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Hatchability of End of Lay Egg Production Broiler Breeder Eggs as Influenced by Prestorage Warming

Kyle Homan

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by

Kyle Homan

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Dr. Dennis R. Ingram

School of Animal Sciences

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Louisiana State University
& Agricultural and Mechanical College
Baton Rouge, Louisiana

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ABSTRACT

Hatchability of chicken eggs has been of great concern to researchers due to the increased demand of poultry over the past 20 years. Incubation is a critical part of a chicken's life and has been extensively reviewed to determine optimum conditions. There are many factors that contribute to incubation, and they can have a major impact on hatchability if altered. This research was conducted to determine the effects of prestorage warming on the hatchability of end of lay egg production broiler breeder eggs. An experiment was conducted with 1,800 freshly laid eggs from Hubbard UY and Ross 708 broiler breeders at 63 and 56 weeks of age, respectively. These eggs were used to determine if prestorage warming treatments of 0, 3, 6, 9, 12, or 15 hrs (at 27°C) could improve the hatchability of eggs stored (at 15.5°C) for three days. After storage, the eggs were incubated for 21 d. Eggs that were unhatched were broken to confirm fertility or stage of embryonic death. The stages of embryonic death consisted of the following: early dead (1 – 7 d), mid dead (8 – 14 d), and late dead (15 – 21 d). Pips also were recorded. True fertility, fertile hatchability, and total hatchability were calculated. A randomized block design was used. Statistical significance was assessed at $P < 0.05$. True fertility was found to be consistent with industry standards. Neither fertile hatchability nor total hatchability were significantly affected by treatment. Prestorage warming of 3 hr significantly increased early embryonic mortality. When warming for 12 – 15 hr, mid dead embryonic mortality was significantly decreased when compared to the control. However, late embryonic mortality increased significantly with prestorage warming of 9 hr. When considering all embryonic mortality, 3 hr was significantly higher than the control. The results lend support to the argument that a certain stage of embryonic development must be reached before placed into storage.

INTRODUCTION

There has been a gradual increase in demand for poultry in the U.S. over the past few decades. In contrast, demand for beef and pork has remained steady. Poultry has become the largest income producing animal commodity exceeding the combined value of all other animal commodities, including beef cattle, dairy, swine, and sheep. Chosen for its low fat content and price, poultry is seen in a diverse set of food products that include such items as wings, drumsticks, and tenders.

Commercial poultry production is currently one of the fastest growing capital-intensive animal industries in North America. The value of the US broiler industry has grown from $5.68 billion in 1985 to $20.9 billion in 2005 (Schaal, 2007). Turkey production has increased in value since 1985 by 77% with a total value of $3.23 billion in 2005 (Schaal, 2007). Due to increased consumer demand and exports, the poultry industry saw an increase in the number of broiler (98%) and turkey (33%) eggs set over the past 20 years. U.S. exports of poultry during this same time rose a substantial 502% (Schaal, 2007).

Poultry is a very important industry in Louisiana. More than one billion pounds of broiler meat are produced in Louisiana each year. The value of this amount, including value-added poultry products, is in excess of one billion dollars annually. Companies have to set more than three million broiler breeder eggs per week to meet this demand. Overall, broiler breeder companies are looking to ensure that the set eggs are fertilized and hatch and that the chicks grow fast and produce a lot of meat. Successful companies are able to supply large orders of breeding stock that perform competitively in the global market.

American consumers prefer convenience and breast meat so companies have to emphasize producing higher live weight rather than higher yielding birds. Because the modern chicken has been modified by population genetics (and not steroids), companies have selected for certain traits that help produce a heavier chick. For male lines, companies choose such traits as growth rate, edible meat yield, and feed conversion ratio. For female lines, these traits are the same except egg production also is considered.

These major traits are improved by positive selection while minor traits like fertility, hatchability, and livability are affected by eliminating the few worst families. These minor traits are generally considered to have low heritabilities (Chambers, 1990). Therefore, it makes it extremely difficult to select for these traits, and geneticists now focus more on yield.

The recent increase in the research of incubation can be attributed to the lack of up-to-date management techniques. Incubation and egg handling procedures from the 1950s are still being used today although the modern broiler has changed considerably. Additionally, it has been reported that genetic selection for increased bird size has resulted in low-quality eggs from breeder flocks (Hocking and Robertson, 2005).

The total calculated economic impact associated with hatchability for both broilers and turkeys is a $500 million loss to the poultry industry annually (Schaal, 2007). Finding the optimum handling and incubation techniques has the potential of a huge economic impact on the industry. If the poultry industry could increase the hatchability of both broiler and turkey eggs by just 1%, the increase in returns would total more than $25 million (Schaal, 2007). This means nearly a $30,000 gain per week for Perdue Farms, a top five broiler company (Pollock, 1999).

Chicken embryonic development takes place in the egg making the embryo a target of poultry research. Due to their immobility, eggs are easily accessible to intervention.

Additionally, genetic breeding has shortened growout times making the development process 30 - 40% of the chick's total lifespan. Vaccination companies have developed new technology systems that utilize high-speed automated equipment to vaccinate many eggs in a short period of time (Ricks *et al*., 2003). Researchers have specifically studied incubation because companies have full control over the process. The factors during incubation that influence hatchability will be reviewed within this thesis.

LITERATURE REVIEW

The level of hatchability has not improved over the past 20 years and has ranged from 79 to 82% (Schaal, 2007). Yet, there have been advances in nutrition, genetic selection, and management. These advances have largely resulted in increased bird growth, increased carcass yield, and decreased number of days to market. Industry trends over the last five years show that egg production, fertility, and hatchability have been devalued in the choice of breeds in the U.S. (Pollock, 1999). Current management of breeders does not place enough emphasis on hatchability. The process from time of egg formation to hatch is very complex and involves rapid development of undifferentiated blastodermal cells.

Hatchability is used in broiler breeder operations and hatchery management to monitor reproductive success and as an economic efficiency indicator. There are numerous factors that influence hatchability but there are three main effects of concern: breeder flock, storage, and incubation. The breeder flock effect includes variables directly affected by the parent flock and prior to lay. Storage consists from the time of lay to the time of setting. Because storage is inevitable, the poultry industry standard is to keep this period to a maximum of four days. The last effect is the conditions during incubation. This important part of the bird's production life cycle lasts for 21 days.

Breeder Flock Effect

Characteristics of the parent flock are important to understand because of their effect on the reproductive cycle. Because the poultry industry relies heavily on genetic selection, these physiological changes in birds can affect the egg and embryo development. Several researchers have found that populations of both turkeys and chickens selected for low body weight produce eggs with an advanced embryonic development (McNary *et al.*, 1960; Kosin and Arora, 1964).

Hens that are selected for low body weight produce eggs with an increased hatchability (Coleman and Siegel, 1966). These eggs also were reported to have a higher rate of embryonic development. Genetic selection has been found to be responsible for changes in the rate of growth and development. These results affirm the idea that there are slight differences between selected lines, and management techniques can vary accordingly. There are several other factors of the breeder flock that are consistent among strains.

Breeder Age

Researchers that have studied the effect of breeder age have found that hatchability is essentially a function of age. Originally, it was believed that hatchability declined at a uniform rate similar to that of the general egg production cycle. However, Creel and Maurice (1998) found that the relationship between age and hatchability could be described by a segmented regression model. Hatchability increases steadily and then slows after 33 weeks of age. After 49 weeks of age, there is an abrupt increase in the rate of decline in hatchability (Creel and Maurice, 1998). The age-associated decline in fertility and hatchability has male and female components.

There are many aspects of aging in females that influence hatchability. Females can have multiple ovulations or an impaired capacity of the sperm storage tubules. During egg formation, there could be retrograde transport or faulty shell deposition. Another age-related explanation for the decline in hatchability is an increase in the number of first-of-sequence eggs (Creel and Maurice, 1998). These eggs have developmental changes and are less viable. Additionally, eggs from older laying hens are correlated with a rise in albumen pH which must remain relatively stable (Brake *et al*., 1997). Elibol *et al*. (2002) discovered that flock age has a significant negative effect on hatchability of total and fertile eggs. Flock age also has been found responsible for increasing early and late embryonic mortality (Roque and Soares, 1994). Present

results suggest eggs from older flocks have their maximum hatchability at the time of lay, whereas eggs stored from younger flocks can hatch reasonably well when stored for a short period (Reis *et al*., 1997).

The age of the breeding males also has an effect on hatchability. This effect is alleviated by the commercial practice of spiking. Spiking involves adding younger males to overcome the negative effects of older males. Younger males have higher concentrations of sperm in ejaculates of greater volume (Bramwell *et al*., 1996). As males age, there is a reduction in the number of spermatozoa in the ejaculate and the volume of semen produced (Bramwell *et al*., 1996). Additionally, male competition, physical injuries, and decreased libido are contributing factors to infertility. However, females have a large effect because of their reproductive qualities.

Egg Quality

There are different aspects of egg formation and composition that can have an effect on hatchability. Because the developing embryo relies on gas diffusion in order to survive, pores in the shell play an important role. Eggshell quality has been commonly quantified by calculating egg specific gravity (the egg's density compared to water). Egg specific gravity is positively correlated to shell porosity. Roque and Soares (1994) observed that eggs with a higher specific gravity have a higher hatchability overall. Eggs with a higher specific gravity have lower mid and late embryonic mortality when compared to thin-shelled eggs. Thick-shelled eggs also are more resistant to impact and less likely to break during transportation. However, there are few ways to improve shell quality and research is limited.

During incubation, a certain level of weight loss must be reached for an egg to hatch. The initial egg weight, which is directly controlled by the female, will play a role in the total

weight loss. Eggs have been found to vary in weight by time of lay. Weights of early laid eggs are significantly greater than middle laid and late laid eggs (Zakaria *et al*., 2005). The state of embryonic development at oviposition is also of interest to researchers because of its influences on hatching results. Mather and Laughlin (1979) reported that embryonic development was more advanced in eggs laid by older birds, and these eggs hatched earlier.

Nutrition

The effects of dietary factors on embryonic development in poultry have been well documented. Normal development in a chick requires an adequate, balanced supply of nutrients from the parent birds. Nutritional deficiencies and excesses can result in death, malformation, or some other atypical response (Leeson and Summers, 2001). As these imbalanced levels increase, the severity of these effects increase as well. Generally, overfeeding has been found to reduce fertility (Zuidhof *et al*., 2007). Feed intake has been demonstrated to have more effect on egg size and early production traits rather than body weight. When considering nutrition, it is important to note transfer rates of certain vitamins. Egg levels respond rapidly to dietary increases of vitamins like Vitamin A, Vitamin E, biotin, and riboflavin. However, thiamine has a low transfer level (Wilson, 1997).

Lillie *et al*. (1951) found that the process of making nutrients usable by the body varies by strain. The developing embryos of modern high-breast yield strains are particularly susceptible to vitamin deficiencies. There is also a genetic basis behind inadequate deposition of certain nutrients. Some commercial stocks have a genetic defect that leads to improper deposition of the vitamin riboflavin in the egg. Riboflavin is essential for embryonic development but is a common deficiency. Deficiencies of vitamin A and thiamine are unlikely in current broiler diets. Susceptibility to deficiencies of vitamin B12, Niacin, and Vitamin E is

specific to strain. Breeder hens have a higher requirement of dietary folic acid for hatchability than for egg production (Taylor, 1935).

Minerals also play a crucial role in the subsequent development and hatching of avian embryos. While there are rarely deficiencies in iodine or manganese, there can be deficiencies in calcium and they largely affect eggshell quality. Calcium-deficient diets result in excessive egg weight loss and increased mortality (Wilson, 1997). Phosphorous is necessary for normal embryonic development and must be inorganic in order to increase hatchability. Low levels of zinc, chloride, and potassium also are necessary for a breeder. Unfortunately, marginal deficiencies or excesses may not be observed or detected as easily as acute ones. Hatchability problems would not be discovered for several weeks after the feed is consumed.

Mating Ratio

Fertility of eggs is one of the major factors ultimately determining hatchability of all eggs set. Chicken embryos are unable to develop unless fertilization occurs. There has been research that investigated the influence of mating sex ratio. True fertility of broiler breeder eggs is largely a function of mating frequency (Wishart and Staines, 2002). Lower mating ratios significantly improved fertility and hatchability (Deeming and Wadland, 2002). There was also a significant increase in egg production.

Incubation Effect

From the moment of fertilization of the ovum, embryogenesis starts, and the environment begins playing an important role in embryo development. The environmental conditions that result in the highest hatching percentage of fertile eggs were largely determined half a century ago. Wilson (1990) summarized the current incubation practices. These practices include setting eggs large end up and providing a constant temperature and a relative humidity of 60%

through the first 19 days of incubation. During the last two days, the temperature can be decreased and the relative humidity increased. Temperature is the most important single environment factor that has to be considered as critical in influencing or determining hatchability.

Temperature

Decuypere and Michels (1992) reviewed the history of temperature requirements during incubation. The optimum temperature for both hatchability and chick quality is around 37.8°C (Yalcin and Siegel, 2003). It is believed that the chick embryo needs a fixed amount of heat for full development, which explains longer incubation periods for eggs incubated at lower temperatures. Variation in incubation temperatures has been shown to alter hatchability, embryonic growth, and functional processes. Variation also varies between and within strains. Tolerance for this variation is smaller when exceeding the optimum temperature but remains largely a function of exposure to this variation. This can be offset by dramatic variations in temperature. Incubation temperature reaches a plateau around day 16-17 of incubation (Decuypere and Michels, 1992). Temperatures can be lowered during the last days of incubation due to increased internal heat production from the chick.

Turning

Researching the optimum turning of eggs during artificial incubation is of historic interest to scholars. In 1949, Olsen observed that hens moved their eggs during natural incubation about 96 times per day. This finding along with subsequent reports that turning during incubation increased hatchability helped make turning hourly an industry standard. Maximum hatchability was achieved with a turning frequency of 96 times per day, but 24 times per day was a practical frequency (Wilson, 1990). Turning is believed to prevent adhering of the

embryo or extra-embryonic membranes and to ensure the correct positioning of the embryo within the egg. Adhering may stunt normal development of the chorioallantoic membrane, which leads to death (Zakaria *et al*., 2005). These malformations are more likely in older broiler breeder eggs, and a higher frequency of turning is more beneficial as flock age increases (Elibol and Brake, 2003).

The angle of turning also has been characterized as an important aspect of incubational turning. When turning at angles between 20 and 75° from vertical, Funk and Forward (1944) found that 45° produced the best results. Companies can utilize a reduced turning angle to increase incubator capacity, alter airflow, and reduce costs. The interaction among turning, position, and angle has not been clearly defined. Elibol and Brake (2003) found that the incidence of malpositioned embryos was increased by reduced turning angle but this effect was corrected for by an increase in turning frequency. These data suggest that a lower turning angle could be used commercially but that the frequency would have to be adjusted accordingly to prevent an increase in the incidence of malpositioned embryos.

Storage Effect

Egg storage is a necessity in modern poultry production because of the demand of large numbers of hatchlings within a constrained period. Companies are able to meet market fluctuations by storing eggs and decreasing individual incubations. Storage also occurs at the breeder barn while enough eggs are being collected for the next pick-up. The poultry industry has long recognized that egg storage longer than 7 days is detrimental to hatchability (Fasenko *et al*., 2001b). Egg storage also prolongs incubation time, reduces chick weight, and retards embryonic development (Ruiz and Lunam, 2002). Storage causes morphological changes in the blastoderm and malformations in the embryo (Mather and Laughlin, 1979). The researchers

reported shrinkage of the blastoderm during storage and a delay in initiation of development of the embryo after storage. Hatchability is influenced by preincubation storage conditions like length of storage, temperature, and position.

Position

Traditionally, it was believed that keeping eggs in the small end down position would produce the highest rate of survival because it maintained the air space in the original position. However, it is now known that the embryo moves too much while in this position. After storage, the embryo moves towards the air space and eventually touches the shell membrane. The embryo is more likely to dehydrate and adhere to the membrane in this position. Storing eggs with the small end up keeps the blastoderm and the central yolk in the position for optimum hatchability (Mayes and Takeballi, 1984). The blastoderm is maintained in the standard equatorial zone rather than moving to various areas on the yolk.

Temperature

Once the egg is laid, it cools to the temperature of its surroundings and as it cools, embryonic development slows down and eventually stops. The physiological zero of fowl eggs is the temperature at which the embryo begins to develop. This number has been reported to be as high as 28°C and as low as 21°C (Edwards, 1902; Funk and Bielleier, 1944; Mayes and Takeballi, 1984). For short storage periods of up to 7 days, a temperature of 16-17°C is recommended, but a temperature of 10-15°C is better if the storage period extends beyond 1 week (Mayes and Takeballi, 1984). Ruiz and Lunam (2002) found increasing storage temperature to 20°C did not influence hatchability of fertile eggs.

Temperature works along with relative humidity and air movement to influence weight loss through evaporation. Relative humidity refers to the amount of moisture contained in the air

at a given temperature and expressed as a percentage of the total amount of moisture that the same volume of air will hold when saturated at the same temperature (Mayes and Takeballi, 1984). High relative humidity during preincubation storage is necessary for optimum hatchability (Proudfoot, 1970). Because the rate of weight loss was similar during incubation in both stored and nonstored eggs, weight loss should be minimized during storage by maintaining a high enough relative humidity without causing condensation (Mayes and Takeballi, 1984).

Length

Ideally, hatching eggs should be set immediately after they are laid in order to reduce storage problems and optimize hatchability. Because storage is inevitable, many commercial hatcheries aim to set eggs after only 3 days of storage. It is well known that a dramatic decline in hatchability is observed in broiler breeder eggs stored for extended periods (Heier and Jarp, 2001). Hatchability of eggs from older birds decreases more with increasing storage time (Kirk *et al*., 1980). When storage time is extended, hatchability may be reduced by 0.5% per day (Meijerhof, 1992). Mather and Laughlin (1979) reported each day increase in storage meant an increase in malformed embryos and added one hour to the average hatching time. Storage also adversely affects chick quality (Tona *et al*., 2003) and increases embryonic mortality (Kuurman *et al*., 2002). Eggs incubated on the day of lay were found to hatch later than stored eggs and produce heavier chicks (Reis *et al.,* 1997). Reis and others also suggested eggs from young flocks should be stored because of their ability to hatch reasonably well when stored for short periods. However, researchers have noted that long-term storage effects can be alleviated by exposure to higher incubation temperatures during the initial two weeks of incubation (Christensen *et al*., 2003).

Preincubation Warming

Variability of developmental stage at the moment of oviposition is known to vary by genetic line and parental age. This variability can be caused by the speed of early cell division and development or it may be indirectly linked to variations in length of oviduct transit time or body temperature. The embryos in eggs laid by older birds are more developed than those in eggs from young birds leading to the discovery that the rate of development in eggs increases with parental age (Mather and Laughlin, 1979). Because of these differences in development at lay, it is important to note the results of studies conducted by Kosin (1956) and Coleman and Siegel (1966). These researchers hypothesized that there may be critical stages of embryonic growth at which development should not be altered. Yet, Fasenko (1999) found the stage of embryonic development at the time of egg storage did not significantly influence hatchability.

After oviposition, the blastoderm is differentiated into three embryonic germinal layers: ectoderm, mesoderm, and endoderm. An egg that has reached full development of these three layers is described as entering the gastrulation stage of development. Embryos that are in an early gastrulation stage do not hatch as well as those that are in more advanced stages (Bourassa, 2003). Before enough eggs are produced for a clutch, eggs will receive intermittent stages of heat from the hen. Brake *et al*. (1997) research on avian embryology reveals the importance of albumen pH. Warming the eggs and periodically inducing metabolism reestablishes the proper pH gradients. Otherwise, albumen quality deteriorates as length of storage increases (Lapao *et al*., 1999). The egg takes less time to reach the ambient incubator temperature when warmed prior to incubation (Renema *et al*., 2006).

Warming can be done prior to storage, during storage or just before setting. Researchers studying the effects of warming on short-term storage have seen a significant increase in

hatchability when warming for five hours (Becker and Bearse, 1958). Kan and his fellow workers (1962) achieved similar results but improvements in hatchability were more profound in older eggs. Prestorage warming treatments also were found to improve hatchability of low hatchability lines to the same level as the high hatchability lines (Fasenko *et al*., 2001a). Some researchers even found prestorage incubation to have a detrimental effect on hatchability of egg stored for 15 days (Petek and Dikmen, 2006).

However, researchers have shown conflicting results on storage length effects. Fasenko and others (2001a) reported that various prestorage incubation treatments do not significantly affect mortality or hatchability of eggs stored for four days. These treatments had a large impact on eggs stored for 14 days, which the author attributes to advanced development of the embryo. Different authors have confirmed that eggs stored for longer periods benefited the most from warming (Becker and Bearse, 1958; Proudfoot, 1970). It has been further shown that warming prior to incubation allows the embryo to redress disproportionate development and ensure the required degree of embryonic development for all tissues in a proportional way (Decuypere and Michels, 1992).

The broiler breeder is one of most reproductively inefficient meat type birds in the poultry industry. When confounded with age, hatchability becomes of great concern to scholars due to the economic losses. It is important to research increasing hatchability of end of lay broiler breeder eggs because they have the lowest level of hatchability and are more affected by storage and incubation variations. Research on preincubation warming has shown conflicting results and should be further examined to determine the potential benefits. Therefore, this research was conducted to test the hypothesis that prestorage warming increases hatchability of end of lay egg production broiler breeder eggs when stored for three days.

MATERIALS & METHODS

A total of 1,800 eggs were obtained from two commercial breeder farms and transported for four hours to the LSU Poultry Farm. The eggs came from two flocks: one flock of Hubbard UY at 63 weeks of age and one flock of Ross 708 at 56 weeks of age. The eggs were immediately prepared for treatment upon arrival to LSU. The eggs were randomized and assigned to a treatment group. The eggs were set in trays and numbered from1 to 300 for each treatment of prestorage warming of 0, 3, 6, 9, 12, or 15 hours. Eggs in the 0 hrs control group were immediately placed in an egg cooler at 15.5°C at a relative humidity of 60%.

Eggs in the other treatment groups were placed in a Natureform setter (#2000, Jacksonville, FL, 32202) operating at 27.0°C with a relative humidity of 60% and were turned at a 45° angle once an hour. The appropriate groups were removed after completion of their prestorage warming treatments. After removal from the setter, the eggs were transferred from incubator trays to cardboard egg flats, which were then placed in the same cooler as the control group for three days and received the same storage conditions as the control.

After completion of the three day storage period, the eggs were set for 18 days in a randomized block design. Both level and position were randomly assigned. There were ten levels within the incubator and six positions within each level (Appendix: Figure 1A). After seven days of incubation, the eggs were candled and the infertile and early fertile dead embryos were removed. These eggs were broken to confirm fertility. After 18 days of incubation, the eggs were transferred to a Natureform hatcher (#NOM-45, Jacksonville, Fl, 32202) operating at 37.0°C and a relative humidity of 75%. Level within the incubator was maintained in the hatcher at time of transfer.

After 21 days of incubation, the chicks were removed and counted. All the unhatched eggs were removed and pips were recorded. The remaining unhatched eggs were broken to identify the stage of embryonic mortality. All embryos were classified as early dead, mid dead, or late dead as defined by death during the first, second, or third week of incubation, respectively. From the data, percent true fertility, percent fertile hatchability, percent total hatchability, percent early dead, percent mid dead, percent late dead, and percent pips were calculated.

Statistical Analysis

This research experiment was designed to consider the randomly assigned independent variables, level in the setter (block) and the position within level. These variables were not found to be significant so they were removed from the model. Hatchability data were analyzed by analysis of variance procedures appropriate for a randomized block design using PROC ANOVA procedures of the Statistical Analysis System (SAS, 1996). Arcsine of the square root of the variable was used to convert all percentages prior to analysis. The flat of 30 eggs was the experimental unit.

RESULTS & DISCUSSION

True fertility was not a response variable in this particular experimental research, as fertilization of the eggs occurred in the hens at the breeder farms. However, true fertility represents an important ratio that indicates the productivity of the breeder flock because it is necessary in calculating embryonic mortality and fertile hatchability. True fertility averaged 93.8%, which according to North and Bell (1990) is normal for broiler breeders of this age (Table 1). Fertile hatchability (67%) and total hatchability (63%) were not significantly affected by any of the prestorage warming treatments and were found to be lower than industry standards. However, eggs from flocks with low hatchability were requested.

The effect of prestorage warming also was assessed on embryonic mortality, percent pips, and total dead (Table 2). Early embryonic mortality was found to be significant (P = .101). Prestorage warming of three hours (10.6%) significantly increased (P=.101) early embryonic mortality when compared to the control (4.8%). Prestorage warming also had a significant effect on mid and late embryonic mortality (P = .035, .052). When warming for 12 – 15 hours, all mid embryonic mortality was eliminated. Treatment groups with restorage warming of 0, 3, and 6 hours were not significantly different from the control. Interestingly, nine hours of prestorage warming increased late embryonic mortality significantly when compared to the control. Pips were not significantly affected by treatment. Total dead was significantly affected by treatment (P = .023). Three hours of prestorage warming (24.0%) significantly increased (P = .023) total dead embryos when compared to the control (14.5%).

Table 1. The effect of prestorage warming of 0, 3, 6, 9, 12, and 15 hrs on fertility, fertile hatchability, and total hatchability of eggs from one flock of Hubbard UY at 63 weeks of age and one flock of Ross 708 at 56 weeks of age[1].

Pre Warm (Hrs)	True Fertility	Fertile Hatchability	Total Hatchability
	(%)		
0	92.2 ± 1.7	67.5 ± 3.4	62.2 ± 3.3
3	94.4 ± 1.0	63.4 ± 2.2	59.8 ± 1.8
6	95.1 ± 1.1	68.1 ± 4.6	65.0 ± 4.7
9	93.3 ± 2.4	68.0 ± 3.8	63.7 ± 4.3
12	94.4 ± 1.4	68.2 ± 4.1	64.3 ± 3.7
15	93.3 ± 1.8	67.2 ± 5.8	62.5 ± 5.4
P > F	.874	.922	.915

[1] Values are means ± SEM

Table 2. The effect of prestorage warming of 0, 3, 6, 9, 12, and 15 hrs on early dead, mid-dead, late dead, pips, and total dead from one flock of Hubbard UY at 63 weeks of age and one flock of Ross 708 at 56 weeks of age[1].

Pre Warm (Hrs)	Early dead	Mid dead	Late dead	Pips	Total Dead
	(%)				
0	4.8 ± 1.5^{A}	2.4 ± 1.1^{B}	7.2 ± 1.8^{AB}	17.9 ± 3.8	14.5 ± 1.9^{AB}
3	10.6 ± 1.4^{B}	2.0 ± 1.2^{AB}	11.4 ± 1.9^{BC}	12.6 ± 3.2	24.0 ± 2.4^{C}
6	6.1 ± 1.9^{AB}	0.8 ± 0.5^{AB}	9.8 ± 1.3^{ABC}	15.1 ± 3.4	16.7 ± 2.3^{AB}
9	3.6 ± 1.1^{A}	1.5 ± 0.6^{AB}	15.2 ± 2.7^{C}	11.6 ± 2.0	20.4 ± 2.4^{BC}
12	5.4 ± 1.7^{AB}	0.0 ± 0.0^{A}	11.0 ± 2.4^{ABC}	15.3 ± 3.8	16.5 ± 2.5^{AB}
15	7.9 ± 1.7^{AB}	0.0 ± 0.0^{A}	5.5 ± 1.4^{A}	19.4 ± 5.1	13.3 ± 2.0^{A}
P > F	.101	.035	.052	.741	.023

[1] Values are means ± SEM.

Total dead and prestorage warming length tended (P=.023) to have a negative linear relationship (Figure 1). Total embryonic mortality was highest at three hours of prestorage warming and declined as prestorage warming reached 15 hours. However, the difference between total embryonic mortality at 15 hours and 0 hours is negligible. Early embryonic mortality appears to be increasing as prestorage warming length increases (Figure 2). Late embryonic mortality is highest at nine hours but returns to the control group level by 15 hours.

These data suggest prestorage warming has no beneficial effect during short-term storage. Because the poultry industry storage length standard is three days, prestorage warming would be no benefit to the commercial industry. However, the data do lend support to the hypothesis that a certain stage of embryonic development does withstand storage better. This stage of development could possibly be between three to nine hours of warming. Due to small sample size, this experiment should be replicated to confirm the results. The prestorage warming temperature was lowered in this research and may have had unknown adverse effects. It is recommended to adjust this back to normal incubation temperature.

Figure 2. The effect of prestorage warming on total embryonic mortality.

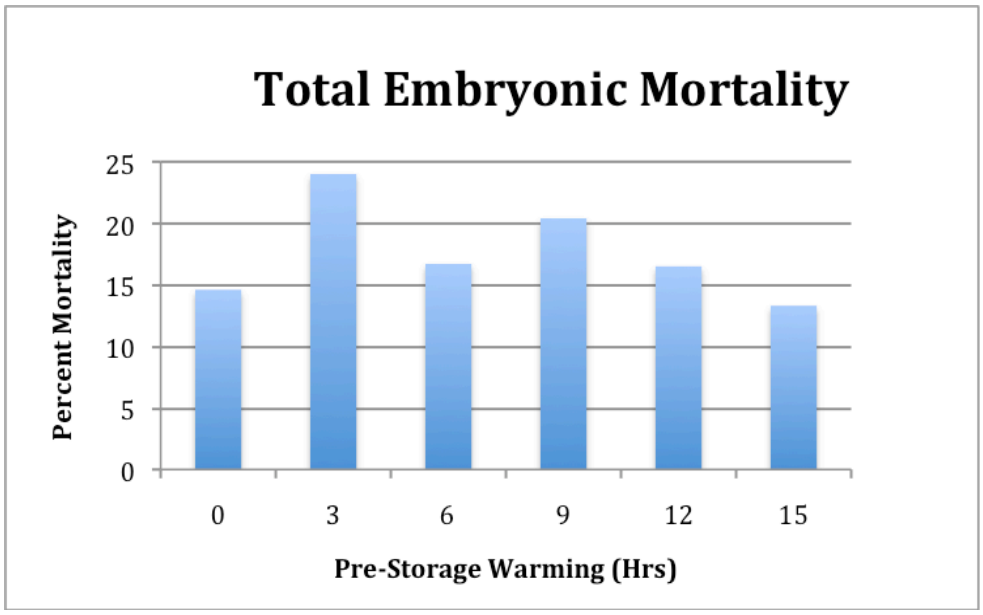
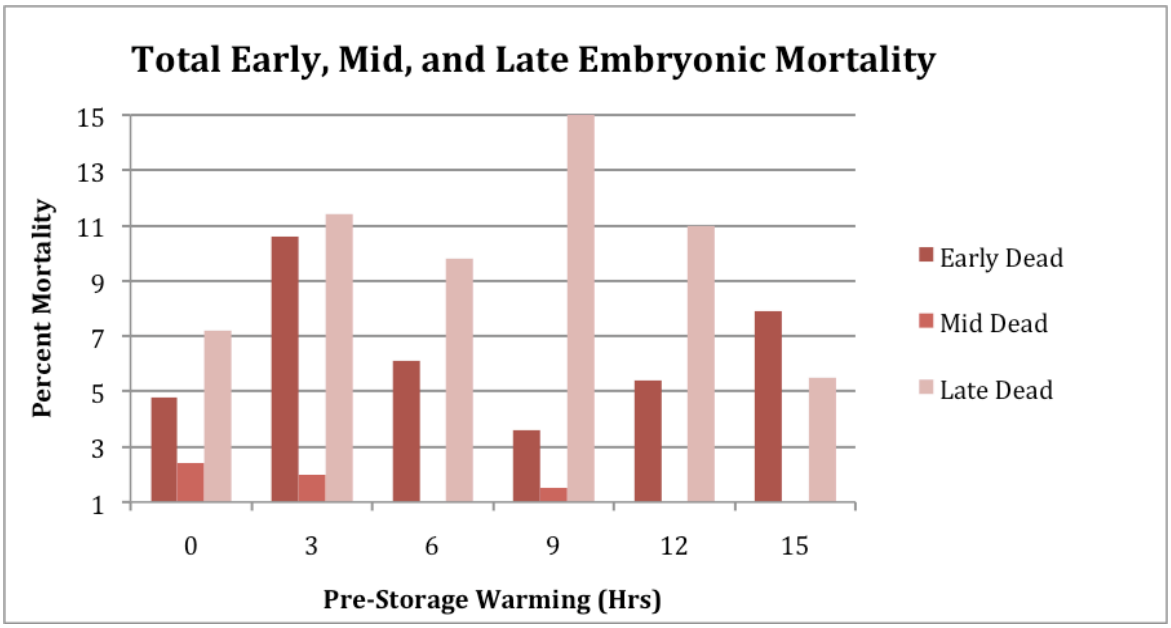


Figure 3. The effect of prestorage warming on early, mid, and late embryonic mortality.



SUMMARY

This study was conducted to determine the effect of prestorage warming for 0, 3, 6, 9, 12, and 15 hrs on the percentage of fertile hatchability, total hatchability, dead embryos, and pips in eggs from end of lay broiler breeders. The two flocks were Ross 708 and Hubbard UY. The results of this study can be summarized as follows:

1) The percent true fertility, fertile hatchability, total hatchability, and pips were not significantly affected by prestorage warming for lengths of 15 hours or less.
2) Mid dead was significantly affected by prestorage warming. The treatment groups of 12 and 15 hours prestorage warming eliminated mid embryonic mortality. The percent late dead mortality was significantly increased by prestorage warming of nine hours. Total dead was significantly higher in the three hour treatment group.
3) These data suggest a certain stage of embryonic development should be reached before storage. The exact details on this stage should be further examined.

CONCLUSIONS

The following conclusions are based on the results of this experiment:

It appears that prestorage warming treatments used in this experiment were not beneficial in improving fertile hatchability or total hatchability. There was a questionable effect on embryonic mortality.

This may have occurred due to short storage length prior to incubation. Previous work showed prestorage warming has a significant effect on eggs stored for longer than four days. Different authors have confirmed that eggs stored for 12 or 14 days benefited the most from warming when compared to eggs stored for a shorter length (Becker and Bearse, 1958; Proudfoot, 1970). This study aimed to produce results that would be of value to the commercial industry by working within the limitations of normal commercial practice. It appears that prestorage warming of end of lay broiler breeder eggs for 0 – 15 hours at 27.0°C may not improve hatchability when eggs are stored for just three days.

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Appendix

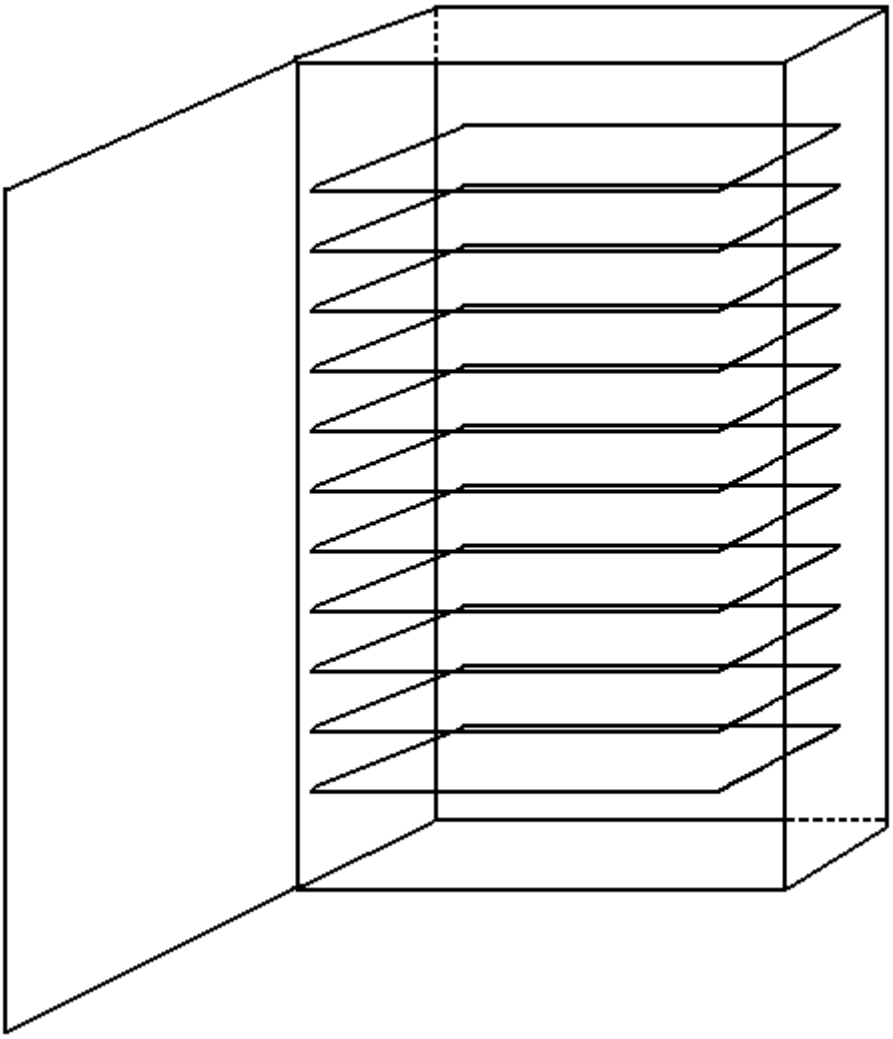

Figure 1A. Natureform© Setter 2000 showing eleven levels

VITA

Kyle Daniel Homan was born in Coldwater, Ohio on August 27, 1985. He is the youngest and only son of Dan and Cathy Homan. He has two older sisters, Christa (26) and Jenny (24), who both reside in Orlando, Florida. His father, Dan Homan, is a systems adminstrator for Crown Equipment Corporation and his mother, Cathy Homan, is a 2nd grade teacher at Ansonia Elementary Schools. His oldest sister, Christa, graduated from Ball State University in Muncie, Indiana. His sister, Jenny, graduated from McNeese State University in Lake Charles, Louisiana. Kyle graduated from Coldwater High School and is currently in his fourth year at Louisiana State University. He is currently pursuing a double degree in Animal, Dairy, and Poultry Sciences and Political Science. Kyle will be graduating in May. This thesis is partial credit for college honors.