Revista Brasileira de Ciência Avícola
ISSN: 1516-635X
revista@facta.org.br
Fundação APINCO de Ciência e Tecnologia Avícolas
Brasil

Vieira, SL; Almeida, JG; Lima, AR; Conde, ORA; Olmos, AR
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Revista Brasileira de Ciência Avícola, vol. 7, núm. 2, abril-junio, 2005, pp. 73-78
Fundação APINCO de Ciência e Tecnologia Avícolas
Campinas, SP, Brasil

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Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X Apr - Jun 2005 / v.7 / n.2 / 73 - 78

Hatching Distribution of Eggs Varying in Weight and Breeder Age

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Keywords

breeder age, egg weight, and hatchability

Supported by FAPERGS.

Arrived: december / 2004
Approved: april / 2005

ABSTRACT

Broiler chicks from one incubator hatch within long periods of time, which leads to dehydration and reduction in yolk sac reserves of those chicks that have hatched earlier and potentially impairs early performance. The present research investigated the hatching distribution at intervals of incubation using eggs of different weights within one breeder age or eggs from widely different breeder ages. Eggs from breeders at 27 and 59 weeks of age (54 and 69 g) and from breeders at 40 weeks of age, which were graded as light (58 g) and heavy (73 g), were placed in a commercial incubator. There were a total of 1,184 eggs distributed in four treatments and eight replicates: eggs from 27-week-old breeders (27B), eggs from 59-week-old breeders (59B), light eggs from 40-week-old breeders (40BL) and heavy eggs from 40-week-old breeders (40BH). Replicates were comprised of 37 eggs that were placed in each incubator tray. The treatments were physically separated from each other using a plate. Eggs were transferred to a hatcher after 432 hours of incubation and the first chick hatched at 449 hours of incubation. Afterwards, the number of completely hatched chicks from each replicate was recorded at six-hour intervals until 503 hours of incubation, when the hatchings stopped. Hatched chicks were removed from the trays after each measurement. Data were submitted to an analysis of variance with repeated measures. There was a significant interaction between breeder age and incubation length. The hatching onset of eggs from the old breeders was later compared to young breeders. Hatchability (%incubated eggs) was lower for the old breeders; however, differences in hatchability as a percentage of the hatched eggs were not so evident. Complete hatchability occurred only at 503 hours of incubation; however, more than 90% eggs had hatched 18 hours earlier.

INTRODUCTION

In commercial operations, chicks are usually removed from hatchers after 504 hours of incubation. This has been regarded as an optimum length of time to maximize the hatching of incubated eggs. However, the window of time between the hatching of the first and the last chick is greater than 48 hours in any group of eggs (Sklan *et al.*, 2000). Therefore, groups of chicks originated from any batch of eggs set together in the incubator show high variability in the number of hours spent between hatching and placement in the broiler house.

Wyatt *et al.* (1985), Nir & Levanon (1993), and Sklan *et al.* (2000) observed reductions of 32% in the weight of chicks that remained in the incubator for 32 hours after hatching. Losses due to starvation and dehydration are related to the time that the chicks are left in the hatcher before placement (Fanguy *et al.*, 1980; Wyatt *et al.*, 1985). Delays between hatching and placement also lead to permanent losses in live performance and breast meat yield at market age (Vieira & Moran, 1999a; Halevy *et al.*, 2000). In this regard, research has clearly demonstrated the benefits of allowing the chicks to eat and drink as soon as possible after hatching, such as improvements in several characteristics of live performance, digestive metabolism and meat yield (Noy & Sklan, 1995; Uni *et al.*, 1995).

Early chick performance is influenced by egg source, since egg weight and chick weight at hatching are highly correlated (Halbersleben & Mussehl, 1922). Embryo size before hatching and at hatching may be altered by egg weight and incubation environment, regardless of the avian species (Wilson, 1991). After hatching, however, the effect of egg weight decreases with the age of the progeny (O'Neil, 1955).

Egg contents vary according to breeder age, but also to egg weight within any breeder age (Vieira & Moran, 1998a; Vieira & Moran, 1998b). Yolk percentage increases in eggs as the breeders age, but is decreased in heavy eggs sorted from those produced within any breeder age. In chicken eggs, the total incubation period needed to produce a complete embryo might depend on contents differences (Shanawany, 1987). Therefore, alterations in egg contents, which affect hatching time, may be correlated to egg weight and breeder age. This study was conducted with the objective of evaluating the incubation period needed to the complete hatching of eggs originating from breeders varying widely in age and eggs from breeders with the same age but varying in weight.

MATERIAL AND METHODS

This study was conducted in a commercial hatchery using a multiple stage Cumberland incubator and a Rooster hatcher. Eggs were sampled from Ross *vs*. Ross 308 breeders aged 27, 40 and 59 weeks housed in the same breeder farm. All eggs were collected within the same period of time, and therefore time elapsed between oviposition and placement in the incubator was similar between the different egg sources. After placement in the incubator, eggs were turned hourly from 0 to 18 days. Eggs were transferred to hatchers after 18 days. Temperature was 37.4°C in the incubator and 36.8°C in the hatcher. Relative humidity settings in the incubator and hatcher were 56 and 70%, respectively.

The following egg sources (treatments) were used: 27 week-old breeders (27B), 59 week-old breeders (59B), light eggs from 40 week-old breeders (40BL) and heavy eggs from 40 week-old breeders (40BH). There were 296 eggs set to incubate per treatment, and eight replicates per treatment (37 eggs each). Mean weight and standard deviations of eggs from breeders with 27 and 59 weeks of age were 54.1 ± 4.4 and 69.1 ± 4.7 g, respectively. Eggs from forty-week-old breeders were graded as light and heavy and mean weights were 57.7 ± 1.8 and 72.7 ± 2.5 g, respectively. A sample of 90 eggs from each treatment was weighed, and their contents were separated and weighed as yolk, albumen and shell.

A completely randomized design was used. A metal plate physically separated replicates in each incubator tray. At 18 days, the eggs were transferred from the incubator to the hatcher and placed also as replicate groups in the corresponding tray level in the hatcher. Chicks completely hatched from each replicate were recorded from the moment the first chick hatched (449 hours) and every six hours afterwards until hatchings completed ceased (503 hours).

Hatched chicks were removed from the hatcher after each measurement and were immediately feather-sexed and killed by cervical dislocation. Chick carcass and yolk sac were separated and weighed.

In this study, the model included "time", so that "time" was the six-hour periods (incubation lengths) at which the completely hatched chicks were taken from the hatcher. Therefore, it was possible to separate time effects from breeder source effects and to evaluate the interaction between these two sources of variation. This objective was accomplished by submitting the data to an Analysis of Variance with repeated measures using the Proc Mixed procedure of SAS (1998). Variance and covariance were chosen for this analysis in accordance to the Akaike (1987) criteria. The data structure that produced the best adequacy for data analysis was a first-order auto regressive analysis, which admits heterogeneity of variances and also a larger existing correlation between measurements taken at adjacent periods. Results are presented as cumulative hatchability, expressed as percentage of incubated eggs and as percentage of hatched chicks. Therefore, it is possible to visually separate confounding effects due to egg source such as hen age, which is known to interfere with the hatchability of incubated eggs. Mean differences were separated using the Tukey's test and are presented for the isolated factors as well as for the interaction between factors.

RESULTS AND DISCUSSION

The weights of eggs and egg components are presented in Table 1. Eggs from breeders aged 59 weeks were heavier and showed greater proportions of yolk when compared to eggs from the breeders with 27 weeks of age. However, eggs from breeders aged 40 weeks and graded as heavy were the heaviest between all treatments, but the proportion of yolk was not different between eggs of forty-week-old breeders and fifty-nine-week-old breeders. Heavier eggs produced heavier chicks. Yolk sac proportion was similar between chicks from the two treatments with low egg weight (27B and 40BL), but it was lower when compared to chicks from heavy eggs (40BH and 59B) of both breeder ages. However, yolk sacs from 40BH chicks were greater in proportion than those from chicks from 59B (Table 3). Information corroborating these findings is widely known and has been extensively reviewed (Shanawany, 1987; Vieira & Moran, 1999b).

Table 1 - Percentage of yolk, albumen and shells of eggs from breeders of widely different ages (27 and 59 weeks) or graded according to weight within one breeder age (40 weeks).

Egg source	Egg Weight, g	Yolk, %	Albumen, %	Shell, %
27 B	54 ^{d}	26.9 ^{b}	61.3 ^{a}	11.8 ^{ab}
59 B	69 ^{b}	34.1 ^{a}	54.5 ^{c}	11.4 ^{c}
40 BL	58 ^{c}	31.4 ^{ab}	56.7 ^{c}	11.9 ^{a}
40 BH	73 ^{a}	29.7 ^{ab}	58.8 ^{b}	11.5 ^{b}
Probability	0.0001	0.0064	0.0001	0.0018
CV, %	5.76	52.03	5.53	7.74

Means followed by the same letter within a column are not different according to Tukey's test.

Table 2 - Hatchability (% incubated eggs) of eggs originated from breeders of widely different ages (27 and 59 weeks) or graded according to weight within one breeder age (40 weeks).

Egg source	Hatchability, %
27 B	88.3 ^{a}
59 B	73.5 ^{b}
40 BL	82.3 ^{ab}
40 BH	82.7 ^{ab}
Probability	0.0007
C.V., %	7.86

Means followed by the same letter within a column are not different according to Tukey's test.

Hatchability of eggs from the different sources used in this experiment showed the highest and lowest values for the younger and older breeders, respectively. Intermediate values were seen in the forty-week-old breeders, regardless of egg weight (Table 2). Eggs from old breeders are known to have an overall reduction in hatchability when compared to those from young breeders, which is mostly related with increased embryo mortality and reduction in fertility (Reis *et al.*, 1997; Lapao *et al.*, 1999; Hudson *et al.*, 2004). Therefore, this is always a confounding source for the numeric interpretation of hatchability of incubated eggs when comparing breeders at different ages. Thus, hatchability data expressed as a percentage of hatched eggs eliminates this confounding element and allows for numeric estimations on the same basis.

Table 3 - Chick weight and percentage of yolk sac from eggs of breeders of widely different ages (27 and 59 weeks) or graded according to weight within one breeder age (40 weeks).

Egg source	Chick Weight, g	Yolk Sac, %
27 B	40.3 ^{c}	14.9 ^{c}
59 B	51.0 ^{b}	16.4 ^{b}
40 BL	41.0 ^{c}	14.9 ^{c}
40 BH	53.4 ^{a}	17.6 ^{a}
Probability	0.0001	0.0001
C.V., %	15.09	13.96

Means followed by the same letter within a column are not different according to Tukey's test.

Results presented in Tables 4 and 5 and Figures 1 and 2 demonstrate diversity in hatching patterns for chicks originated from breeders producing heavy eggs compared to light eggs, regardless of age. Overall, light eggs initiated to hatch earlier and produced chicks in a wider range of time between the first and the last hatched chick than heavy eggs. Most of the differences in hatchability patterns seen between heavy and light eggs, irrespective of breeder age, were observed between 467 and 485 hours of incubation.A slower rate of hatchability was seen for heavy eggs during this period on the basis of hatched chicks; nevertheless, differences disappeared afterwards.

Several factors, such as genetics and environment, have been reported to affect hatchability. Nevertheless, results are not consistent in many cases, and the nature of the effect on hatchability is not clearly evident in others (Bohren *et al.*, 1961). Although reduction in incubation length has not been specifically targeted in genetic improvement, it may have occurred in the chicken by unconscious selection following selection for egg size (Bohren et al., 1961). Lerner & Gunns (1952) have demonstrated in flocks selected for large egg size that the eggs with optimum hatchability were usually below the mean egg size of the population. Therefore, the total period of incubation needed to produce a complete and viable embryo may be longer nowadays than in the past, since the mean egg weight has increased in the current genetic lines.

Table 4 - Cumulative hatchability of eggs from breeders of widely different ages (27 and 59 weeks) or graded according to weight within one breeder age (40 weeks), % incubated eggs.

Incubation length (hours)	Egg source: 29 B	59 B	40 BL	40 BH	Incubation length mean
449	0	0	0.9	0	0.2 d
455	0	0	0.9	0	0.2 d
461	2.0	0	3.3	1.0	1.6 d
467	9.9 ^{a}	2.6 ^{b}	9.3 ^{a}	6.1 ^{ab}	7.0 d
473	29.5 ^{a}	15.6 ^{b}	26.6 ^{a}	18.8 ^{b}	22.6 c
479	60.1^{a}	45.1 ^{b}	59.6 ^{a}	45.1 ^{b}	52.5 b
485	81.8 ^{a}	66.3 ^{b}	76.0 ^{a}	75.0 ^{ab}	74.8 a
491	87.3 ^{a}	72.5 ^{b}	82.0 ^{a}	82.3 ^{a}	81.0 a
497	87.9^{a}	73.5 ^{b}	82.3 ^{ab}	82.3 ^{ab}	81.5 a
503	88.3 ^{a}	73.5 ^{b}	82.3 ^{ab}	82.6 ^{ab}	81.7
Egg source mean	44.7 a	34.9 c	42.3 ab	39.3 b	
Probability					
Egg source		0.0062			
Incubation length		0.0001			
Interaction		0.0449			

Means followed by the same letter within incubation length are not different according to Tukey's test.

Table 5 - Cumulative hatchability of eggs from breeders of widely different ages (27 and 59 weeks) or graded according to weight within one breeder age (40 weeks), % hatched eggs.

Incubation length (hours)	Egg source: 29 B	59 B	40 BL	40 BH	Incubation length mean
449	0	0	0.9	0	0.2 f
455	0	0	0.9	0	0.2 f
461	2.3	0	3.8	1.4	1.9 ef
467	10.9 ^{a}	3.8^{b}	11.1^{a}	8.1^{ab}	8.5 e
473	33.0 ^{a}	21.1^{b}	32.4 ^{a}	23.1^{b}	27.4 d
479	67.6 ^{ab}	61.4^{bc}	72.4 ^{a}	54.6 ^{c}	64.0 c
485	92.6	90.1	92.0	90.8	91.4 b
491	98.9	98.5	99.6	99.5	99.1 a
497	99.6	100.0	100.0	99.5	99.8 a
503	100.0	100.0	100.0	100.0	100.0
Egg source mean	50.5 ab	47.5 b	51.3 a	47.7 b	
Probability					
Egg source			0.0121		
Incubation length			0.0001		
Interaction	0.7016				

Means followed by the same letter within incubation length are not different according to Tukey's test.

Reported results show a great deal of contradiction regarding the relation between incubation time and egg source. At least part of the difficulty in comparing research in this area is related to the type of measurements taken by each author. Incubation time has been defined as the average number of hours of the first to the last chick to hatch, but has also been confounded with the distribution of hatched chicks within a period of time. In the present study, authors were interested in searching for differences between

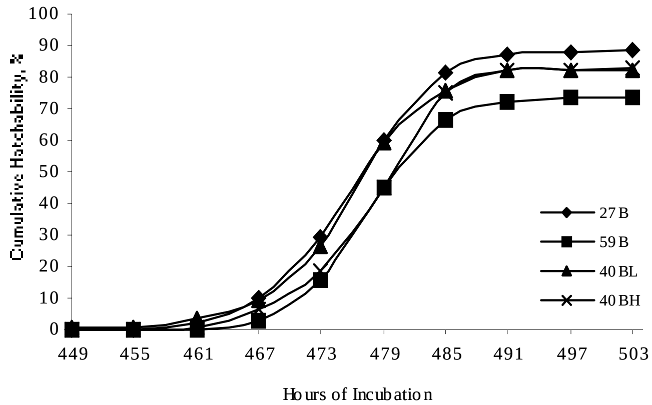

Figure 1 – Cumulative hatchability of eggs from breeders of widely different ages (27 and 59 weeks) or graded according to weight within one breeder age (40 weeks), % incubated eggs.

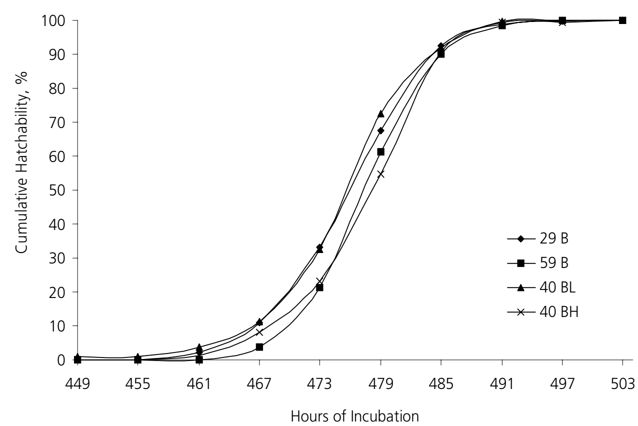

Figure 2 – Cumulative hatchability of eggs from breeders of widely different ages (27 and 59 weeks) or graded according to weight within one breeder age (40 weeks), % hatched eggs.

the distributions of hatching that were affected by egg sources. Since the time lag between the hatching of the first and the last chick may be long, this may be an important factor affecting early chick performance. Incubation period have been found to lengthen (Olsen, 1942; Williams *et al.*, 1951, Hudson *et al.*, 2004) to shorten (McNally & Byerly, 1936; Smith & Bohren, 1975; Burton & Tullet, 1985) or not to change (Reis *et al.*, 1997) with the aging of hens and the consequent increases in egg size. Variations in incubation length may be related to breed and line within breed and therefore this trait may be altered by selection (Crittenden & Bohren, 1961; Smith & Bohren, 1975). Studies in this matter should always consider similar periods between oviposition and setting in incubators since pre-incubation storage time affects the incubation period (MacLaury & Insko, 1968; Reis *et al.*, 1997).

The time spent until the hatching onset may not be correlated with incubation length. Reis et al. (1997) reported that hen age did not change hatching distribution during the incubation period. However, a delay of hatching onset has been reported in light eggs from young hens when compared to heavy eggs from old hens (Hudson et al., 2004). Differences in terms of embryo development and embryo metabolic rates during incubation, as well as reduced gas exchange due to superior albumen quality of eggs from young breeders are considered as possible reasons for the earlier hatching of chicks from heavy eggs (Mather & Laughlin, 1979; Brake *et al.*, 1997). In our study, chicks from light eggs began to hatch earlier. Since the pre-incubation period between egg sources and genetics were potentially the same for the breeders used, speculation on the reasons for our findings are open and may be related to other factors, such as external environment. Increased ambient temperature in Brazil when compared to studies from temperate countries may have an impact on acceleration of embryo development. This effect is likely to be greater in light eggs because of their reduced volume and mass.

Data from this study allow generalizations in terms of the total time needed to collect chicks of diverse egg sources from the hatcher. Chicks from larger eggs are expected to hatch closer to the moment in which they are removed from the hatcher when compared to chicks originated from breeders that are 40 weeks-old or younger.This may improve early chick performance due to reduced dehydration of chicks from heavier eggs, which adds on to the natural advantage of larger than smaller chicks in most of the commercial hatchers running on a 504-hour incubation period.

In spite of the different egg sources, a maximum cumulative hatchability was seen between 497 and 503 hours of incubation. However, more than 90% of eggs had already hatched at 485 hours, and less than 1% increase in hatchability occurred after 491 hours of incubation. Therefore, a delay of at least 12 hours was imposed on 99% of the chicks that had already hatched in order to gain 1% in hatchability. This involuntary starvation represents growth potential and meat production that have been wasted under the current hatchery practices. This finding is not new, but the numeric estimations from this study support a recommendation to remove chicks out of the hatcher at least once before the traditionally used period of 504 hours of incubation (21 days). Removing chicks that hatch earlier and providing them immediately with feed and water has been shown to improve subsequent growth compared to what is achieved by birds placed with those that hatch later (Hager & Beane, 1983; Fanguy *et al.*, 1980; Kingston, 1979; Williams *et al.*, 1951; Wyatt et al, 1985).

Yolk sac is important during the transition from the embryonic to independent life. It is especially important until 3 days of age, when the bird is expected to be completely adapted to the external environment. Heavier eggs originate heavier yolk sacs, but proportions are expected to be similar (Vieira & Moran, 1998a; Vieira & Moran, 1998b). In the present study, however, major differences were found between egg sources, so that chicks originated from heavy eggs had higher yolk sac percentages when compared to chicks from light eggs. Difference was also observable between heavy eggs in favor of chicks from 40BH hens, which is not usually seen. A greater proportion of yolk sac represents increased amounts of energy and nutrients, but also passive immunity, which protects the chicks against microbiological challenges experienced by the breeder (Vieira & Moran, 1998a; Vieira & Moran, 1998b, Vieira & Moran, 1999a). This characteristic, as well as the reduced range in hatching time, also supports the benefits obtained with chicks from heavier eggs and may be related with the better response in performance and early survival of heavy chicks compared to light chicks.

CONCLUSIONS

In this experiment 90% of the chicks hatched within 485 hours of incubation or less. Therefore, it is suggested that hatcheries should remove chicks from the hatchers at least once before 504 hours, which is the traditionally used period. The period of starvation before placement with feed and water would be thus reduced for most of the hatched chicks.

Chicks from heavy eggs showed a delay to initiate hatching and a slower increase in hatchability to 479 hours of incubation when compared to chicks from light eggs. Therefore, they hatch within a narrower range of time, which may represent an advantage compared to the other egg sources due to a reduced number of chicks starving between hatching and placement.

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