Europ.Poult.Sci., **86.** 2022, ISSN 1612-9199, © Verlag Eugen Ulmer, Stuttgart. DOI: 10.1399/eps.2022.365

Effects of egg weight and breeder age on egg quality, hatching parameters and post-hatch performance of Cherry Valley broiler ducks

Auswirkungen von Eigewicht und Alter der Elterntiere auf Eiqualität, Schlupfparameter und Leistung nach dem Schlupf von Cherry Valley Mastenten

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Manuscript received 16 February 2022, accepted 14 June 2022

Abstract

This study was conducted to evaluate the effects of egg weight and breeder age on hatching egg quality, incubation parameters, and post-hatch growth performance of Cherry Valley broiler ducks. A total of 1512 hatching eggs obtained from a flock of Cherry Valley duck broiler breeders were evaluated in two experiments. Seven hundred and fifty-six (756) incubating eggs were categorized into three weight groups as small (77 – 81 g), medium (84 – 89 g) and large (91 – 95 g) and two breeder age groups (32 and 73 weeks). At hatch, day-old ducklings were randomly assigned to their respective groups with 6 replicates and 15 ducklings per pen using a completely randomized design. Results (experiment 1) showed that hatching egg weight significantly influenced ($P = 0.028$) eggshell thickness, Haugh unit, albumen weight, yolk weight, and egg weight loss during incubation. Egg weight also influenced ($P < 0.05$) feed intake and slaughter weight of the ducklings. The results obtained in study 2 clearly showed a negative effect ($P = 0.0004$) of breeder age on eggshell percentage and thickness, Haugh unit and hatchability. Hatching weight and average daily weight gain for the first 7 days were higher ($P < 0.05$) for chicks from the older breeders. Feed consumption and feed conversion ratio were not affected ($P > 0.05$) by the breeder age. Higher mortality was observed in the 73-week-old group in the early phase of the rearing period. It can be concluded that breeder age altered egg quality, which is manifested during the embryonic and post-embryonic development, especially in hatching rate and survivability of the ducklings during the early rearing phase. The weight of the day-old ducklings increased with egg weight without impact on embryo mortality, hatchability and fertility.

Key words

breeder age; hatching egg size; incubation parameters; growth performance; mortality

Zusammenfassung

In dieser Studie wurden die Auswirkungen von Eigewicht und Alter der Elterntiere auf die Qualität der Bruteier, die Inkubationsparameter und die Wachstumsleistung nach dem Schlupf bei Cherry Valley Mastenten untersucht. In zwei Versuchen wurden insgesamt 1512 Bruteier aus einer Cherry Valley Mastentenherde getestet. Siebenhundertsechsundfünfzig (756) Bruteier wurden jeweils in drei Gewichtsgruppen (klein: 77 – 81 g, mittel: 84 – 89 g und groß: 91 – 95 g) sowie in zwei Elterntieraltersgruppen (32 und 73 Wochen) eingeteilt. Zum Zeitpunkt des Schlupfes wurden die Eintagsküken nach dem Zufallsprinzip aus den jeweiligen Gruppen ausgewählt, wobei 6 Wiederholungen mit je 15 Küken pro Einheit in einem vollständig randomisierten Design durchgeführt wurden. Die Ergebnisse (Experiment 1) zeigten, dass das Gewicht der Bruteier einen signifikanten Einfluss ($P = 0{,}028$) auf die Dicke der Eierschale, die Haugh-Einheit, das Eiklargewicht, das Dottergewicht und den Gewichtsverlust der Eier während der Bebrütung hatte. Das Eigewicht beeinflusste auch ($P < 0{,}05$) die Futteraufnahme und das Schlachtgewicht der Entenküken. Die in Studie 2 erzielten Ergebnisse zeigten eindeutig einen negativen Effekt ($P = 0{,}0004$) des Elterntieralters auf den Prozentsatz und die Dicke der Eischale, die Haugh-Einheit und die Schlupffähigkeit. Das Schlupfgewicht und die durchschnittliche tägliche Gewichtszunahme in den ersten 7 Tagen waren bei den Küken der älteren Elterntiergruppe höher ($P < 0{,}05$). Die Futteraufnahme und die Futterverwertung wurden durch das Alter der Elterntiere nicht beeinflusst ($P > 0{,}05$). Bei den Küken der 73 Wochen alten Elterntiere wurde in der Anfangsphase der Aufzucht eine höhere Sterblichkeit beobachtet. Daraus lässt sich schließen, dass das Alter der Elterntiere die Eiqualität veränderte, was sich in der embryonalen und postembryonalen Entwicklung, insbesondere in der Schlupfrate und der Überlebensfähigkeit der Entenküken in der frühen Aufzuchtphase, zeigte. Das Gewicht der Eintagsküken erhöhte sich in Abhängigkeit vom Eigewicht, ohne dass dies Auswirkungen auf die Sterblichkeit der Embryonen, die Schlupfrate und die Fruchtbarkeit hatte.

Stichworte

Elterntieralter; Bruteigröße; Brutparameter; Wachstumsleistung; Mortalität

Introduction

Poultry meat production is one of the main sources of animal protein for the human population and an important source of income in developed and developing countries. In the world today, broiler chicken is a major source of animal protein but in the last decade, duck meat production has improved because ducks have a high weight at slaughter (Sözcü and Ipek, 2017). Commercial poultry production depends on artificial incubation with the main objective of attaining a high hatching rate, quality day-old chicks and better post-hatch growth rate (Decuypere and Bruggeman, 2007). However, the weight and quality of the broiler chicks depend on several factors, such as egg quality, age of the breeder, egg storage duration and condition, health of the breeder flock and genotype. In addition to these factors, egg weight plays a major role in day-old chick weight quality and overall post-hatch performance (Ipek and Sahan, 2002; Weis et al., 2011). Tona et al. (2004) reported a positive correlation between egg weight and day-old chick weight because all the nutrients, minerals, energy sources and water utilized by the embryo are kept in the incubating eggs by laying breeders. Several studies have also shown that the performance of chickens in terms of hatchability and hatch weight may be closely related to egg weight, as the main effect of egg weight (size) is the mass of the remaining yolk sac that the chick retains at hatching (Rashid et al., 2005; Kingori et al., 2003). Nelson et al. (1992) also indicated that the hatching weight in avian species is around 60–70% of the hatching egg weight.

The age of the breeder has been known to influence hatching egg internal quality, embryonic life of the chick, quality of hatched chick and performance during post-hatch (Tona et al., 2004). It is reported that as breeder age increases, shell percentage, shell thickness and shell strength decrease (Al-Batshan et al., 1994) and the proportion of yolk increases (Suarez et al., 1997). Other studies have demonstrated that the performance of the breeder flock decreases with the increasing age of the hens because this decline results in poorer egg quality. This in turn also negatively affects egg conductance (lower eggshell), albumen quality and late embryo mortality (Elibol and Brake, 2003; Tona et al., 2004). Additionally, Fasenko et al. (1992) showed a decline in fertility with the increasing age of the breeder hens. Rosa et al. (2002) demonstrated that lower hatchability was obtained from hatching eggs from older breeders. The authors pointed out that the lower hatchability of eggs laid by older breeders may be explained by the decline in eggshell quality and egg quality characteristics. Tona et al. (2004) noted that day-old chick quality is correlated with the age of the breeder flock. To our knowledge, most of these reported studies were focused on chicken and quail hatching eggs and very little attention has been given to duck hatching eggs in terms of their quality, hatching parameters, the quality of ducklings and their performance. Therefore, the current study aimed to investigate the influence of egg weight and age of breeder on egg quality, embryo development, duckling quality, duckling post-hatch performance and carcass quality.

Material and Methods

The research was carried out following the Institute of Animal Ethics Committee guidelines of the Regional Center of Excellence on Poultry Sciences (CERSA-UL).

Experiment 1: Experimental design

A total of 756 hatching eggs obtained from two Cherry Valley duck breeder flocks at 35 weeks of age were used for this study. These eggs were stored at 12.5°C and 70% relative humidity for 3 days. After storage, the eggs were assigned into 3 groups according to their weight: small (77–81 g), medium (84–89 g) and large (91–95 g). Before setting into the incubator, the eggs were numbered, weighed and assigned into 4 replicates of 63 eggs per group. Thirty eggs per group were randomly selected, weighed individually and broken to determine egg quality characteristics. Egg weight, egg length and width, eggshell weight, shell thickness and shell strength were measured. Yolk weight, yolk colour; albumen height, albumen weight, and albumen Haught unit were determined as well. The eggs were incubated in an EIFDMS incubator at 37.5°C, relative humidity of 62% and turning each hour at an angle of 90° for the first 24 days of incubation. At 12 days of incubation, all eggs were candled and all infertile eggs were removed from the trays. At 24 days of incubation, the eggs were weighed, and those with evidence of living embryos were transferred from turning trays to hatching baskets. This weight was used to determine the weight loss during incubation. The hatcher was operated at 37.0°C and 72% relative humidity on day 28 of incubation; all hatched ducklings were recorded and weighed. Eggs that failed to hatch were broken, opened and visually evaluated to classify them into infertile eggs and eggs containing dead embryos. The embryonic mortality was recorded. The data obtained were used to calculate the hatchability of the fertile eggs. Ducklings with physical malformations were classified as culled ducklings and sorted out.

Egg weight loss during incubation

On day 24 of incubation, all incubated eggs were weighed. These weights and the weights determined prior to incubation were used to calculate relative egg weight loss up to day 24 of incubation using the formula:

$$WL = \frac{W0 - W24}{W0} x100$$

Where: WL = relative egg weight loss; W0 = egg weight at setting; W24 = egg weight at day 24 of incubation.

Management of Ducklings

After hatch, 270 ducklings were reared until 35 days of age according to the weight groups each with 6 replicates of 15 birds using a completely randomized design. Birds were fed on the same diets during the first week. Ducklings were fed a starter diet until 2 weeks of age and then were given a grower diet. Feed and water were offered *ad libitum* during the experiment. During the experimental period, the amount of feed consumed, body weight and feed conversion ratio were recorded weekly. At 35 days of age, the feed was withdrawn for 12 hours before slaughter. A total of 36 ducks (2 ducks per replicate) were individually weighed to determine slaughter weight and then were slaughtered in the processing plant of the university farm. After slaughter, the heart, liver and spleen were removed and weighed.

Experimental 2: Experimental design

A total of 756 hatching eggs obtained from two Cherry Valley duck breeder flocks at 32 (young flock) and 73 (older flock) weeks of age were used for this study. Both breeder flocks were kept under the same management and environmental conditions according to the standards of the breeding company. Eggs, according to experimental groups, were numbered and stored at 12.5°C and 84.59% relative humidity for 3 days before setting for incubation.

After the storage period, 15 eggs per group were randomly selected, weighed individually and broken to determine egg quality characteristics. Egg weight, egg length and width, eggshell weight, shell thickness and shell hardness were measured; Yolk weight and yolk colour; albumen height, albumen weight, and albumen Haught unit were determined as well. Before setting for incubation, the eggs were numbered, weighed individually and assigned into 6 replicates of 63 eggs each according to storage treatment.

Then, eggs were incubated in the same incubator at 37.5°C and 62% relative humidity and turned each hour at an angle of 90° for the first 24 days of incubation. At 12 days of incubation, all eggs were candled and all infertile eggs were removed from the trays. At 24 days of incubation, the eggs were weighed, and those with evidence of living embryos were transferred from turning trays to hatching baskets. These weights were used to determine the weight loss during incubation. The hatcher operated at 37.0°C and 72% relative humidity until day 28 of incubation. All hatched ducklings were counted, recorded and weighed. Eggs that failed to hatch were broken, opened and visually evaluated to distinguish infertile eggs from eggs containing dead embryos.

The embryonic mortality was classified as early (from day 0 to day 24) and late (from day 24 until the end of incubation). The late embryonic mortality was recognized by evidence of the yolk sac that entered the abdominal cavity and the beak in the piping position. These data were used to calculate the hatchability of the fertile eggs. Ducklings with physical malformations were classified as culled ducklings and sorted out.

Shell surface area, egg component weights and eggs weight loss during incubation

Eggshell width, eggshell weight, shell thickness and shell strength were measured to calculate shell surface area (Baryeh and Mangope, 2003) and the percentages of egg components (Yolk percentage, albumen percentage and shell percentage) were calculated as follows:

S = Ks L B;

Ks is a coefficient for calculating surface area; L = Egg Length; B = Egg Width

$$\text{Egg component percentage} = \frac{\text{Weight of the egg component}}{\text{Egg weight at setting}}$$

On day 24 of incubation, all incubated eggs were weighed. These weights and those recorded before incubation were used to calculate relative egg weight loss up to d 24 of incubation as:

$$WL = \frac{W0 - W24}{W0} x100$$

Where: WL = relative egg weight loss; W0 = egg weight at setting; W24 = egg weight at day 24 of incubation.

Management of day-old ducklings

After hatching, 180 ducklings were reared until 35 days of age according to the treatments. Each experimental group at the rearing period consisted of six replicates of 15 ducklings using a completely randomized design. Ducklings were fed a starter diet for 2 weeks and then were given a grower diet. Feed and water were offered *ad libitum* during the experiment. The amount of feed intake, body weight and feed conversion ratio were recorded weekly. Mortality was recorded daily. The data were used to calculate, average daily weight gain, daily feed intake and feed conversion ratio.

Statistical Analysis

The data were processed with the statistical software package SAS. The effect of egg weight and age of the breeders on egg quality and egg components; duration of incubation and post-hatch weights, feed intake, feed conversion ratio, intestine measure and weight were investigated using a two-way ANOVA model. A probability value of 0.05 was used as the degree of significance. When the means of the general model were statistically different, the means were further compared using Tukey's test. In the second analysis, hatchability was considered as a binomial distribution. The model was as follows:

$$Yijk = \mu + \alpha i + \tau j + eijk$$

where Yijk = egg quality parameter, egg weights of the egg from treatment, k; post-hatch weights, body weight, body gain duckling feed intake and feed conversion rate j, of duckling from breeder age, j; μ = overall mean; αi = main effect of egg weight, τj = main effect of breeder age, j; and eijk = random error term.

Results

Egg quality parameters

Table 1 shows the result of the egg quality parameters according to egg weight groups. Egg shape index, shell strength and the eggshell ratio were similar for all groups but the shell thickness of the large eggs group was significantly (P = 0.028) higher than that of the small eggs group. Between the medium and large groups, the shell thickness was similar. The small eggs group had a higher (P = 0.017) ratio of albumen than that of the medium eggs group but was comparable (P > 0.05) to the large eggs. The ratio of the yolk was similar (P > 0.05) between the medium and large eggs groups but the small eggs group had a lower (P = 0.042) ratio of yolk compared with the medium eggs group. The albumen plus yolk weights of the large egg group were significantly (P = 0.017) higher than those of small eggs. However, between the medium and large groups, the albumen plus yolk weights were similar. The eggshell weight and ratio were similar in all groups. Albumen Haugh unit of the small eggs group was significantly higher (P = 0.028) than that of the large eggs group but was comparable to that of the medium-sized eggs.

Table 1. Effect of duck egg weights on egg quality traits.

Einfluss des Gewichts von Entenbruteiern auf die Eiqualität.

	Hatching egg weight groups			
Egg quality traits	Small	Medium	Large	P-value
Average egg weight (g)	79.34 ± 0.45^{c}	86.60 ± 0.23^{b}	92.58 ± 0.38^{a}	0.015
Egg shape index	74.92 ± 0.69	73.00 ± 0.34	73.90 ± 0.76	0.123
Shell thickness (mm)	0.35 ± 0.01^{b}	0.37 ± 0.01^{ab}	0.40 ± 0.01^{a}	0.028
Shell strength (kg.cm^{-2})	4.28 ± 0.39	4.74 ± 0.21	5.07 ± 0.08	0.128
Albumen ratio (%)	58.42 ± 0.79^{a}	55.63 ± 0.92^{b}	56.73 ± 0.64^{ab}	0.017
Yolk ratio (%)	30.79 ± 0.76^{b}	33.60 ± 0.94^{a}	31.88 ± 0.72^{ab}	0.042
Shell ratio (%)	10.79 ± 0.13	10.78 ± 0.20	11.40 ± 0.28	0.072
Albumen Haugh unit	73.27 ± 2.32^{a}	66.46 ± 2.42 ^{ab}	65.46 ± 2.21^{b}	0.028

^{a,b} Data that do not share a common letter differ significantly (p < 0.05)

Table 2 shows that eggs from the older flock (73 weeks) were significantly heavier (P < 0.0001) than those from the younger flock (32 weeks). Despite the higher (P < 0.0001) shell surface area of the eggs from the older flock, the shell ratio and shell surface area relative to egg weight were significantly lower (P = 0.0004) than that of the young flock (32 weeks of age). Shell thickness was significantly higher (P = 0.0162) for the older flock eggs but the shell strength was not affected by the age of the breeders. Albumen Haugh unit of eggs from 73- weeks-old breeders was significantly lower (P = 0.005) than that of eggs from 32-weeks-old breeders. The albumen ratio was similar for both age groups. The ratio of yolk weight of the old breeder group was significantly higher than that of the young breeder group (P = 0.0091), but the yolk colour index of the eggs from the 73-weeks-old breeders was lower (P = 0.0254) than that of young breeder flock group.

Table 2. Egg quality parameters in relation to breeder age.

Eiqualitätsparameter in Abhängigkeit vom Elterntieralter.

	Breeder age		
Egg quality parameters	32 Weeks	73 Weeks	P-value
Egg weight (g)	86.02^{b} ± 0.13	101.23^{a} ± 0.32	< 0.0001
Shell ratio (%)	10.89^{a} ± 0.15	10.11^{b} ± 0.08	0.0004
Shell thickness (mm)	0.39^{a} ± 0.01	0.35^{b} ± 0.01	0.0162
Shell strength (kg.cm^{-2})	4.74 ± 0.18	4.04 ± 0.30	NS
Egg surface area (mm^{2})	8874.67^{b} ± 44.08	9979.27^{a} ± 30.58	< 0.0001

Egg quality parameters	Breeder age		P-value
	32 Weeks	73 Weeks	
Egg surface area/egg weight ($mm^2.g^{-1}$)	103.17[a] ± 0.46	98.59[b] ± 0.35	< 0.0001
Albumen ratio (%)	57.08 ± 0.47	55.78 ± 0.46	NS
Albumen Haugh unit	68.07[a] ± 1.39	60.04[b] ± 2.11	0.0059
Yolk ratio (%)	32.03[b] ± 0.50	34.12[a] ± 0.49	0.0091
Yolk colour index	9.26[a] ± 2.11	3.83[b] ± 0.63	0.0254

[a,b] Data that do not share a common letter differ significantly ($p < 0.05$)

Effect of egg weight and the age of the breeder on incubation parameters and day-old duckling weights

Egg weight loss, fertility, hatchability of set eggs, hatchability of fertility eggs, total embryonic mortality, day-old duckling weights, and day-old duckling quality according to egg size are presented in Table 3. Absolute egg weight loss up to the 24th day of incubation in the large group was significantly higher than those of the other groups. In addition, egg weight loss from the medium group was higher than that of the small egg group. However, when converted into percentage loss, the amount of weight loss was similar in all groups. Fertility, total hatchability and hatchability of fertile eggs were similar between the three groups. The highest day-old duckling weight was recorded in the large eggs group compared with the medium and small eggs groups. The lowest day-old duckling weight was recorded in the small eggs group. The number of culled duckling was similar for all groups. Up to day 24 of incubation, the absolute egg weight loss from old breeders was lower than those of young breeders (Table 4). However, relative weight loss was similar for both groups. Fertility ($P = 0.004$), hatchability (of fertile eggs and hatchability of total eggs) ($P = 0.005$) in the young breeders' group were significantly higher than those of the old breeders. The early embryonic mortality rate was similar for both age groups while late mortality ($P = 0.010$) and absolute mortality rate ($P = 0.013$) of embryos of the egg from old duck breeders were significantly higher than those of younger duck breeders. A difference was observed between the percentages of culled ducklings in the two groups. There were more culled ducklings ($P = 0.015$) in the group of the old breeders than those of the young breeders.

Table 3. Effect of duck egg weight on hatching traits.

Einfluss des Gewichts der Entenbruteier auf die Bruteigenschaften.

Hatching traits	Hatching egg weight groups			P-value
	Small	Medium	Large	
		Egg weight loss		
24 days (g)	10.41 ± 0.21[c]	11.12 ± 0.16[b]	11.78 ± 0.18[a]	0.0016
24 days (%)	13.14 ± 0.27	12.83 ± 0.19	12.72 ± 0.19	0.3998
		Hatching characteristics		
Fertility rate (%)	93.06 ± 1.19	91.83 ± 0.01	93.47 ± 0.67	0.4621
Hatchability of set eggs (%)	88.17 ± 1.18	88.17 ± 1.9	88.16 ± 0.45	0.4310
Hatchability of fertile eggs (%)	94.74 ± 0.05	96.01 ± 2.20	94.34 ± 0.36	0.6683
Embryo mortality (%)	5.26 ± 0.48	3.99 ± 1.45	5.67 ± 0.52	0.6683
Culled duckling rate (%)	2.30 ± 1.36	2.32 ± 0.51	5.071 ± 2.26	0.4520
Day-old duckling weight (g)	48.85 ± 0.22[c]	51.84 ± 0.43[b]	58.49 ± 0.61[a]	0.0010

[a,b,c] Data that do not share a common letter differ significantly ($p < 0.05$)

Table 4. Incubation results in relation to breeder age.

Brutparameter in Abhängigkeit vom Elterntieralter.

	Breeder age		
	32 Weeks	73 Weeks	P value
Absolute egg weight loss (g)	$10.77^{b} \pm 0.36$	$12.50^{a} \pm 0.52$	0.0193
Relative egg weight loss (%)	12.50 ± 0.41	12.39 ± 0.52	NS
Fertility (%)	$94.97^{a} \pm 0.53$	$85.19^{b} \pm 1.61$	0.0045
Hatchability of fertile eggs (%)	$96.79^{a} \pm 1.92$	$90.22^{b} \pm 1.01$	0.0387
Hatchability of total eggs (%)	$91.74^{a} \pm 2.08$	$76.3^{b} \pm 1.93$	0.0055
Early embryonic mortality (%)	0.29 ± 0.29	0.34 ± 0.34	NS
Late embryonic mortality (%)	$2.33^{b} \pm 1.05$	$9.45^{a} \pm 1.16$	0.0107
Absolute embryonic mortality (%)	$2.62^{b} \pm 1.34$	$9.78^{a} \pm 1.00$	0.0130
Percentage of culled ducklings (%)	$1.53^{b} \pm 0.82$	$15.63^{a} \pm 3.34$	0.0150

[a,b] Data that do not share a common letter differ significantly ($p < 0.05$)

Egg size and breeders age effect on growth performance

Feed intake, according to egg weight groups during the trial period, is shown in Figure 1. Overall, the feed intake of ducklings of the medium-sized eggs was higher than that of ducklings from large and small egg groups. But, between ducklings of the eggs from the heavy group and small group feed consumption was similar. Weekly body weight according to treatments is presented in Figure 2. Overall, duckling's body weight increased with age. From 1 to 3 weeks of age, body weight was similar between small and medium groups but heavy egg weight was higher. From 3 to 4 weeks of age, body weight was similar between all groups. However, from 5 weeks of age, the body weight of ducklings of the medium sized eggs group started to differ from those of the large and small eggs to become higher in body weight until the end of the experiment.

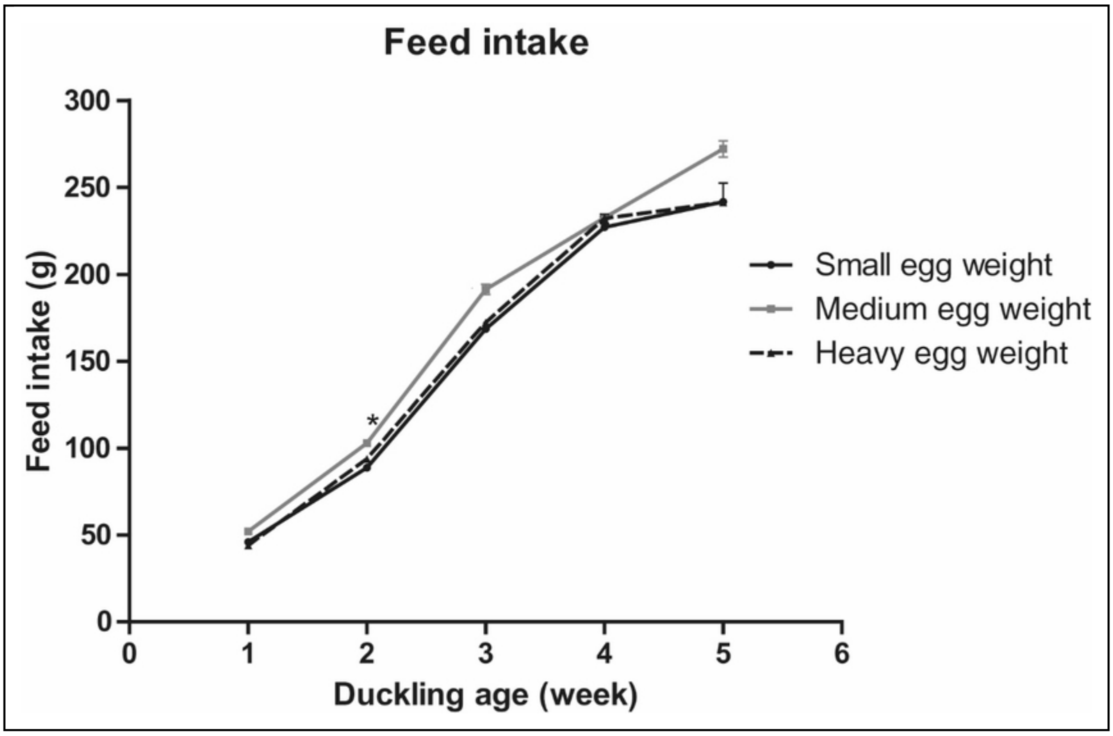


Figure 1. Effect of duck egg weights on the duckling feed intake.

Einfluss des Gewichts der Entenbruteier auf die Futteraufnahme der Entenküken.

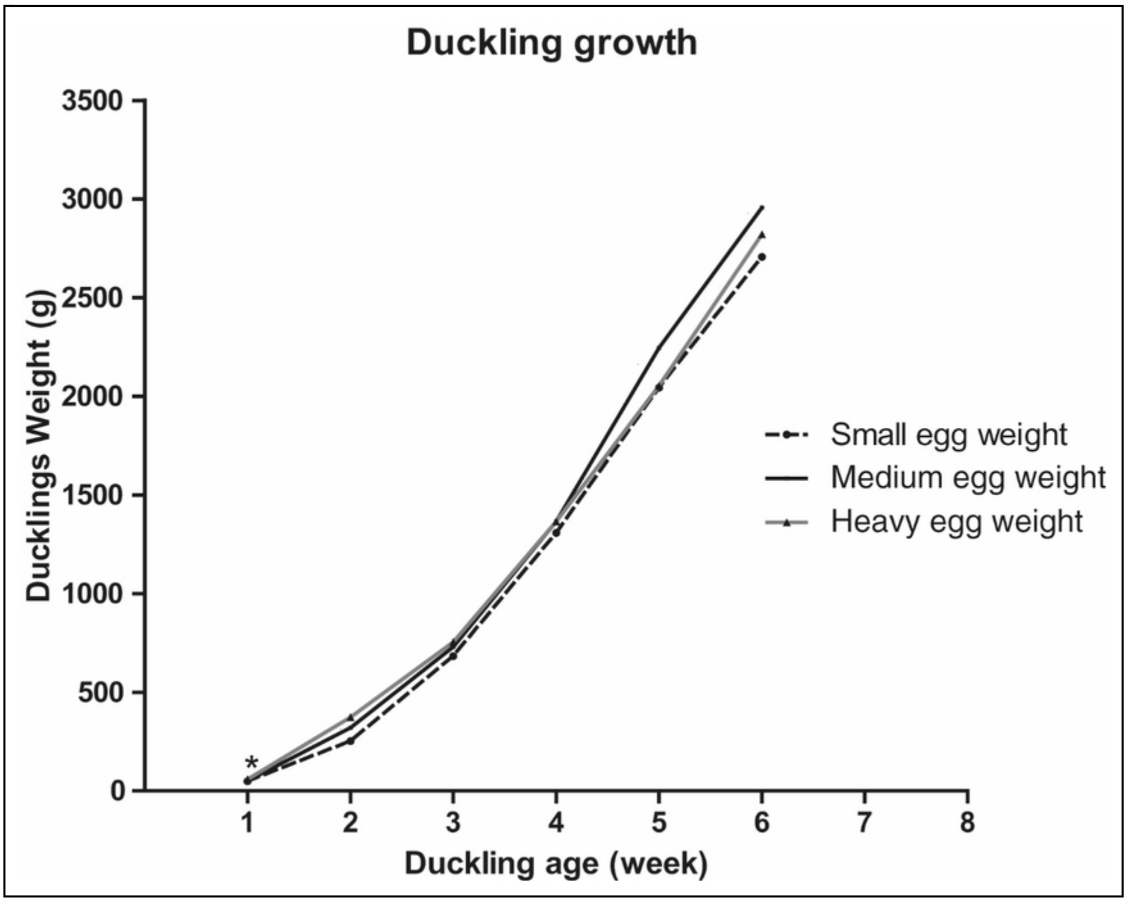


Figure 2. Effect of duck egg weights on the duckling growth.

Einfluss des Gewichts der Entenbruteier auf das Wachstum der Entenküken.

Overall, weekly body weight increased from one to 5 weeks of age. From 1–3 weeks of age, the body weight of ducklings from old duck breeders was heavier than those of ducklings from young duck breeders (Figure 3). But from 4 weeks onward, the body weights of ducklings were similar for all groups. Absolute feed intake and absolute average daily weight gain (Figure 4) were not affected by breeder age.

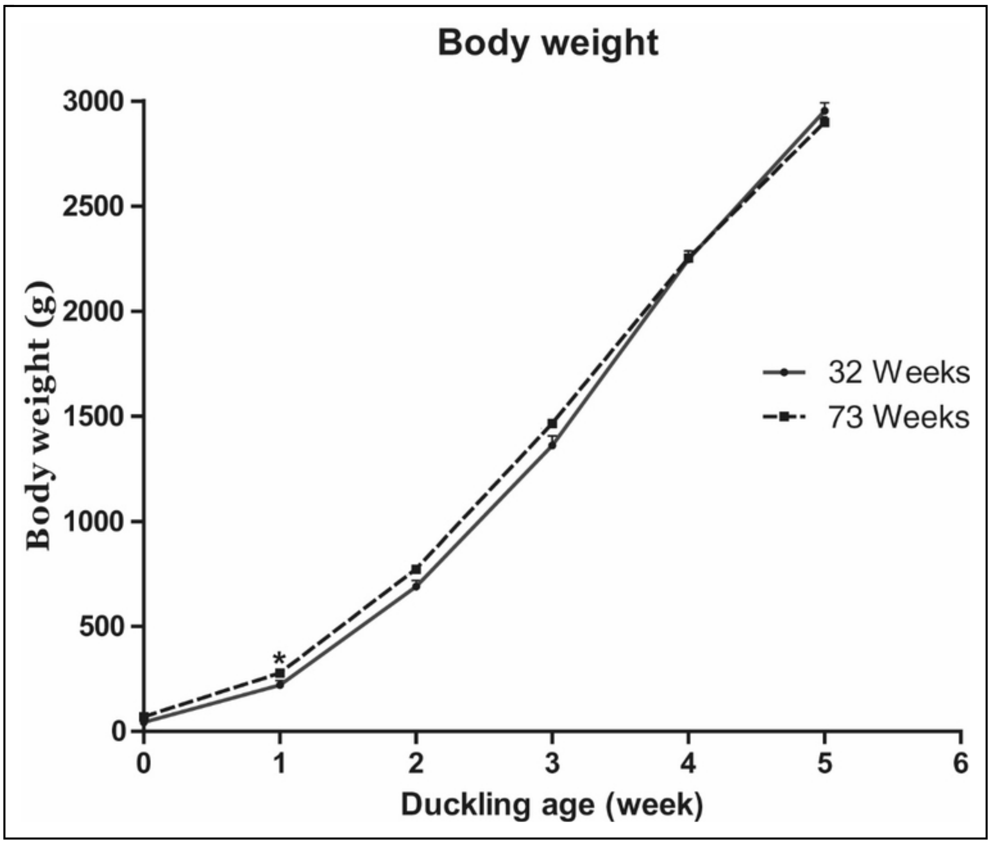


Figure 3. Weekly Body Weight (g) of ducks in relation to breeder age.

Wöchentliches Körpergewicht (g) der Enten in Abhängigkeit vom Elterntieralter.

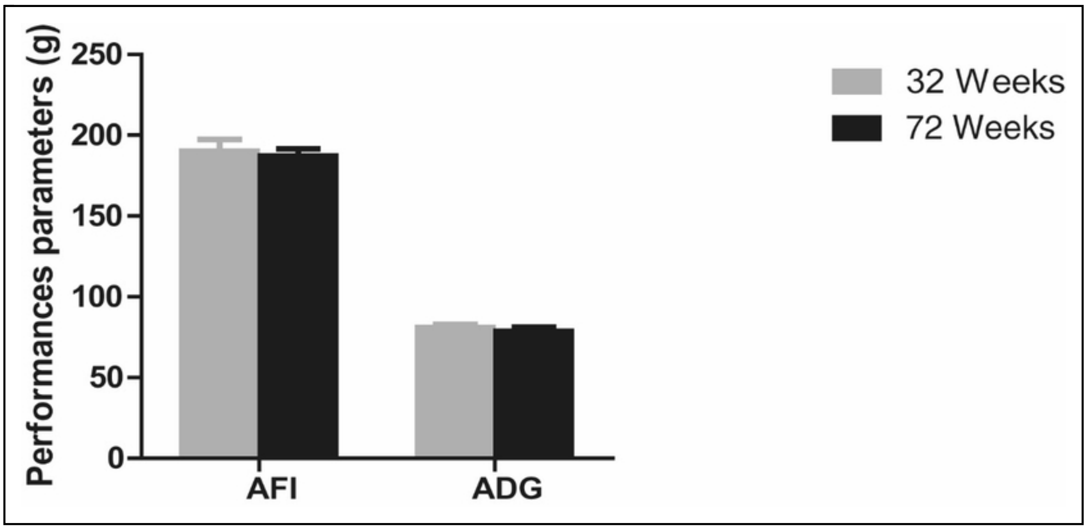
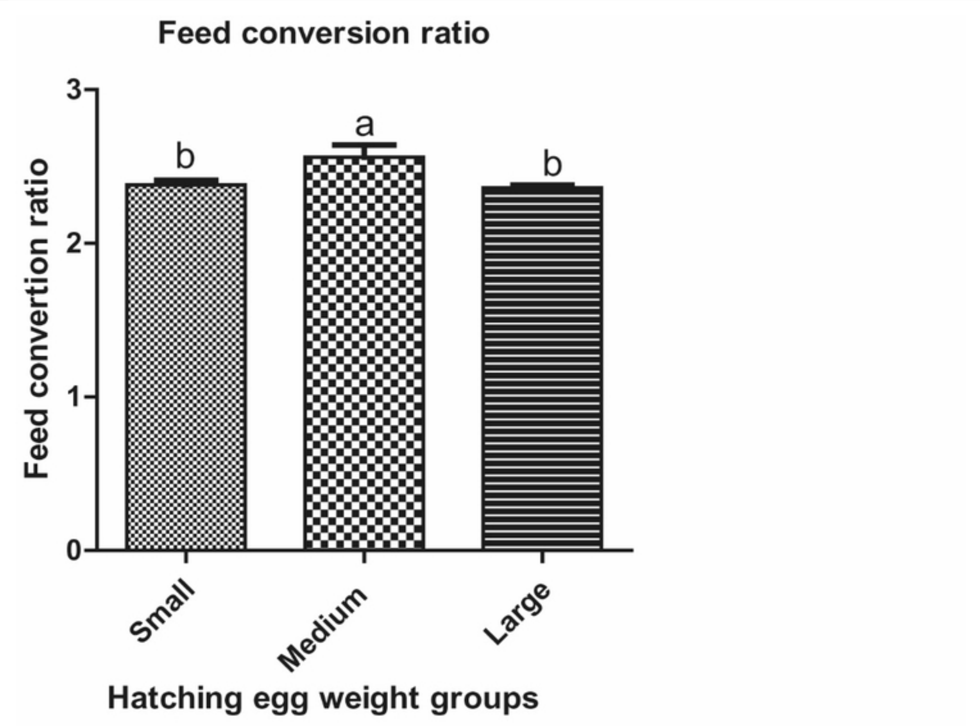


Figure 4. Absolute feed intake (AFI) and absolute average daily weight gain (ADG) in relation to breeder age.

Absolute Futteraufnahme (AFI) und absolute durchschnittliche tägliche Gewichtszunahme (ADG) in Abhängigkeit vom Elterntieralter.

The feed conversion ratio in ducklings from the medium egg weight was higher ($P < 0.05$) than that of medium and heavy egg weight groups (Figure 5). In addition, the absolute feed conversion ratio (Figure 6) was not affected by breeder age. The breeder age had a negative effect on the viability of the ducks during the first three weeks of the rearing period. During this period, the ducklings from the old breeders had the highest ($P = 0.038$) mortality rate (Figure 7) compared to those from the young breeders (5.37% versus 16.48% at the first seven weeks, 1.73% versus 13.67% at the second seven weeks, 0% versus 7.65% at the third seven weeks) respectively for the young and old flock group.

Europ.Poult.Sci., 86. 2022, ISSN 1612-9199, © Verlag Eugen Ulmer, Stuttgart. DOI: 10.1399/eps.2022.365



[a,b] Data that do not share a common letter differ significantly ($p<0.05$)
[a,b] Daten, die keinen gemeinsamen Buchstaben aufweisen unterscheiden sich signifikant ($p<0{,}05$)

Figure 5. Effect of duck egg weights on the duckling feed conversion ratio.

Einfluss des Gewichtes der Enteneier auf die Futterverwertung der Entenküken.

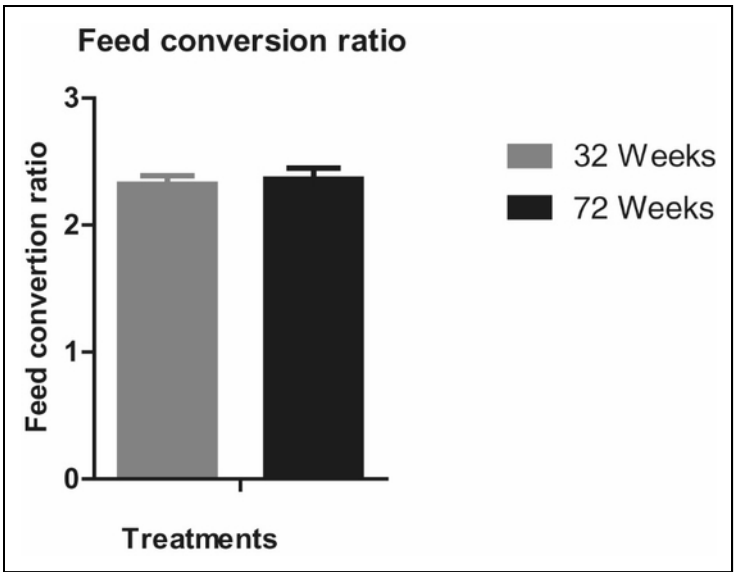


Figure 6. Absolute feed conversion ratio in relation to breeder age.

Absolutes Futterverwertungsverhältnis in Abhängigkeit vom Elterntieralter.

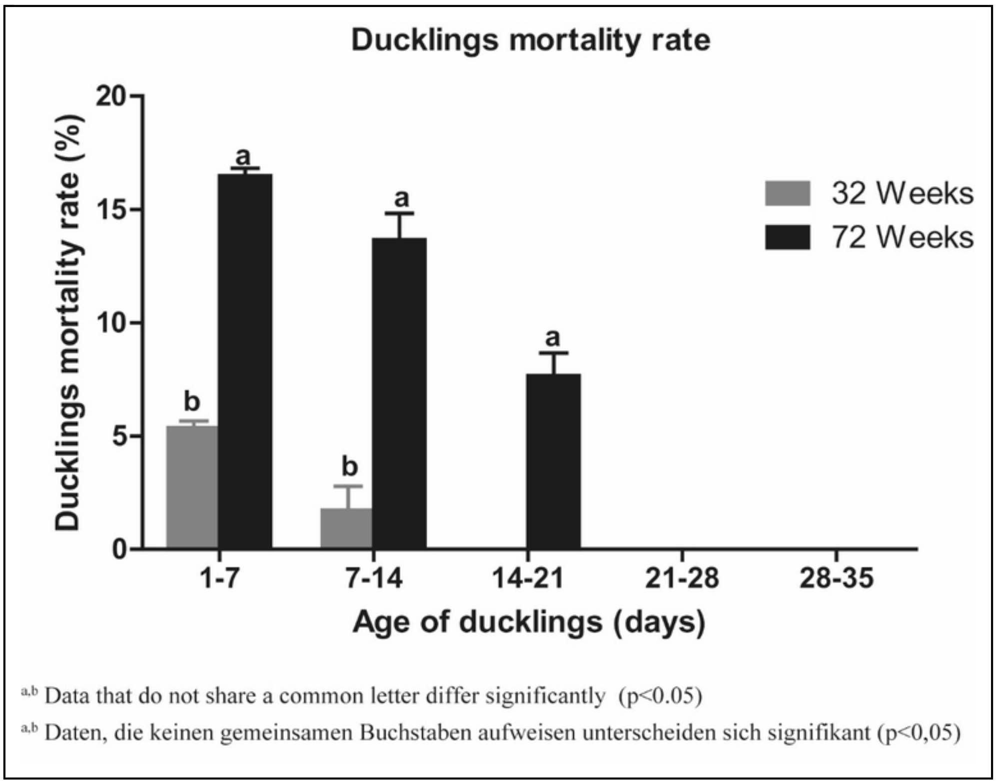


Figure 7. Mortality rate of ducks in relation to breeder age.

Mortalitätsrate der Enten in Abhängigkeit vom Elterntieralter.

Slaughter weight and internal organs weight

The effects of egg weight on slaughter weight and organ weight of Cherry Valley ducks are shown in Table 5. The ducks from the medium eggs size group had a higher slaughter weight (P = 0.0025) relative to the other groups. The slaughter weight of the ducks from the large eggs group was also higher (P = 0.0025) than that of the small eggs size group. However, heart, liver and spleen weights were similar (P > 0.05) among all the groups.

Table 5. Effect of duck egg weight on the duckling slaughter parameters.

Einfluss des Gewichtes der Entenbruteier auf die Schlachtparameter der Entenküken.

	Hatching egg weight groups			
Traits	Small	Medium	Large	P-value
Slaughter weight (g)	2843.33 ± 64.04^{c}	3023.33 ± 21.99^{a}	3003.33 ± 50.20^{b}	0.0025
		Organ relative weight (%)		
Heart	0.52 ± 0.15	0.54 ± 0.12	0.53 ± 0.01	0.0661
Liver	1.75 ± 0.04	1.85 ± 0.04	1.82 ± 0.05	0.0786
Spleen	0.07 ± 0.01	0.07 ± 0.01	0.08 ± 0.01	0.1508

Discussion

Hatching eggs contain all the essential nutrients for the development of the bird during embryogenesis. The amount of nutrients may depend on welfare and nutrition of the breeder. The weight/size of the eggs laid may also dictate the amount of nutrients and the quality of nutrients available for embryonic development and duckling quality. Thus, egg quality and egg weight play a major role in the day-old chick weight quality and potentially post-hatch growth performance (ABANIKANNDA et al., 2007, TONA et al., 2004).

In this study, the egg shape index was similar for all groups. This is consistent with a previous reported study which indicated that duck egg weight had no effect on egg shape index (ETUK et al., 2012). The shell thickness of large eggs was significantly thicker than those of small eggs. Contrary to this study, SUKI and PARK (2001) did not observe a positive correlation between shell thickness and egg size. Albumen is an important marker of internal egg quality parameters and the best reservoir of water and nutrients like protein usually much needed for embryonic growth. The observed albumen ratio between the groups in this study is contrary to that reported by NARUSHIN and ROMANOV (2001) who found a positive correlation between egg weight and albumen ratio. For the yolk ratio, our finding is consistent with that of SUKI and PARK (2001) who noted that the egg yolk weight of small eggs was less than that of large egg hens.

The breeder age affected egg quality. In general, hatching egg weight and quality depends on breeder age to great extent. Several studies have shown that avian egg weight follows a curvilinear function with breeder age (FRENCH and TULLETT, 1991; EL-HANOUN et al., 2012; IPEK and SOZCU, 2015). Our results indicated an increase in weight but reduced internal and external quality of eggs from 73-weeks-old breeders compared to those from the young breeders (32 weeks). The increase in the yolk to albumen ratio may be related to the decreased number of follicles to reach the final stage of rapid growth (JOHNSON, 2000). Because fewer follicles receive a proportionally greater amount of yolk constituents, yolk size increased more rapidly than the albumen. This leads to a decrease in the albumen ratio and therefore an increase in the yolk-to-albumen ratio. Yolk colour is influenced by carotenoids (SURAI et al., 1999). These pigments are deposited in eggs to provide antioxidant protection to chicks during embryogenesis and at hatching time, which is a period of high oxidative stress (SURAI and SPEAKE, 1998). The reduction of yolk colouration in eggs from a 73-weeks- old breeder may therefore be linked to carotenoid deficiency and would have made the embryo more vulnerable to oxidative stress. This may partly explain the high embryonic mortality rate observed in the old breeders' group. Since the shell is composed of calcium and carbonate, the decrease in its ratio and thickness is related to a decrease in intestinal absorption of calcium in old breeders as shown by AL-BATSHAN et al. (1994) and/or a decrease in carbonic anhydrase activity in the shell gland of old breeders (PEREK and SNAPIR, 1970).

The results of the present study partly confirm the observations of ONBASILAR et al. (2014) who also obtained similar results for egg weight, yolk-to-albumen ratio, shell thickness and shell hardness in Peking duck eggs. However, contrary to our observations, the authors did not report any effect of breeder age on eggshell ratio and the albumen Haugh unit. These contradictions could be attributed to the different duck strains used. However, our results corroborate those of TONA et al. (2004) who recorded a low Haugh unit value for eggs from 45-week-old Cobb breeders compared to 35-week-old.

The results of the present study showed that absolute egg weight loss (in grams) increased with increasing egg weight but there were no differences in percent egg weight losses between the egg weight groups. These results disagree with the findings of ABIOLA (2008) who reported higher absolute egg weight loss in medium weight eggs of broiler chickens. Many other reports are, however, in congruence with our trend of absolute weight loss (KIRIKÇI et al., 2006; REIS et al., 1997). It is also consistent with the trend of percent loss of weight by eggs during incubation with chicken eggs as a weight loss equivalent to 12–15% is lost during incubation (ÇAĞLAYAN et al., 2009). The weight loss in this study falls within that level without variation, notwithstanding the size of the eggs. This suggests that the 3 categories of eggs used in this study probably had an equal proportion of pore areas and pore diameter regardless of the size of the egg (ABIOLA et al., 2008).

Our results showed that the fertility of the eggs was comparable in all groups. Similarly, TOPLU et al. (2007) reported that egg size had no effect on egg fertility.

The hatchability percent was not influenced by egg weight, which disagrees with the finding of ABIOLA et al. (2008) which showed a positive correlation between egg weight and hatchability. In addition, SEKER et al. (2005) also pointed out that large egg weight categories had a higher hatchability percentage in Japanese quail. This higher hatchability was attributed to more sufficient nutrients to support embryonic growth compared to those of the small weight eggs.

The results of this study showed that the percentage of culled ducklings was similar for all groups. This finding is in contrast with that of JAVID et al. (2017) who reported that large eggs had the highest percentage of culled chicks. Chick weight is one of the most widely used indicators for day-old chick quality assessment (DECUYPERE et al., 2002). There is significant interaction between poultry egg weights, hatching results and offspring performance. Results of the present study demonstrated that egg weight and day-old ducklings from large eggs were heavier compared with the small eggs size group. A positive correlation exists between egg weights in broiler chicken (Tona et al., 2004). The current result on ducklings affirms this assertion.

Egg weight loss during incubation was significantly higher in 73-week-old breeder's eggs, but the relative weight loss was not affected by breeder age. These results indicate that the susceptibility of eggs to lose weight during incubation increases with breeder age. This result is consistent with Javid et al. (2014) in broiler breeders. This could be explained by the associated increase in egg weight with breeder age, as larger eggs have less shell surface area and low shell thickness than eggs from old breeders.

However, the rate of weight loss per gram of egg decreases with eggs from old breeders. This could be explained by the shell surface area that was raised in old breeders and its thickness (Reis et al., 1997), as well as its relative area per gram of eggs that, was low in this group. The large shell surface area and the low shell thickness of eggs from old breeders observed in this study would increase the water conductance of the whole egg. The discharge of water is a result of the alteration of albumen and low shell thickness with subsequent passage of water through the eggshell due to breeders' age (Zakaria et al., 2009). However, since the shell area available per gram of egg is smaller in these eggs, the weight loss that would have induced the small thickness and the large surface of the shell would be buffered. This could explain the similarity between relative weight losses in both age groups. In addition, other egg quality parameters, such as the number of age-related pores, can also influence absolute and relative weight loss (Tona et al., 2001).

Our results showed that low fertility, low total hatchability of eggs and hatchability of fertile eggs was recorded in eggs from the older breeder ducks at the age of 73 weeks. These results are in line with the findings of El-Hanoun et al. (2012), who found a decrease in total and fertile hatchability of eggs from Beijing Duck breeders aged 56 to 65 weeks compared to those from breeders aged 36 to 65 weeks.

Similarly, our results showed a reduction in the fertile and total hatchability in the 73-week-old breeder group as a result of an increase in the late embryonic mortality in this group. The result is further supported by Tona et al. (2001) who reported that the lowest hatchability and highest rate of embryo mortality were recorded in older breeder flocks. In a previous report (El-Safty, 2012), higher infertility and higher total embryo mortality of eggs laid by older breeders resulted in a lower hatching percentage, especially after 45 weeks of age.

This increase in late embryonic mortality can be linked to oxidative stress and the increase in egg weight in this group. Indeed, according to Deeming (1996), larger eggs, because of their size, do not allow an optimum rate of ventilation but produce more heat at the end of the incubation. In addition, Nangsuay et al. (2013) showed an increase in heat production for eggs of the same weight from parents of different ages. These authors indicate that the increase in heat production of the embryo at the end of incubation is not only related to the weight of the egg, but is also a direct effect of the age of the parents. The combined effects of low ventilation and high heat production could therefore have led to an increase in embryo mortality in response to an increase in embryo temperature as demonstrated by Deeming (1996). The result of the present study in both ages of duck breeders indicates that the percentage of abnormal ducklings was high in the 73-week-old group. These results agree with those of Tona et al. (2004) who reported that the percentage of chicks of low quality obtained from older breeders was higher than from young breeders. This could be due to the deterioration of albumen quality (Tona et al., 2004) and increased yolk cholesterol content (Dikmen and Sahan, 2007). Our results further clarify how the age of the breeder influence eggs weight and day-old duckling weight. We found that day-old ducklings from an older breeder were heavier than those from young breeders. The increase in the hatchling weight of ducklings from older breeders could be attributed to the difference in the egg weight. Eggs from 73-weeks-old breeders were heavier and resulted in heavier ducklings. There is a positive correlation between egg weight and day-old duckling weight from older duck breeders in this study with previous reports (Wilson, 1991; Tona et al., 2004). The hatchling weight in avian species is around 60–70% of the hatching egg weight (Nelson et al., 1992).

The feed intake of duckling of the egg from the medium group was higher than those of eggs from the large and small groups. It has been reported that feed intake is not influenced by egg size (Ulmer-Franco et al., 2010). Similarly, a previous study also pointed out that egg weight did not influence broiler feed intake (Vieira and Moran, 1998). In the present study, the growth of ducklings in the first 2 weeks was correlated with egg size, however by the 3rd week, the influence of egg size disappeared. These results are in line with the findings of Tufft and Jensen (1991) who found a correlation between egg size and the growth of chick. The authors also indicated that the growth of chicks from large eggs diminishes with the increasing age of the chick. Results of the current study indicated that the feed conversion ratio in the medium egg weight group was higher than that of the small and large egg weight groups and that body weight growth was higher in ducks from the medium-sized eggs. Similar was the slaughter weight. These results disagree with the findings of ULMER-FRANCO et al. (2010) who indicated that feed efficiency in broilers was not affected by egg size. The present study complies with DUMAN and ŞEKEROĞLU (2017) who noticed that there is a significant effect of egg size on slaughter weight but the basis of the trend of influence is not clear.

The rapid growth of ducklings from older breeders can be related to the high yolk ratio of eggs in this group which is likely to lead to a larger yolk sac as shown by SHANAWANY (1987). Yolk sac is an important source of nutrients during the first week of rearing. In addition, ALI et al. (2007) showed a reduction in growth rate in the first week of age in chicks without yolk sacs compared to chicks whose yolk sacs were not removed followed by compensatory growth after the first week. The results of our study also showed an increase in average daily weight gain of ducklings from young breeders after 3 weeks of rearing so that at the fourth week, the live body weights in both groups were similar and this remained statistically identical until the slaughter age. The live body weight of ducks at slaughter was therefore not affected by breeder age. These results are in part comparable to those obtained by EL-HANOUN et al. (2012) in Beijing ducks. In agreement with the observations reported by ONBAŞILAR et al. (2008) in broiler chickens, our results showed no effect of breeder age on feed intake and absolute feed conversion ratio.

In the current study, mortality during rearing was affected by breeder age. The negative effect of breeder age on the survivability of ducklings during the early rearing period agrees with YALCIN et al. (2008) who observed higher mortality of chicks from old breeders. The high mortality observed in this study in the old flock group could be due to an alteration of maternal immunity in these birds. Indeed, studies conducted by BARUA et al. (2000) showed a decrease in the immunoglobulin Y (IgY) level in the yolk of eggs from old breeders. In female poultry breeders, the immunoglobulin G (IgG) from the blood is transferred into the egg yolk. IgG in the yolk is often named IgY.

Conclusion

It was concluded that all egg weight groups were found to favor hatchability, but fertility and total hatchability were not affected by egg size. Egg size improved the duckling weight and did not influence the duckling yield. However, the ducks of medium weight eggs had better carcass slaughter weight. This current study further clarifies how the age of the breeder duck affects the quality of incubating egg quality, the incubation parameters, the day-old duckling quality and their growth potential. Furthermore, results on influence of breeder age indicate that the quality of incubating eggs, fertility, and hatchability rate of the duck flock was decreased with increasing age of the breeder duck. However, embryonic mortality, percentage of culled ducklings and mortality rate during rearing were increased with advancing age of the breeder ducks. But post-hatch growth performance of ducklings decreased with increasing breeder age. Therefore, it was recommended that medium weight eggs are preferable for hatching purposes. Further studies on egg storage duration would be valuable to understand the interactive effect egg storage duration and Chery Valley duck breeder age on egg internal quality, hatching parameter and post-hatch performance of ducklings.

Acknowledgement

The study was supported by Shandong Agricultural University and CERSA (Regional Excellence Center on Poultry Sciences) of the University of Lome (Togo). The authors express warm gratitude to World Bank IDA 5424 which is the main sponsor of CERSA.

Author’s contributions

D. Nideou: Experimental design, data collection, analysis and interpretation, drafting of the article.

K. Kouwonou: Assistance for data collection.

A. Midodzi: Assistance for data collection.

Y. A. E. Kouame,: critical revision of the manuscript.

O. Onagbesan: Language and critical revision of the manuscript.

H. Lin: Supervision and approval of experimental design, critical revision of the manuscript.

K. Tona: Supervision, approval of the experimental design, critical revision of the manuscript and final approval of the version to be published.

Conflict of interest

The authors declare no competing interests.

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