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Egg Weight but Not Egg Shape Index, Determines the Hatchability in Japanase Quail (*Coturnix coturnix japonica*)

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Abstract: This study was carried out to investigate the effect of egg Shape Index (SI) and Egg Weight (EW) on hatchability parameters, hatching weight and weekly live weight in Japanese quails (*Coturnix coturnix japonica*). Quail eggs were divided into three groups according to their SI (SI-1: ≤76: SI-2:77-78 and SI-3: ≥79%) and into three groups according to their weight (A1:<13.00 g, A2:13.01-14.00 g and A3: ≥14.01 g), respectively. The mean values of hatching weight were found as 8.41, 9.40 and 10.27 g in A1, A2 and A3 egg weight groups and as 8.97, 9.37 and 8.90 g in SI-1, SI-2 and SI-3 SI groups, respectively. The differences between groups in terms of these traits were statistically significant ($p<0.01$). The fertility rate was not affected significantly by egg weight. The hatchability of fertile eggs was not affected by (SI) groups but it was affected by egg weight groups ($p<0.01$). The highest hatchability of fertile eggs was observed in A1 group (79.47%) and this was followed by A2 (78.67%) and A3 (74.86%) groups. The difference in hatchability between egg weight groups was statistically significant ($p<0.01$) and the mean value of this trait in A3 group was lower (64.31%) than those in A1 (72.12%) and A2 (70.45%) groups. The differences between SI groups in terms of hatchability of total eggs, embryonic mortality rates, pipped and discarded chick rates were not statistically significant. The average Body Weights (BW) for the first 2 weeks between egg weight groups were statistically significant ($p<0.01$) but these differences were not statistically significant after 3 weeks of age.

Key words: Shape index, egg weight, live weight, hatchability, significantly, quail

INTRODUCTION

Hen breeding has been having the largest share in poultry sector. Healthy nutrition, consumer awareness and increase in level of prosperity encourage breeding of other poultry species in breeding companies. In this context, quail is becoming an important alternative livestock because of its high reproductive performance, early sexual maturation, higher egg production and a shorter generation interval.

Factors that effect properties of hatchability, start to operate in breeding facilities from which the eggs were obtained, continue during various processes in hatchery and take final shape during the incubation process.

Hatchability, hatching time, embryonic mortalities, chick weight at hatch and chick's developmental performance at post-hatch period are directly affected by hatching egg weight (Shanaway, 1987; Skewes *et al*., 1988; Baspinar *et al*., 1997; Altan *et al*., 1995). Late embryonic mortality in heavier eggs is higher compared to lighter eggs whereas hatchability of fertile eggs is lower in heavier eggs (Reinhart and Hurnik, 1984; French, 1994; Ogunshile and Sparks, 1995; Copur, 2004). The low rate of hatchability in heavier eggs is due to higher amount of metabolic heat production in heavier eggs in comparison to lighter ones (Meijerhof and Van Beek, 1993; French, 1994; Ogunshile and Sparks, 1995). A positive correlation was found between egg weight and the hatchling weight (Constantini and Panella, 1984; Tservi-Gousi, 1987; Shanaway, 1987; Altan *et al*., 1995; Yildirim and Yetisir, 1998; Ozcan *et al*., 2001).

Hatchling weight constitutes 68.4% of egg weight in chicken, 63.5% of egg weight in Turkey, 57.8% of egg weight in duck, 57.8% of egg weight in goose, 61.9% of egg weight in pheasant and 66.9% of egg weight in quail, respectively (Shanaway, 1987).

Quail egg weight at various age periods were reported to be 10.9-12.19 g (11.49 g) (7-20 weeks) (Altinel *et al*., 1996), 11.25-12.95 g (7-22 weeks) (Yannakopoulos and Tserveni-Gousi, 1986), 9.34-11.19 g (10.41 g) (8-24 weeks) (Nazligul *et al*., 2001) and the average in 3 lines were reported as 12.72, 12.59 and

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12.56 g (Baylan *et al*., 2007), respectively. Eggs equal to or over 9.5 g weight possess the best hatching egg quality, fertility and thus the hatchability of fertile eggs increase proportionally with egg weight (Nazligul *et al*., 2001). While egg weight has effect on chick weight at hatch and chick livability (Shanaway, 1987; Tservi-Gousi, 1987; Baylan *et al*., 2007), hatchling weight has no effect on chick livability in later age periods (Yildirim and Yetisir, 1998). Correlation of egg weight with chick weight decreases over chick's age (Wilson, 1991).

Fertility and hatchability rates in <9.5 g (light), 9.5-10.5 g (medium) and >10.5 g (heavy) Japanese quail hatching eggs are 54.54, 64.22 and 66.43% and 55.55, 57.14 and 64.06%, respectively (Esen, 1988). Fertility, hatchability of fertile eggs and hatchability rates of Japanese quail in heavy egg groups (≥11.01 g) are higher than in light (≤10.0 g) and middle egg weight (10.01-11.00 g) groups (Ozbey and Ekmen, 2006).

While there is a direct relationship between the low pore count, SI, shell permeability of quail eggs and increased early and late embryonic mortalities (Turkyilmaz *et al*., 2005), there is no effect of SI on hatchability (Baspinar *et al*., 1997; Kul and Seker, 2004; Turkyilmaz *et al*., 2005).

This study was performed to determine the effects of SI and egg weight of quail eggs on the properties of hatchability, hatchling weight and weekly BW gain.

MATERIALS AND METHODS

In this study, incubating eggs were obtained from 16 weeks old breeding Japanese quail that was obtained after 9 generations of individual selection for BW at 5 weeks of age in the M.K.U. Samandag Research Unit. A total of 715 eggs were used. Eggs with no cracks that were free of fecal contamination were collected daily for a week and they were stored at 15-18°C temperature with 75% relative humidity. Before incubation, the eggs were divided into 3 groups (≤76% (SI-1), 77-78% (SI-2) and ≥79% (SI-3) according to their SI which was the ratio of their length to their width that was measured by a 0.01 mm digital compass. Three weight groups, consisted of ≤13.00 g (A1), 13.01-14.00 g (A2) and ≥14.01 g (A3) were established based on SI.

The hatching eggs from each group were fumigated using double strength commercial formaldehyde (USDA, 1985) (2X = 79.86 mL formalin: 39.93 g potassium permanganate m^{-3}) for 20 min at 24°C. After disinfection eggs from each treatment group were placed randomly into trays in triple layers. In this experiment setter and hatcher machines were used that have a capacity of 3328 quail eggs. Eggs were incubated at 37.6°C and 55-60% Relative Humidity (RH) until 15th day of incubation, until incubator conditions were changed to 37.2°C and 65-70% RH for the actual hatching process. Once all chicks hatched, non-hatched eggs were broken in order to macroscopically inspect their contents to determine the real fertility rate and to estimate the time of death for non hatched fertile eggs. Hatchability of fertile eggs was determined by subtracting all truly infertile eggs and dividing the number of chicks hatched by the total number of fertile eggs. In addition to these parameters, early embryonic mortality (0-6 days of incubation), middle embryonic mortality (7-15 days of incubation), late embryonic mortality (16-18 days of incubation), discarded chicks rate, pipped and contamination rate were determined.

Hatched chicks from each treatment group were weighed to determine initial BW (g) using a 0.1 g sensitive scale. All hatched chicks were kept in brooder with a size of 100×50×25 cm for first 2 weeks where automatic heating and drinking system exist and they were then transferred to growing cages (100×50×20 cm) and were kept there until 5 weeks of age. Feed and water were provided *ad-libitum* during the 5 weekly growing period. Along the study, the quail were fed with grower diet containing 22% CP and 3000 kcal kg^{-1} ME for 5 weeks. Individual BW data were recorded weekly until 5 weeks of age by using a 0.1 g sensitive electronic scale.

Numerical data were presented as mean±Standard Error ($\bar{X} \pm S\bar{x}$). The properties of hatchability of fertile eggs, hatchability, fertility, discarded chicks, early, middle, late embryonic mortalities and pipped rate were transformed into arcsin to $\sqrt{\%P}$ obtain normal distribution. Two-way ANOVA was used for comparisons using SPSS (release 13.00) with Duncan's Multiple Range Test to identify the significant differences between means. The linear model of properties are written as follows:

$$Y_{ijk} = \mu + a_i + b_j + (ab)_{ij} + e_{ijk}$$

Where:

- Y_{ijk} = The hatching results, hatchling weight and live body weight values of the ith SI group that was belonged to the jth weight group of kth tray
- μ = Overall mean
- $a_{i=}$ = The effect of SI (I = 1, 2, 3)
- b_j = The effect of egg weight) (j = 1, 2, 3)
- $(ab)_{ij}$ = The interaction effect between SI and egg weight
- e_{ijk} = Random error

RESULTS AND DISCUSSION

The effect of egg SI and egg weight on the hatchling weights shown in Table 1. The mean values of

Table 1: The Effects of egg shape index and egg weight groups on hatchling weights

	Egg weight groups (Mean±Standart Error) ($\bar{X} \pm S\bar{x}$)			
Groups shape index	A1(g) (≤13.00 g)	A2 (g) (13.01-14.00 g)	A3 (g) (≥14.01g)	Total
Egg weight means				
SI-1 (≤ 76%)	12.34±0.043	13.47±0.028	14.77±0.092	13.25±0.065^{A}
SI-2 (77-78%)	12.34±0.041	13.49±0.032	14.64±0.066	13.30±0.063^{A}
SI-3 (≥ 79%)	12.18±0.041	13.44±0.030	14.34±0.055	12.93±0.058
^{B}Hatchling weight means				
SI-1 (≤ 76%)	8.24±0.045	9.43±0.042	10.32±0.116	8.97±0.068^{B}
SI-2 (77-78%)	8.77±0.062	9.50±0.052	10.58±0.085	9.37±0.066^{A}
SI-3 (≥ 79%)	8.28±0.050	9.26±0.069	9.93±0.086	8.90±0.064^{B}
Total	8.41±0.033^{c}	9.40±0.032^{b}	10.27±0.062^{a}	

$^{A, B}$Different superscripts in the same column indicate significant differences (p<0.01) among mean values. $^{a, b, c}$Different superscripts in the same row indicate significant differences (p<0.01) among mean values

Table 2: Average live weights in different age periods according to egg weight groups

	Egg weight groups (Mean±Standard Error) ($\bar{X} \pm S\bar{x}$)				
Age (day)	A1(g) (≥13.00 g)	A2 (g) (13.01-14.00 g)	A3 (g) (≤14.01 g)	Total	p-value
7	40.19±0.347^{c}	42.48±0.426^{b}	44.25±0.668^{a}	41.58±0.263	**
21	170.51±3.810	157.90±1.560	167.10±2.935	165.97±5.894	-
35	269.76±1.920	267.91±2.635	268.25±4.344	268.93±1.475	-

Not significant **:p<0.01, $^{a, b, c}$Different superscripts in the same row indicate significant differences (p<0.01) among mean values

Table 3: Average live weights in different age periods according to egg shape index groups (g)

	Shape index groups (Mean±Standard Error) ($\bar{X} \pm S\bar{x}$)				
Age (day)	SI-1 (≤76%)	SI-2 (77-78%)	SI-3 (≥ 79%)	Total	p-value
7	42.61±0.38^{A}	41.44±0.46^{AB}	40.19±0.51^{B}	41.58±0.26	**
21	160.18±1.30	158.32±1.91	183.98±2.17	165.97±5.89	-
35	268.14±2.33	268.57±2.61	270.46±2.79	268.93±1.47	-

Not significant, **p<0.01, $^{A, B}$Different superscripts in the same row indicate significant differences (p<0.01) among mean values

hatchling weight were determined as 8.41, 9.40, 10.27 g in A1, A2 and A3 egg weight groups and as 8.97, 9.37 and 8.90 g in SI-1, SI-2 and SI-3 SI groups, respectively. Hatchling weights significantly varied among egg weight and SI treatments (p<0.01). The highest hatchling weights were obtained from A3 egg weight and SI-2 SI groups, the lowest hatchling weights were obtained from A1 and SI-3 treatments (Table 1).

Chick BW values of various egg weight groups at different age periods are shown in Table 2. The average body weights at 7 and 14 days old age periods were parallel to chick hatchling weights and this was higher in heavy egg weight groups than in middle and light egg weight groups (p<0.01). Differences between egg weight groups on BW at the 21 and 35 day old age were statistically not significant. The chick live weight of A1 (40.19 g) at 7 day old age was lower than A2 (42.48 g) and A3 (44.25 g) groups. The effect of SI groups on BW was statistically significant at 7 and 14 day old age but this difference was not statistically significant after 3 weeks of age (p>0.05) and that continued as same until 5 weeks old age (Table 3). The fertility rate was not changed in A1 (89.81%), A2 (89.71%) and A3 (87.92%) egg weight groups. The changes in hatchability of fertile eggs, hatchability and culled chicks rates of egg weight and of SI groups can be shown in Table 4. The hatchability of fertile eggs was not affected by SI groups but it was affected by egg weight groups (p<0.01). The highest hatchability of fertile eggs was determined in A1 group (79.47%) and this was followed by A2 (78.67%) and A3 (74.86%) groups.

The difference between egg weight groups of the hatchability was statistically significant (p<0.01) and the mean value of this trait in A3 which has ≥14.01 g weigh was lower (64.31%) than those A1 (71.26%) and A2 (70.45%) groups. The effect of SI on the hatchability was not significant. Discarded chick rates were not significantly different in SI and egg weight groups. The interaction between SI and egg weight groups on the hatchability of fertile eggs and the hatchability was statistically significant (p<0.01).

Early, middle and late embryonic mortality rates and pipped value varied among egg weight and SI treatments but those differences between treatments were not statistically significant (Table 5). The late embryonic mortality values varied between 6.27 and 8.36%. The

Table 4: The effects of egg shape index and egg weight groups on hatchability results

		Egg weight groups (Mean±Standart Error) ($\bar{X}\pm S\bar{x}$)			
Parameters	Shape index groups	A1 (g) (≤13.00 g)	A2 (g) (13.01-14.00 g)	A3 (g) (≥14.01 g)	Total
Hatch of fertile egg (%)	SI-1 (≤76%)	82.80±1.257	84.72±0.831	62.18±3.093	76.56±3.740
	SI-2 (77-78%)	83.50±2.467	78.84±0.579	71.41±0.410	77.92±1.910
	SI-3 (≥79%)	72.10±4.191	72.46±2.898	85.00±3.469	76.52±2.768
Total		79.47±2.345^{a}	78.67±1.978^{ab}	72.86±3.577^{b}	
Hatch of egg (%)	SI-1 (≤76%)	73.99±1.293	76.18±0.372	52.96±4.061	67.71±3.901
	SI-2 (77-78%)	74.70±0.716	66.73±1.427	61.47±0.753	67.63±1.989
	SI-3 (≥79%)	65.10±2.463	68.44±1.777	78.50±0.888	70.68±2.210
Total		71.26±1.752^{a}	70.45±1.599^{a}	64.31±3.946^{b}	
Culled chick (%)	SI-1 (≤76%)	1.15±1.450	1.28±1.282	2.22±2.222	1.55±0.828
	SI-2 (77-78%)	1.19±1.190	0.00±0.000	0.00±0.000	0.39±0.396
	SI-3 (≥79%)	0.00±0.000	0.00±0.000	3.33±3.333	1.11±1.111
Total		0.78±0.516	0.43±0.427	1.85±1.255	

[a,b]Different superscripts in the row indicate significant differences (p<0.01) among mean values

Table 5: Embryonic mortality rates in different egg shape index and egg weight groups

		Egg weight groups (Mean±Standart Error) ($\bar{X}\pm S\bar{x}$)			
Parameters	Shape index groups	A1(g) (≤13.00 g)	A2 (g) (13.01-14.00 g)	A3 (g) (≥14.01 g)	Total
EEM (%)	SI-1 (≤76%)	3.82±1.954	10.42±3.132	14.67±1.771	9.64±1.972
	SI-2 (77-78%)	8.25±1.233	8.46±0.231	14.66±4.598	10.46±1.731
	SI-3 (≥79%)	15.43±3.572	15.94±1.449	8.89±0.555	13.42±1.598
Total		9.17±2.091	11.61±1.500	12.72±1.725	
MEM (%)	SI-1 (≤%76)	1.91±0.977	0.00±0.000	2.22±2.222	1.38±0.782
	SI-2 (77-78%)	0.00±0.000	0.00±0.000	1.96±1.960	0.65±0.653
	SI-3 (≥79%)	0.00±0.000	2.90±1.449	0.00±0.000	0.97±0.639
Total		0.64±0.425	0.97±0.639	1.40±0.924	
LEM (%)	SI-1 (≤76%)	5.28±1.397	4.97±0.967	12.31±6.157	7.52±2.199
	SI-2 (77-78%)	5.87±1.151	11.25±1.310	10.00±1.444	9.04±1.042
	SI-3 (≥%79)	7.67±1.877	7.24±1.449	2.77±2.777	5.90±1.313
Total		6.27±0.834	7.82±1.112	8.36±2.457	
PIPPED (%)	SI-1 (≤76%)	4.20±1.360	0.00±0.000	2.22±2.222	2.14±0.966
	SI-2 (77-78%)	1.19±1.190	1.45±1.449	0.00±0.000	0.88±0.585
	SI-3 (≥79%)	1.93±0.966	1.44±1.449	0.00±0.000	1.13±0.580
Total		2.44±0.745	0.97±0.639	0.74±0.740	

Different superscripts in the same row and column indicate not significant differences (p>0.05) among mean values. EEM: Early Embriyonic Mortality, MEM: Middle Embriyonic Mortality, LEM: Late Embriyonic Mortality

highest and lowest late embryonic mortality were obtained from A3 and A1 groups, respectively. The early embryonic mortality values varied between 9.17 and 12.72%. The lowest and highest early embryonic mortality value were found in A1 (9.17%) and A3 (12.72) groups, respectively. Pipped value in A3 (0.74%) was lower than A2 (0.97%) and A1 (2.44%).

Hatchling weight increased in parallel to increase in hatching egg weight (p<0.01). This finding is in accord with other studies (Constantini and Panella, 1984; Tservi-Gousi, 1987; Shanaway, 1987; Yildirim and Yetisir, 1998) that reported a positive correlation between hatching egg weight and hatchling weight. In the study, the best chick weight at hatch was obtained from eggs in the 77-78% SI group. This value was close to the 79% SI group that was reported by Kul and Seker (2004) whereas it was significantly different from papers that reported a 74% SI for the best chick weight. Although hatchling weights directly affects average BW in the first 2 weeks, this effect disappears at the 3rd week. Incubating eggs were obtained from 16 weeks old breeding Japanese quails that were previously subjected to weight selection for 9 generations at their 5th week according to live BW that ended up in an increase in BW and in turn, an increase in egg weight up to 13-14 g level.

The reason of lack of weight difference from 3 weeks can probably be explained by the rapid developmental performance of chicks with a 8.41 g of BW being hatched from the lowest egg weight group (≤13.0 g). Researcher report that low BW healthy chicks may reach normal BW by compensatory developmental performance if they have no health problems (Deeming, 1999; Akcapinar and Ozbeyaz, 1999; Ozbey and Ekmen, 2006). This finding concurs with studies reporting rapid compensational development of hatched chicks from lower egg weight group (Nazligul *et al*., 2005) but differs from studies reporting (Uluocak *et al*., 1985) higher body and slaughter weights of hatched chicks from heavy eggs (12.0-12.9 g) compared to lower (9.0-9.9 g) and medium egg weight (10.0-10.9, 11.0-11.9 g) groups.

Fertility rate did not change according to incubating egg weight (p>0.05). This observation differs from other papers reporting higher fertility rate of heavy group eggs (>10.5 g, ≥11.01 g) compared to lower and medium egg (9.5-10.5 g, 10.01-11.00 g) weight groups (Esen, 1988; Ozbey and Ekmen, 2006). The higher average weight of our arbitrarily chosen lower weight group from higher weight group of other reports might explain this difference.

Hatchability of fertile eggs and hatchability were changed according to egg weights (p<0.01). The highest hatchability of fertile eggs and hatchability were obtained from eggs weighed 13.00 g or lower at the higher weight levels the hatchability of fertile eggs and hatchability decreased. This finding differs from studies (Constantini and Panella, 1984; Baspinar *et al*., 1997; Nazligul *et al*., 2001) reporting a parallel increase in hatchability of fertile eggs and hatchability with egg weight. This difference can be explained by the much lower average egg weight in the highest weight group of other reports compared to the average egg weight of the lowest weight group in the study.

The lower hatchability of fertile eggs in the heavy egg group supports research (Reinhart and Hurnik, 1984; French, 1994; Ogunshile and Sparks, 1995; Copur, 2004) reporting higher late period embryonic mortality but a lower hatchability in heavy eggs compared to lighter ones. The lower hatchability of fertile eggs in heavier eggs was explained by the embryonic intolerance to higher metabolic heat that is produced by higher metabolic activity rate by some researchers (French, 1994; Ogunshile and Sparks, 1995).

CONCLUSION

Hatchling weight in ≥14.01 g eggs were higher than the hatchling weight in <13 and 13.01-14.00 g eggs, respectively and this difference disappeared at 5th week BW. In conclusion, 13 g hatching egg weight group in quail is the appropriate optimal weight in terms of hatchability of fertile eggs, hatchability and growing period performances, although those properties do not change according to variations in SI.

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