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The Effect of Broiler Breeder Strain and Parent Flock Age on Hatchability and Fertile Hatchability

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Abstract: The effect of genetic strain (Ross 308; Cobb 500) and parent flock age (Ross at 32 and 36 weeks; Cobb at 26 and 44 weeks of age) on hatchability, fertile hatchability, Egg Weight Loss (EWL) and egg break out analysis were examined. At each flock age, 300 eggs from each treatment group were incubated. Thirty eggs from each treatment group were labeled individually for the measurements of Egg Weight Loss (EWL) and the newly hatched chicks from all groups were weighed individually. All the eggs that failed to hatch were examined for fertility and determine the embryo death cause. Data were analyzed by ANOVA for a randomized complete block design, using GLM procedure of SAS. Hatchability and fertile hatchability were affected by age of the breeder flock. Egg and chick weight were influenced by hen age ($p < 0.001$), the older the hen the heavier the egg. Total egg weight loss from 1-19 d was significantly higher as percent for Cobb strain ($p < 0.001$). Mid death of embryos as well as pips percentages were associated with eggs from older hens ($p < 0.01$). In summary, hatching eggs produced by older broiler breeders have been shown to be larger in size and they also exhibit a reduced fertility. It is evident that egg management and incubation procedures need to be altered, as current recommended egg management and incubation procedures are not adjusted for breeder age.

Key words: Broiler breeder strain, flock age, hatchability, breakout analysis

INTRODUCTION

The hatchery plays a basic role in the breeder-hatchery-broiler production chain. It hatches eggs from multiple breeder farms and delivers chicks to even more broiler farms. Optimization of hatchery and breeder farm management can lead to improvement of the result throughout the broiler production chain (Heier and Jarp, 2001). In an ideal setting, every fertile broiler breeder egg would produce a healthy chick. Unfortunately, this is never the case in a commercial hatchery. The process from the time of egg formation to hatching is very complex; reasons for low hatchability could be improper management of the breeder flock, an incorrect incubation procedure, or a failure within any step between the breeder flock and the final hatch. There are many factors contributing to the failure of a fertile egg to hatch, which is known as embryonic mortality, and these include: Lethal genes, insufficient nutrients in the egg, and the fact that the egg may be exposed to conditions that do not meet the needs of the developing embryo. Previous research has shown that quality hatching eggs improve the likelihood of optimum hatchability as well as result in good chick quality (Yoho *et al.*, 2008). It is well documented that larger eggs produce larger chicks (Lourens *et al.*, 2006). Weight loss as an effect of evaporation was reported to be related to egg weight between large eggs from post-peak broiler breeders,

and small eggs from young broiler breeders (Reis *et al.*, 1997). Breeder factors that affect hatchability include strain, health, nutrition and age of the flock, egg size, weight and quality, egg storage duration and conditions (Kirk *et al.*, 1980; Wilson, 1991;1997; Tona *et al.*, 2005). The efficiency of reproduction of broiler breeders decreases with age, because it is related to the quality of hatching egg such as the internal egg composition or ratio, larger egg weight, poorer shell quality, increased early and late embryo mortality, and other complications unique to large eggs from old broiler breeders (North and Bell, 1990; Vieira and Mora, 1998; Leeson and Summers, 2000; Elibol and Brake, 2003; Tona *et al.*, 2004; Joseph and Moran, 2005a). Management at the breeder farm as well as at the hatchery should be adjusted according to the strains, because every strain responded differently to hatchability. Fertility of an egg and embryonic mortality during the hatching process are known to be different for different strains. Deeming and Van Middelkoop (1999) reported that as the flock ages, there was more infertility and early embryonic mortality in eggs from Ross 308 compared with Cobb 500. The effect of strain could be explained by difference in egg weight and egg components like the yolk and albumen percentage, yolk:albumen ratio, shell thickness, and incubation time (Suarez *et al.*, 1997; Joseph and Moran, 2005b).

The aim of this research was to study the relationship between broiler breeder strain and parent flock age and their effects on hatchability and fertility of two broiler breeder strains at two ages.

MATERIALS AND METHODS

Egg management: A total of 1200 eggs were collected at the same day from local broiler breeder farms. The eggs were obtained from two strains at two different ages [(Cobb 26 and 44 and Ross 32 and 36 weeks of age)] for a total of four treatments T1 = Cobb 26, T2 = Cobb 44, T3 = Ross 32 and T4 = Ross 36). Eggs were graded according to weight then were divided into 12 trays, 3 trays (replicates) for each treatment group. Thirty eggs from each treatment group were labeled individually for the measurements of egg weight loss at 7, 14 and 19 d of incubation. Trays representing all egg weight groups were distributed in the setter. One tray from each group was placed in the top, middle and lower part of the setter. The setter was operated at a temperature of 37.5°C and a relative humidity of 60% during the first 19 d of incubation. At 19 d of incubation, those eggs deemed infertile by candling were identified and removed. The remainder from each group was transferred to hatch baskets and placed in a hatcher. The temperature was decreased to 37.0°C and the humidity was increased to 75%. The trays that have the labeled eggs were divided into small rooms by using small pieces of wood, in order to get an accurate weight of the hatched chicks.

At the time of removing the chicks from the hatchers the newly hatched chicks from all groups were weighed individually and all unhatched eggs were opened and examined to determine the break out analyses. The variables measured were true fertility, fertile hatchability, early dead, mid-dead, late dead, pips and total hatchability percentages.

Statistical analysis: Data were analyzed by analysis of variance procedures appropriate for a randomized complete block design, using General Linear Model procedure of the Statistical Analysis System (SAS, 1996). When significant differences among treatments were found, means were separated using LSD test. Statistical significance was assessed at (p<0.05).

RESULTS

Egg weight was influenced by hen age (p<0.001), the older the hen the heavier the egg. Egg weight ranged from 58.2 for Cobb strain at 26 week to 72.8 g for the same strain at 44 weeks of age. While for the Ross strain no significant difference was detected for the two age groups, 67.4 and 66.4 g for 32 and 36 weeks of age, respectively (Table 1).

Egg Weight Loss (EWL) from Ross strain was significantly higher than those from Cobb strain (p<0.01) at 7, 14 and 19 d of incubation and as a result of that, the total EWL from 1-19 d was significantly higher (p<0.001). While, there was no significant difference due to age of the hen within the strain (p>0.05) (Table 1).

Hen age was significantly related with chick body weight (p<0.001). At the age of 44 week, Cobb produced the heaviest body weight chicks (51.5 g). While, at the age of 26 week, average chick body weight was 41.3 g. On the other hand, no significant difference in body weight was detected in Ross strain at 32 or 36 week of age (49.3 vs. 48.3 g, respectively) (Table 1).

Hen's age affected hatchability significantly (Table 2). The lowest hatchability among all groups (70.4%) was obtained from eggs from the oldest group (Ross 44). The average estimated hatchability increased to 85.2% for the younger group of the same strain. On the other hand, no significant difference was detected between the two age groups for the Ross strain (p>0.05). Generally, higher hatchability percentages were obtained for all treatments when the calculation was based on the fertile eggs (Table 2). Fertile hatchability differed between treatments. Fertile hatchability averaged 92.2, 85.2, 97.7 and 94.1% for Cobb 26, Cobb 44, Ross 32 and Ross 36, respectively (Table 2).

Hatch breakout analysis (Table 3) showed no significant differences in both early and late death of the embryo due to strain or age (p>0.05). However, embryo mid death was detected and it was associated with eggs from older hens (p<0.01) compared to the other three treatments (Table 3). Pipped not hatched percentage was higher (p<0.01) for eggs from Ross strain at 36 week of age. While, no significant difference between the other three groups were detected (Table 3). Infertility was associated with age (Table 3). Higher infertile eggs were obtained from eggs from the oldest group 14.8% (Cobb

Table 1: Egg weight, weight loss of hatching eggs and chick weight

Treatments	Avg beginning egg weight	EWL at 7 d	EWL at 14 d	EWL at 19 d	Total EWL 1-19 d	Chick weight	Egg: chick weight
	g	%	%	%	%	g	%
Cobb 26	58.2 ^c	2.9 ^b	4.1 ^c	3.8 ^b	10.8 ^b	41.3 ^c	71.0 ^b
Cobb 44	75.8 ^c	2.7 ^b	4.2 ^{bc}	4.0 ^b	10.9 ^b	51.6 ^a	71.5 ^b
Ross 32	67.4 ^b	3.4 ^a	4.6 ^{ab}	4.9 ^a	12.9 ^a	49.3 ^b	73.0 ^a
Ross 36	66.4 ^b	3.5 ^a	4.7 ^a	4.7 ^a	12.9 ^a	48.3 ^b	73.1 ^a
SEM	0.53	0.11	0.14	0.21	0.41	0.45	0.59
ANOVA	***	***	*	***	***	***	*

EWL = Egg Weight Loss, ^{a-c} Within columns, values with different superscript differ significantly (*p<0.05, **p<0.01, ***p<0.001, NS: Not Significant)

Table 2: Hatchability of all eggs set (all) and hatchability of fertile eggs set (fertile)

Treatments	Hatchability (all)	Fertile hatchability
Cobb 26	85.2 ^a	92.3
Cobb 44	70.4 ^b	82.8
Ross 32	87.3 ^a	90.3
Ross 36	80.8 ^a	85.9
SEM	2.9	2.2
ANOVA	*	NS

^{a-c}Within columns, values with different superscript differ significantly (*p<0.05, **p<0.01, ***p<0.001, NS: Not Significant)

Table 3: Break out analysis

Treatments	Early death	Mid death	Late death	PNH	Infertile eggs
	(%)				
Cobb 26	1.8	0.7 ^b	2.2	0 ^b	7.8 ^b
Cobb 44	1.8	8.5 ^a	2.2	0.3 ^b	14.8 ^a
Ross 32	2.6	1.1 ^b	1.1	0 ^b	3.3 ^c
Ross 36	2.5	3.0 ^b	1.1	1.5 ^a	5.9 ^{b,c}
SEM	1.12	1.2	0.63	0.01	1.35
ANOVA	NS	**	NS	*	**

PNH = Pipped Not Hatched, ^{a-c}Within columns, values with different superscript differ significantly (*p<0.05, **p<0.01, ***p<0.001, NS: Not Significant)

44 week) followed by eggs from Cobb 26, 7.8% (p<0.05). Ross at 32 week had the lowest percentage of infertile eggs (3.3%).

DISCUSSION

It is well documented that there is a strong relationship between breeder age and egg weight such that older hens produce larger eggs (Lourens *et al.*, 2006). Same results were obtained in this experiment; there was a 20% increase in egg weight for Cobb strain between the two ages examined. The results of this experiment showed that chick weight was influenced by egg weight; heaviest chicks were those hatched from the older hens (Cobb 44) while the lightest chicks were those hatched from the youngest hens (Cobb 26). This results corresponds with observation made by Sinclair *et al.* (1990) who reported that chicks that hatch from older breeder flocks are larger and of higher quality because they are naturally more resistant to dehydration upon hatching as compared to smaller chicks from young breeder flocks. In a study conducted by Reis *et al.* (1997) which examined weight loss as an effect of evaporation between large eggs from post-peak broiler breeders, and small eggs from young broiler breeders. Older breeders tended to lose more weight in grams but less in percentage when compared to eggs from younger breeders, same results were obtained in this study. This can be explained by the associated increase in egg weight, as larger eggs have less shell area per unit of interior egg weight than smaller eggs (Kirk *et al.*, 1980; North and Bell, 1990; Roque and Soares, 1994). On the other hand, as egg size increases, yolk size increases more than the quantity of albumen (North and Bell, 1990).

Hatchability decline with age and ideal hatchability is achieved when the egg weight ranges between 55 to 65 g (North and Bell, 1990). The present research shows that hen's age affected hatchability and there was reduction of hatchability with advance age. This effect was more pronounced in the Cobb strain because of the bigger range of age (18 weeks difference) compared to 4 weeks for Ross strain. In previous work (Kirk *et al.*, 1980), it was observed that fertility and hatchability decreased with age, fertility of 60 weeks broiler breeders declined by 11% and hatchability declined 9% in eggs weighing more than 70 g. This effect was explained in part by a relationship between breeder age and egg weight, as younger breeders produced eggs with superior hatchability at an average weight of 60 g. Hatchability reduction of eggs from older broiler breeders is a result of many contributing factors, including: larger egg size (Leeson and Summers, 2000) increased early and late embryo mortality (Elibol and Brake, 2003) poorer shell quality due to bigger surface area (North and Bell, 1990; Bennett, 1992) albumen quality deterioration (Lapao *et al.*, 1999; Tona *et al.*, 2004) and increased the yolk cholesterol content (Dikmen and Sahan, 2007).

The difference in hatchability among strains was related to the age of the parent flock. Management at the breeder farm as well as at the hatchery should be adjusted according to the strains, because every strain responded differently to hatchability. Fertility of an egg and embryonic mortality during the hatching process are known to be different for different strains and these characteristics are very important in determining hatchability. Deeming and Van Middelkoop (1999) reported that withholder breeder flock, there was more infertility and early embryonic mortality in eggs from Ross 308 compared with Cobb 500.

In practice, eggs of different age classes or eggs with different sizes are incubated together with an average incubation temperature however; different incubation condition is required for different age classes. Eggs from older breeders are known to hatch earlier and suffer more from postemergent holding in the hatcher than those from younger breeders (Vieira and Mora, 1998). Also, more heat is produced from larger eggs during incubation from older breeders since they have larger embryos (French, 1997). If eggs of different age classes are to be incubated together, adjustments should be made to the incubation condition accordingly. The present research shows that true fertility differed significantly because of age and strain. True fertility averaged 85.2% for Cobb 44 while it was 97.7 for Ross 32. In several studies, age has been shown to have a significant effect on fertility of broiler breeders (Brommer and Rattiste, 2008; Brotherstone *et al.*, 2000). Fertility generally declines after a peak (Brotherstone *et al.*, 2000) while the effect of age on female breeders is more

significant than on male breeders (Brommer and Rattiste, 2008). Factors affecting fertility which originate from the male include several sperm quality traits such as sperm metabolism, semen concentration, sperm motility and the percentage of abnormal or dead sperm cells (Bramwell *et al.*, 1996). Factors originating from the female include egg quality and behavioral and physiological factors such as prevalence of sperm storage tubules (Siegel, 1965).

There are three periods of embryonic mortality: early (first seven days of incubation), middle (between day eight and 14 of incubation) and late (during the last week of incubation). The early dead embryo mortality period is a result of failure of the embryo to resume development after having been stored and placed in the setter (North and Bell, 1990). The mid-dead embryo mortality period is usually related to nutritional deficiencies in the broiler breeder diet or embryonic abnormalities. In this study, higher mid death mortality was observed for the older Cobb strain which could be due to the breeder management. The late dead embryonic mortality peak represents death due to abnormal positioning, complications in physiological changes and lethal genes. Pipped not hatched represents death due to chick failure to penetrate egg at hatching. In this study it was high for Ross 36 and this could be explained by stronger egg shell of this group. As described in the literature, eggs from young breeders have thick shells and produce smaller chicks that may have less physical strength to break the shell during hatching, resulting in embryo mortality after pipping (Pedroso *et al.*, 2005). Moreover, the lower eggshell conductance of young breeders results in inadequate movement of water vapor and respiratory gasses during the incubation process (Christensen *et al.*, 2005). Besides, genetic strain and parent flock age influence daily embryonic metabolism during the early and latter days of incubation, which coincides with the incidence of greater embryonic mortality during this period of incubation (Hamidu *et al.*, 2007).

The process from the time of egg formation to hatching is very complex and the hatching results may be influenced by many factors. The above-mentioned findings suggest that different strains at different ages require different management at the breeder as well as at the hatcheries. It is evident that egg management and incubation procedures need to be altered, as current recommended egg management and incubation procedures are not adjusted for breeder age. In this study, most factors studied were significantly related with age and strain of the hens. The results reported in this experiments corresponds with the results of Creel *et al.* (1998) the age and the strain of the breeders could be an important indicators for management decisions made by breeder farms as well as the hatcheries.

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