Effects of egg weight on the egg quality, chick quality, and broiler performance at the later stages of production (week 60) in broiler breeders

Javid Iqbal,* Nasir Mukhtar,* Zaib Ur Rehman,*† Sohail Hassan Khan,‡ Tanveer Ahmad,* Muhammad Safdar Anjum,* Riaz Hussain Pasha,* and Sajid Umar*§

*Faculty of Veterinary and Animal Sciences, PMAS Arid Agriculture University, Muree Road, Rawalpindi, Pakistan; †Shanghai Veterinary Research Institute, Graduate School of Chinese Academy of Agricultural Sciences, Beijing, China; ‡Poultry Research Institute, Muree Road, Rawalpindi, Pakistan; and §National Veterinary School, Chemin des Capelles, Toulouse, France

Primary Audience: Broiler farmers, hatchery managers, broiler breeder farmers, researchers

SUMMARY

The objective of the present study was to determine the effect of broiler breeder egg weight on egg quality, chick quality, and broiler performance using Hubbard Classic broiler breeder flock. Hatching eggs from a commercial broiler breeder flock (Hubbard classic strain) were obtained at the age of 60 wk and divided into 3 egg-weight categories, namely small, medium, and large. For this purpose, 930 eggs having weights 63.09 ± 0.21, 68.85 ± 0.23, and 74.81 ± 0.11g were divided into 3 egg categories labeled small, medium, and large respectively. We further divided these eggs into 2 categories, eggs for quality parameters and eggs for incubation and posthatch performance parameters. Eggs from the small egg category had greater proportion of the shell weight and more shell strength. Egg weight did not significantly affect the albumen and yolk weight percentage. Egg weight affected the shape index and specific gravity for which lower values were observed for large eggs. Egg weight positively affected the chick weight, chick yield, and chick length ($P < 0.05$) of both male and female chicks. Results of the body weight gain showed that effect of egg weight on the posthatch performance of chick diminishes with the age of broilers. Egg weight significantly affected the body weight gain of male and female chicks up to 3 wk of age. Egg weights did not significantly affect the feed intake and mortality of broiler. Different egg-weight categories significantly affected the feed conversion ratio of female chicks at wk 2 and 3 of age and did not affect the feed conversion of male and female chicks at the end of wk 5. In conclusion, egg weight positively affected the chick characteristics (e.g., chick weight, chick length) and did not affect the final live body weight, feed conversion ratio, feed intake, and mortality in broilers.

Key words: Egg weight, egg quality, chick quality, broiler performance, feed intake

http://dx.doi.org/10.3382/japr/pfw061

§Corresponding author: zaib_rehman90@yahoo.com
DESCRIPTION OF PROBLEM

Production of good-quality chicks is the prime objective of modern hatcheries in the world [1,2]. Several factors directly or indirectly affect the chick quality and subsequent growth performance. One of the main factors that affect the subsequent productivity of layer and broiler chicken is egg weight [3,4]. Egg size of broiler breeder hens increased with flock age. Effect of egg size on posthatch performance of broiler chicks has an important economic impact [5]. Although a very close correlation between egg and hatching weights has been reported [6,7] the effect on posthatching growth and broiler market weights are variable. A number of studies have shown that egg size is an important factor in the performance of broiler chicks to market weight [4,6], while others have found that any advantage of chicks hatched from large-sized eggs diminishes rapidly after hatching [5,8]. The age of broiler breeder was found to influence the performance of broiler differently during the various phases of the growing period. Relationship between egg weight and posthatch performance of chick is considerably affected by the breed and strain [12]. The effect of egg weight on posthatch feed conversion of broilers varies in different studies [12]. Some have reported that egg weight positively affect the feed conversion [13], while others found no or opposite effects [4,14]. Conversion of feed into live body weight (BW) by growing broilers did not appear to be directly related to their egg size of origin. A portion of the BW gain attributable to birds from large eggs may be associated to their related increased feed intake [5]. Results of the mortality of broilers hatched from different size of the eggs are also variable [4,13,14,15]. Due to paucity of information on posthatching performance of Hubbard broiler breeder and contradictions between studies, the present study was designed to study the effect of flock age and egg size on egg quality and posthatch performance of both male and female broilers.

MATERIALS AND METHODS

Collection and Selection of Eggs

Eggs laid during 4- to 8-h light periods were collected from the Hubbard classic broiler breeder house after every hour. Nine hundred and thirty (930) hatching eggs from a broiler breeder flock (60 wk of age) were selected on the basis of weight, shape (oval), and quality for hatching. At each collection time, the average egg weight for that flock age was determined by randomly selecting and weighing 80 eggs. Eggs were weighed and classified in 3 weight ranges having 310 eggs, each based on the average egg weight: Small (S), Medium (M), and Large (L). Eggs were categorized in the following way: the M eggs were within ±1.5 g from the average egg weight, the S eggs were 3.0 to 6.0 g lighter than the M, and the L eggs were 3.0 to 6.0 g heavier than the M eggs [26]. Eggs from each treatment were further divided into 2 subcategories: 10 eggs for quality parameters and 300 eggs for the incubation and posthatch performance of chicks. Eggs selected for the incubation and posthatch chick performance were further divided in to 3 replicates having 100 eggs each.

Egg Quality Parameters

The study of egg quality parameters of 10 hatching eggs from each egg category was conducted within 24 h of egg laying, at the Poultry Research Institute Rawalpindi. The egg specific gravities of each egg weight category were measured on the same day of laying by the Archimedes method using a formula as described by Hampe et al. [16]. All the eggs of each egg weight category were weighed individually by an electronic balance, then broken to determine other quality parameters. The shells of the broken eggs were washed, air-dried and then weighed to measure shell weight in grams to calculate the shell weight percentages of egg. Shell thickness of all eggs within each egg weight category was measured without the shell membrane, using a digital caliper (ORKA Technology LLC, Bountiful, UT) with a sensitivity of 0.001 mm at the broader end, the equator, and the pointed end of the fertile egg and then average thickness was calculated. Yolks were separated and weighed individually to calculate yolk weight percentage. Albumen weight was calculated by subtracting the wet yolk and shell weight from individual egg weight. From the yolk and albumen weights, yolk to albumen ratio in percentage
was calculated. Egg shape index was calculated by dividing the short diameter by long diameters of each egg weight and multiplying by 100.

**Chick Quality Parameters**

Eggs from all the egg categories were divided in 3 replicates having 100 eggs each. Eggs were provided with same incubation conditions. Hatchable eggs from each egg category were selected and shifted to Rose hatchery, located near Khannapul, Islamabad, Pakistan. These eggs were stored at 20°C and 75% relative humidity for 3 d. Eggs were marked individually and put in different trays randomly. The trays were randomly placed to account for possible environmental differences caused by position in the incubator. Double-yolked eggs, misshapen eggs, eggs with poor shell quality, and dirty eggs were not considered for hatching. All eggs were incubated for 18 d at a dry bulb temperature of 37.5°C and a wet bulb temperature of 29.4°C. At 18 d of incubation, all eggs were removed from the incubator, individually weighed, and transferred to a hatcher. The eggs were further incubated for an additional 3.5 d at a dry bulb temperature of 35.2°C and a wet bulb temperature of 29.4°C.

Chicks (male and female) hatched out of all replicates from each egg category (S, M, and L) were weighed by an electronic balance to calculate the average chick weight in grams (Hatchability = 85 to 89%; Male to female hatchability ratio 53:47). Then weights were obtained at 1-h intervals for the chicks hatched during that hour. The length of each chick was measured in centimeters from the point of the beak to the middle toe (nail excluded) by using a ruler. The weight (g) and length (cm) of individual chicks were recorded. From these readings, average chick length (cm) and chick weight (g) for each egg weight category was calculated.

Chick yield was calculated by dividing the average chick weight at the day of hatch with the average egg weight at the time of setting into incubator multiplied by 100. Grade-A chicks in all trays of each egg weight treatment were vent sexed, counted, and weighed by an accurate electronic weighing balance to get average chick weight for the measurement of chick yield.

**Broilers Housing and Production Parameters**

This trial was conducted in a commercial semi-controlled shed located at Tumair Village, Islamabad. This shed was divided into 18 pens (experimental units) by the partitions each measuring $5 \times 3 \times 10$ feet (length x width x height). The shed was cleaned, disinfected and fumigated before arrival of day-old chicks. A 2- to 3-inch-thick layer of rice husk was used as litter material in each pen.

Chicks from each egg category were further divided into males and females. The 45 males and 45 females from each egg category (S, M, and L) were selected at random from the hatchery and replicated 3 times, each replicate having 15 day-old chicks, and shifted to a commercial semi-controlled shed. These replicated day-old chicks were allotted randomly into 18 experimental units of the shed. Temperature (68°F), humidity (60 to 70%), and ventilation were strictly controlled in all pens to be the same. Stocking density was 0.07 m²/bird. The broilers were reared on wood shavings for 35 d with a photoperiod of 23 h of light and 1 h of darkness. Commercial broiler starter, grower, and finisher diets were offered to the birds at d0 to 10, d11 to 25, and d26 to 35 of age, respectively. Birds were fed a crumbled starter diet (23.0% CP and 3,067 kcal of ME/kg) from d1 to 14; a crumbled grower diet (20.2% CP and 3,152 kcal of ME/kg) from d15 to 28; and a crumbled finisher diet (19.0% CP and 3,196 kcal of ME/kg) from d29 to 41. Feed and water were provided ad libitum throughout the experiment. Immediately after arrival of day-old chicks at the farm, chicks were weighed by an electronic balance to record the average day-old weight for male and female broiler chicks of each egg-size category. At the end of each week, all the chicks in each replicate were weighed by an electronic weighing balance to measure the average BW (g) for each replicate was also calculated at the completion of each week until the termination of experiment.

The feed consumed by the chicks in each replicate group was measured on a weekly basis (total feed consumption = cumulative feed intake per bird from d1 to 35). Cumulative feed consumed (g) for each replicate was calculated at
the completion of each week until the end of the experiment. Feed conversion ratio \( \text{FCR, g/g (g of BW gain/g of feed consumed)} \) for each replicate was determined. Weekly mortality percentage for male and broiler chicks due to unhealed navals, congenital abnormalities, omphalitis, etc. of each replicate were also recorded during rearing period.

**Statistical Analysis**

Data were evaluated using one-way analysis of variance (ANOVA) and analyzed using General Linear Model (GLM) procedures of SPSS 16.0 software. When differences were significant, means were compared using Duncan’s Multiple Range tests at the 0.05 level of significance.

**RESULTS AND DISCUSSION**

Egg size had significant \( (P \leq 0.05) \) effects on shell weight, shell thickness, shape index and specific gravity at this late stage of the production period (Table 1). Overall, shell weight, shell thickness, shape index, and specific gravity reduced with increasing the egg size. Maximum shell weight percentage, shell thickness, shape index and specific gravity \( (P \leq 0.05) \) were achieved in S eggs, followed by M and L egg groups. Non-significant \( (P \geq 0.05) \) effect of egg size was observed on yolk weight, albumen weight, and yolk to albumen ratio at late stage of production period in broiler breeders. The results of the present study agreed for egg shell weight percentage and disagreed for the shell thickness with the findings of Shafey [17]. Interestingly, eggs laid at 60 wk of age had smaller yolk percentages and greater albumen proportion than those laid at 59 wk of age (Table 1). These results agree with the findings of Linea et al. [18] and disagree with the findings of Ulmer-Franco et al. [26] and Suarez et al. [36]. Feed nutrients and genetic factors could be the possible reason for this difference. Heavy (L) eggs had a greater proportion of albumen than M and S eggs (Table 1). Small (S) eggs had a smaller proportion of yolk than L and M eggs. These results agree with those of Vieira and Moran [32], who compared heavy and light eggs from 4 different strains. Egg shape index, which can be easily described

<table>
<thead>
<tr>
<th>Table 1. Effect of egg weight (size) on the egg quality parameters.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factors</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Small (S)</td>
</tr>
<tr>
<td>Medium (M)</td>
</tr>
<tr>
<td>Large (L)</td>
</tr>
</tbody>
</table>

\( P \)-value 0.00 0.01 0.02 0.13 0.15 0.58 0.00 0.00

Means with different letters in columns differ significantly \( (P \leq 0.05) \). S = small (3.0 to 6.0 g heavier than the average egg weight); L = large (3.0 to 6.0 g heavier than the average egg weight).
in terms of the ratio of the maximum breadth and length that vary according to egg size, strain, position of the egg in clutch and time of oviposition [19,20]. Egg shape is also influenced by genetic factors and individual traits. The egg shape index ranges between 57 and 92, but values lower than 74 correlate to higher incidence of cracked and broken eggs [21,22]. In this experiment, values of egg shape ranged from 73 to 78.21, which are considered to be normal values. Egg specific gravity is an indirect presentation of the egg shell quality in relation to the egg size. It was expected that specific gravity values would be related to shell percentage (i.e., that eggs with a high shell percentage would have a high specific gravity) as in present study; however, these finding disagree with the finding of Ulmer-Franco et al. [26]. Overall, these results supported that specific gravity is a reliable method for determining shell quality. [23]. Contrary to the current finding Wyatt et al. [4] found that chicks hatched from the eggs possessing lower specific gravities have greater BW at d one.

Egg size had a significant ($P \leq 0.05$) effect on chick weight, chick yield and chick length both for the male and female chick (Table 2). Data revealed that chick weight, chick yield, and chick length were improved ($P \leq 0.05$) with increasing egg size in both male and female broiler chicks. Chick weight is the most widely used indicator for day-old chick quality assessment [24]. It is known that a positive correlation exists between chick weight and egg weight in broiler chickens [6] which is in accordance with the current research. Studies showed that high correlation was found between egg size and day-old chick weight in different domestic birds [5,25]. Chicks hatched out from the heavy eggs have greater weight [26]. Williams [27] suggested that heavier eggs contained more nutrients than small eggs and hence, developing embryos from heavier eggs tended to have more nutrients for their growth requirements. This increase in chick size due to increasing egg weight is attributable to the fact that egg weight, yolk weight and albumen weight improved as the age increased in chickens while egg shell quality deteriorated [28] and may due to the fact that heavier weight eggs have more contents. Recent research showed that the chick length should be considered the best method to evaluate the visual quality of broiler

<table>
<thead>
<tr>
<th>Table 2. Effect of egg size on chick quality (Chick weight, chick yield, chick length) (Means ± SE).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factors</strong></td>
</tr>
<tr>
<td><strong>Egg weight</strong> (g)</td>
</tr>
<tr>
<td>Small (S)</td>
</tr>
<tr>
<td>Medium (M)</td>
</tr>
<tr>
<td>Large (L)</td>
</tr>
<tr>
<td><strong>P-value</strong></td>
</tr>
</tbody>
</table>

*a–cMeans with different superscript letters in columns differ significantly ($P \leq 0.05$).

*Chick body weight at hatching; S = Small (3.0 to 6.0 g lighter than the average egg weight); M = Medium (±1.5 g from the average egg weight); L = Large (3.0 to 6.0 g heavier than the average egg weight).
day-old chick [1,29]. Literature revealed that the large chick length was due to heavier egg weight [30], as in case of present study. Chick length is positively affected by the egg weight.

Egg size had a significant effect on day-old weight. Moreover, egg size also had significant ($P \leq 0.05$) effects on male chick weights at first week and the live BW of both sexes (male and females) at wk 2 and 3 of growth period (Table 3). However, non-significant differences ($P \geq 0.05$) were found on chick weight of different egg size groups at fourth and fifth wk of growth period. Generally, it was observed that average live BW gain of both sexes (male and female) decreased with increasing the egg size but, the effect of egg size on chick weight becomes insignificant ($P \geq 0.05$) from wk 4 of age. However, the chicks hatched from the small-sized eggs attained numerically maximum weight at 35 d of growing period compared to medium and large-sized eggs. In the current experiments, the growth of chicks in the first 3 wk was influenced by egg size but by the fourth week, this effect disappeared. This agreed with previous reports [10,31] that indicated that the correlation between egg size and chick BW diminished with increasing age of the growing chick. This study is not in agreement with Ng’ambi et al. [9], which stated that the performance of Potchefstroom Koekoek chicks (1 to 7 wk of age) hatched from large-sized eggs had higher daily live weight gain and live weight at 7 wk than those hatched from medium and small-sized eggs.

In this experiment with 60 week old broiler breeders, egg size had non-significant ($P \geq 0.05$) effect on chick feed intake during growth period except in males at wk 3 of growth (Table 4). It was observed that male chick feed intake was significantly ($P \leq 0.05$) increased with increasing the egg size at wk 3 of growth. Results of the current study indicated that egg weight did not affect the feed intake of broilers. Egg size did not affect feed consumption of commercial Cobb 500 broiler breeders [26]. Similarly, a previous study also supported that egg size had no influence on broiler feed intake [32]. In the starter phase of Anak broilers, daily feed intake increased with increase in eggs size while in finisher phase there was inverse relationship between feed intake and eggs size [6]. These results

---

**Table 3. Effect of broiler breeder egg size on posthatch broiler chick weight (g) on different wk of life (Means ± SE).**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Day-old chick</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg size</td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
<td>Male Female</td>
</tr>
<tr>
<td>Small (S)</td>
<td>43.33±0.15</td>
<td>48.40±0.16</td>
<td>152.4±1.6</td>
<td>153.1±2.5</td>
<td>408.6±1.0</td>
<td>399.0±2.8</td>
</tr>
<tr>
<td>Medium (M)</td>
<td>48.40±0.16</td>
<td>52.38±0.16</td>
<td>157.4±1.6</td>
<td>157.4±2.5</td>
<td>415.3±3.6</td>
<td>405.8±0.8</td>
</tr>
<tr>
<td>Large (L)</td>
<td>52.36±0.16</td>
<td>52.38±0.16</td>
<td>160.6±1.6</td>
<td>156.9±2.6</td>
<td>422.2±3.3</td>
<td>411.2±0.6</td>
</tr>
</tbody>
</table>

P-value: 0.058

- S = Small (3.0 to 6.0 g lighter than the average egg weight); M = Medium (±1.5 g from the average egg weight); L = Large (0.0 to 6.0 g heavier than the average egg weight).

Means with different letters in columns differ significantly ($P \leq 0.05$).

- a,bMeans with different letters in columns differ significantly ($P \leq 0.05$).
Table 4. Effect of broiler breeder egg size on broiler feed intake (g) and FCR (Means ± SE).

<table>
<thead>
<tr>
<th>Factors/age</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg size</td>
<td>Male FI</td>
<td>Female FCR</td>
<td>Male FI</td>
<td>Female FCR</td>
<td>Male FI</td>
</tr>
<tr>
<td>Small (S)</td>
<td>1.8 ± 0.0</td>
<td>3.7 ± 0.0</td>
<td>4.0 ± 0.0</td>
<td>3.6 ± 0.0</td>
<td>5.0 ± 0.0</td>
</tr>
<tr>
<td>Medium (M)</td>
<td>1.5 ± 0.0</td>
<td>3.1 ± 0.0</td>
<td>3.8 ± 0.0</td>
<td>3.4 ± 0.0</td>
<td>4.5 ± 0.0</td>
</tr>
<tr>
<td>Large (L)</td>
<td>1.3 ± 0.0</td>
<td>2.7 ± 0.0</td>
<td>3.4 ± 0.0</td>
<td>3.1 ± 0.0</td>
<td>4.2 ± 0.0</td>
</tr>
</tbody>
</table>

*Means with different letters in columns differ significantly (P ≤ 0.05).

FI = feed intake in gram.
FCR = feed conversion ratio [FCR, g/g (g of BW gain/g of feed consumed)].
S = small (3.0 to 6.0 g lighter than the average egg weight); M = medium (±1.5 g from the average egg weight); L = Large (3.0 to 6.0 g heavier than the average egg weight).
REFERENCES AND NOTES


