

Relationship of Air Cell Size to Shell Temperature and Weight Loss in Broiler Hatching Eggs



Hatchability of broiler breeder eggs requires fairly tightly controlled humidity parameters so that water lost during incubation is neither too much nor too little and that proper composition and pressure of the air cell gases are maintained. In addition, embryonic development is critically dependent on temperature, but assessing actual temperature of the embryo is difficult.

When Collins et al. (2014) compared eggs from 1955 Athens Canadian Random Bred (ACRB) meat-type chickens with those from 2013 Cobb 500 broiler breeder hens, they found that shell and internal egg characteristics have been altered by genetic selection. Correspondingly, hatching parameters have also changed over time. ACRB chicks, on average, had greater percent water loss and higher gas exchange rates, hatched 6 hours later, and had smaller residual yolk sacs than did the Cobb 500 chicks.

Because there are no reports in the literature that systematically describe air cell profiles in modern broiler strains or that relate air cell characteristics to egg temperature, we conducted a study using Ross 708 hatching eggs between 3 and 12 days of incubation. The overall objective was to determine air cell changes during incubation and their relationship with shell temperature and percent egg weight loss. A secondary objective was to use the results of air cell depth as it changes over time to predict where a temperature transponder might be placed to give the most accurate embryonic body temperature. Data from Pulikanti et al. (2011a, b) show that implanting a temperature transponder (1.0 by 0.2 cm) into the air cell does not negatively affect embryo development, but that improvements in the implantation procedure itself would make transponder use more practical. We are currently working on this technology (Durojaye, 2017).

Daily at 4 p.m., eggs were selected randomly from the incubator and candled to determine the presence of a live embryo. The following were recorded or calculated on a daily basis from 3 to 12 days of incubation: egg weight, cumulative egg weight loss, egg volume, air cell depth, air cell volume, shell temperature, and incubator air temperature.

- Egg volume was determined by placing an egg in a known volume of water and recording the volume of water displaced by the egg.
- Air cell volume was determined in two ways:
 - carefully introducing a known amount of water from a syringe through a small hole in the large end of the egg, and filling the air cell space;
 - converting the difference in weight of the egg with and without the added water to volume (1g water = 1 mL water).

- Relative air cell volume was calculated by dividing air cell volume by egg volume.
- Air cell depth was determined by inserting stiff, wax-coated thread through the hole in the large end of the egg until it just touched the inner shell membrane, and the length of the string measured.
- Shell temperature was measured using infrared thermometry; incubator air temperature was monitored with a wireless data logger.
- Egg weight loss was calculated as the difference between initial weight of egg at set and the respective daily egg weight.

The eggs were obtained from a 36-week-old breeder flock; the 288 eggs used in the study were not cracked, misshapen, or dirty, and all were within +/- 10 percent of the average weight of all eggs collected. Incubation temperatures were 99.5°F (37.5°C) dry bulb and 85°F (29.4°C) wet bulb.

Implications

The effects of incubation temperature on incubating eggs (e.g., weight loss, embryo development, hatchability, body weight at hatch, and post-hatch performance) are well known. Shell temperature has been shown to affect egg weight loss through its effects on water vapor pressure gradient across the shell.

In this study, the lack of a significant correlation between egg weight loss and shell temperature suggests that shell temperature may play only a minor role from 3 to 12 days of incubation. There was, however, a possible indirect effect of shell temperature on egg weight loss through a correlation with relative air cell volume (as a percentage of total egg volume). This would suggest that the size of the egg may be a confounding factor in the relationship between shell temperature and air cell size. The precise relationship between shell temperature and air cell characteristics throughout the incubation period will require additional investigation, including the roles of egg weight loss, embryo metabolism, and possibly other factors such as egg shell structure and incubator humidity.

As in other studies, the air cell depth and volume, as well as shell temperature, of the Ross 708 eggs in this study increased as incubation increased from 3 to 12 days. The progressive increases in air cell depth and volume were also associated with loss of water from the egg and a subsequent decrease in egg weight.

Although most of the results of this study confirm earlier results, some of this study's results are in contrast with an earlier report by Needham (1931), in which the

greatest increase in air cell volume occurred between 6 and 13 days of incubation. In the current study with Ross 708 eggs, the largest percent increase in air cell volume (37 percent overall; 0.44 mL daily) occurred much earlier, between 3 and 6 days of incubation. During this same time period, the relative air cell volume increased by 12 percent daily and 36.1 percent overall.

In contrast with the 1931 study, the average daily increase in air cell volume between 6 and 12 days of incubation was 0.37 mL, and the increase in relative air cell volume was only 10.7 percent. The lower daily increases in both air cell and relative air cell volume in this study during the 6- to 12-day period in comparison to the 3- to 6-day period suggest that eggs from this modern strain of broiler breeder may allow for an earlier or more rapid rate of air cell development, which may be related to differences in embryo metabolism and eggshell permeability.

The increases in air cell depth and volume that occur as incubation progresses suggest that air cell size between 6 and 12 days of incubation is adequate for implantation of thermistor probes. This will allow more accurate estimations of core body temperature of embryos. The results of this study indicate that, as air cell depth increases from 3 to 12 days of incubation, the depth of thermistor probes inserted into the air cell should be adjusted by as much as 0.048 cm per day to allow the tip of the probe to remain in close proximity to the inner shell membrane. This will optimize accuracy of subsequent embryo temperature readings throughout the 3- to 12-day incubation period.

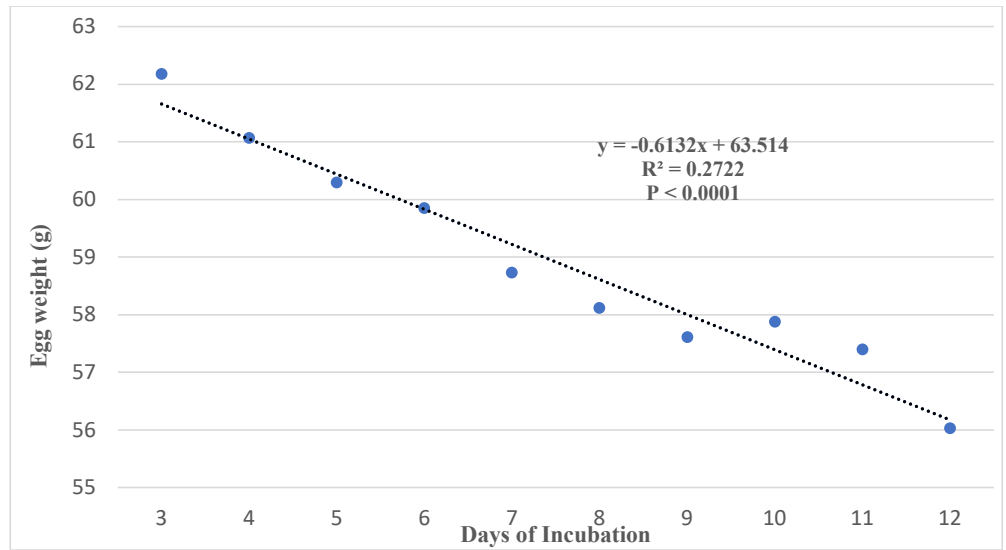


Figure 1. Daily mean egg weight values from 3 to 12 days of incubation.

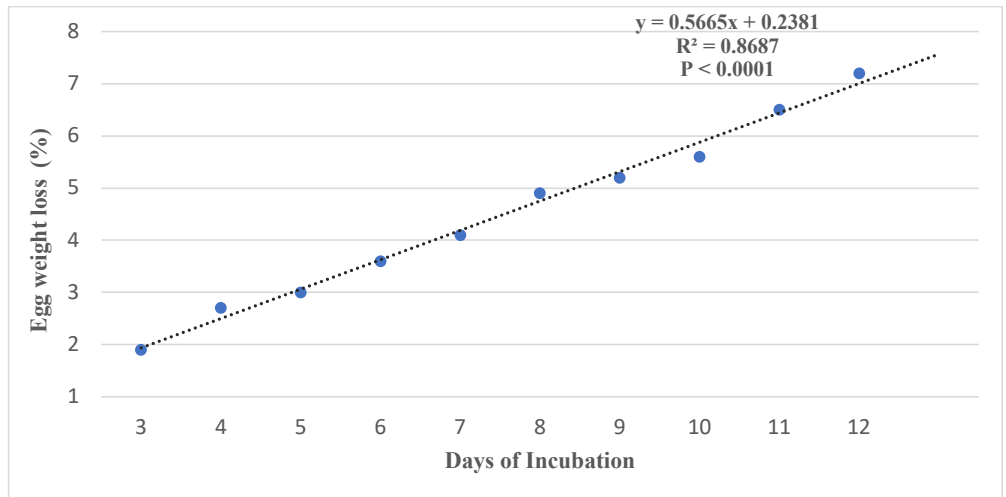


Figure 2. Daily mean cumulative percentage egg weight loss values from 3 to 12 days of incubation.

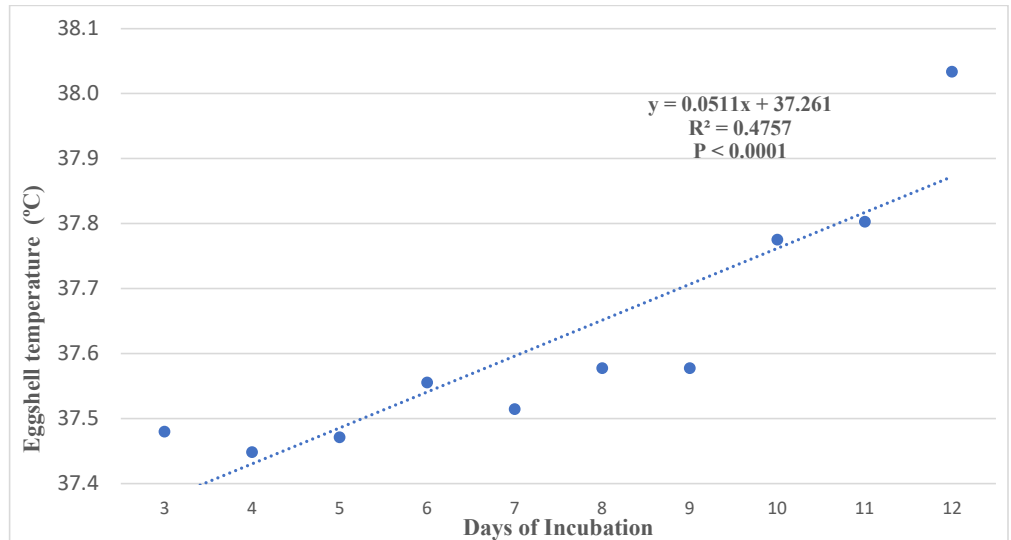


Figure 3. Daily mean eggshell temperature readings from 3 to 12 days of incubation.

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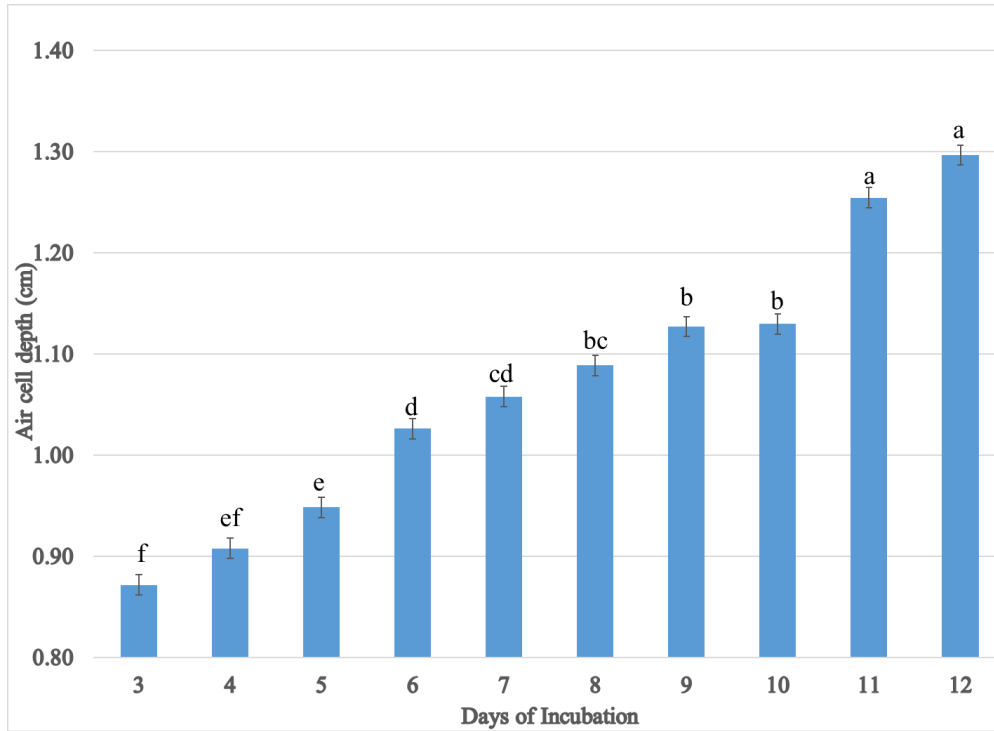


Figure 4. Daily mean air cell depth readings from 3 to 12 days of incubation. ^{a-f}Means with no common superscript differ significantly ($P \leq 0.05$).

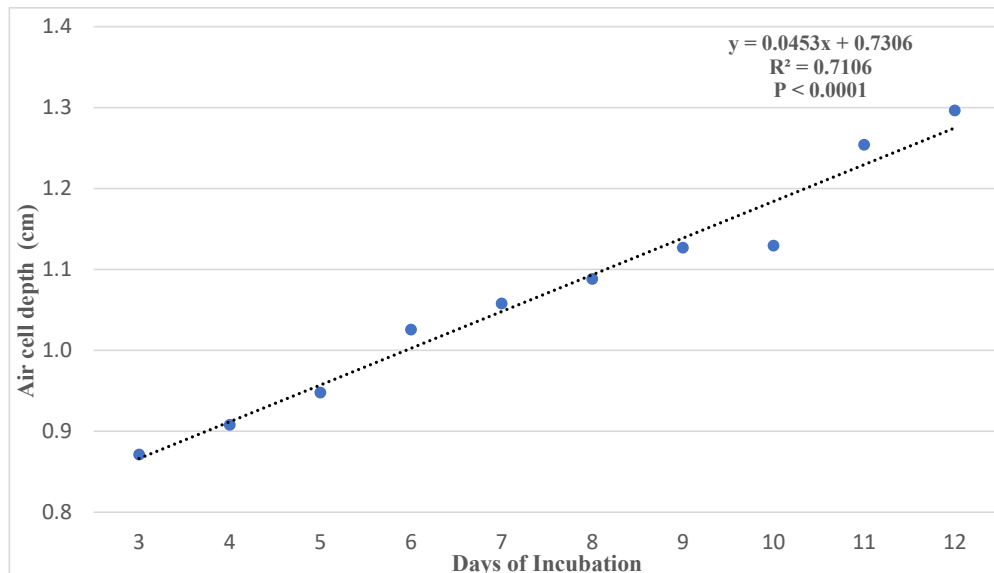


Figure 5. Daily mean air cell depth values from 3 to 12 days of incubation.

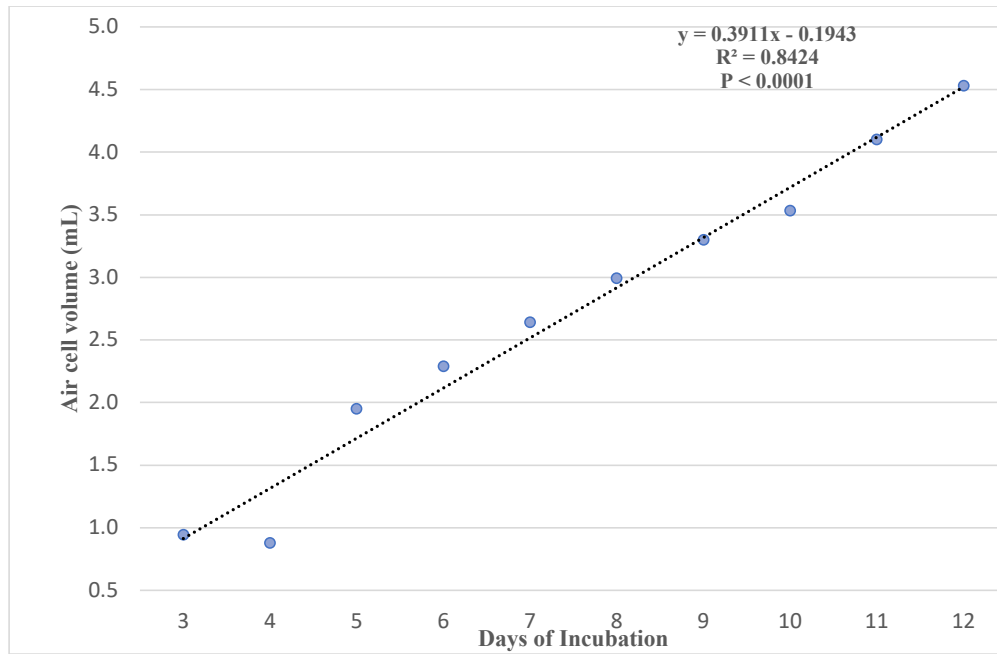


Figure 6. Daily mean air cell volume values from 3 to 12 days of incubation.

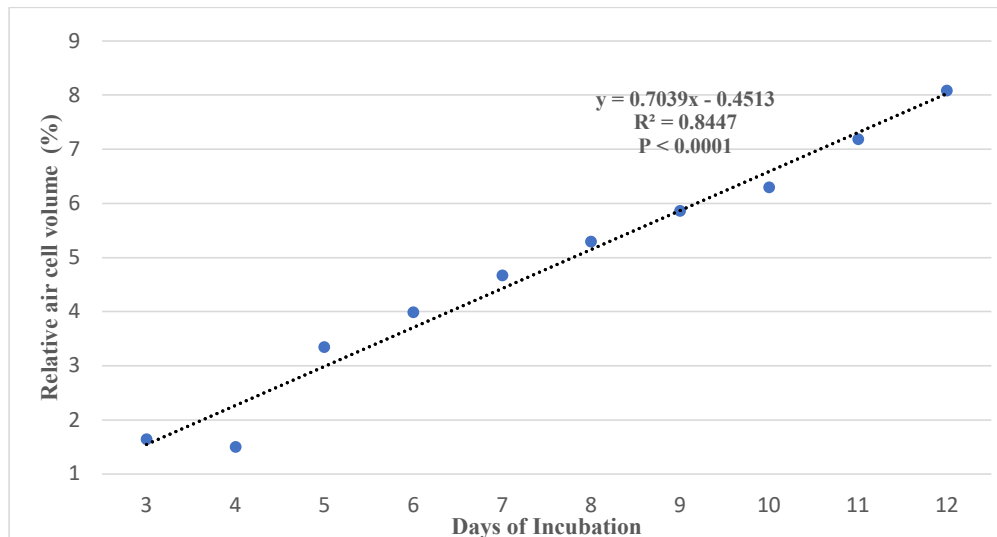


Figure 7. Daily mean relative air cell volume values from 3 to 12 days of incubation.

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