even the morning temperature (25.3°C) was slightly higher than the recommended range and this could be greatly affecting hatchability results. The higher ambient temperature also increased the EST as observed.

Lourens *et al.*[21] reported that the highest hatchability was found at a constant EST of 37.8°C. But comparing it to that of this experiment, from day 12 onwards, EST went above 37.8°C. It has been shown that an EST between 37.5 and 38.0°C from day 0 until day 18 is optimal for embryonic development and hatchability[21-24]. French; Lourens *et al.*[21], Yahav[25] and Hulet *et al.*[26] proposed that keeping the EST at 37.5-38.0°C during the early days of incubation maximizes hatchability. They also recommended setting the incubator temperature such that the incubator air temperature was between 37.0-38.0°C. The avian embryo is known not to be capable of regulating its own body temperature but at a certain point in its development, it begins to generate heat within itself due to increased metabolic activity[11,19,20,27]. Therefore, the EST will only be steady if the developing embryo is dead. By 9 days of incubation, embryo temperature becomes higher than incubator temperature probably due to increased embryonic metabolism[11,20]. Our results were similar to these observations but EST became greater than incubator air temperature beginning from day 15-17 which, also coincides with periods of rising embryonic metabolism.

There are views that increasing EST is not necessarily due to incubator air temperature but EST is aligned to increased metabolic activity of the growing embryo[28-30]. Lourens *et al.*[21] also noted that incubator air temperature was simply not the same as eggshell temperature which is perfectly in line with our findings. Other researchers also argue out that incubator air temperature contributes to EST because the chick cannot regulate its own body temperature until the hatching process is complete[31,32]. A recent study focusing on incubator or machine temperature shows that there is a clear relationship between increasing machine temperature and EST[20].

It is stated by Hawken[6] that for a hatchery to meet optimum profitability, percentage hatch of healthy chicks should be about 85% for which, this present study could not meet. This can be attributed to poor flock management and incubator factors[33]. In another research, Kalita *et al.*[33] obtained hatchability percentage of 58.75% of the total eggs set. An appropriate egg breakout analysis should constantly be used to assess both breeder farm and hatchery performance as carried in the current study.

CONCLUSION AND RECOMMENDATION

This research was done to assess layer breeder parent production practices, pre-and post-incubation of eggs and determine focal points of the problem in the breeder farm and hatchery and suggest mechanisms to minimize them. The following submissions were made from the study. High temperatures in the breeder pens and egg receiving rooms have the tendency of initiating embryo development and these should be checked because these could have increased the early embryonic mortality observed at egg breakout. Egg contamination could be as a result for floor and dirty eggs which could increase contamination if they break in the machine. Though there was only 0.3% recorded the number is still very sufficient to render an entire hatch unwholesome. These eggs should be excluded from incubation. The EST increases because embryonic temperature and metabolism may be increasing and was high after 16 days of incubation. Incubation temperature should be checked to normalize incubator air temperature and rising EST which could result in increased late embryonic mortality.

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