Journal of Poultry Research 15(2): 16-22, 2018
Print ISSN:1302-3209 - Online ISSN:2147-9003
www.turkishpoultryscience.com
Research Article

Effect of Egg Weight on post-Hatch Performance of White Leghorn Chicken Breed from Day-old to Laying Age

Kebede Senbeta Ewonetu*, Asefa Kasaye

ABSTRACT: The objective of the present study was to determine the effect of egg weight on hatchability, body weight, body weight gain, feed intake, feed efficiency, mortality, hen day egg production and egg weight. Hatching eggs (576) from a White Leghorn breeder flock were obtained at the age of 36 weeks and purposively divided into 3 egg-weight categories, namely small, medium, and large sizes having weights 44.26±0.21g, 50.39±0.11g, and 55.39±0.23g, respectively. Each egg group randomly further divided into three replicates each contained of 64 eggs in a completely randomized design. Eggs were incubated and hatched chicks were individually counted and weighed to determine the hatchability. Chicks hatched from similar egg size were grouped according to their initial treatment and replication. The male and female chicks were intensively raised together for 8 weeks and then only female birds maintained in the experimental conditions for fifty weeks. Data were summarized using the General Linear Model of SAS and the means were separated using Fisher's LSD test. This study showed that egg sizes had significantly influenced ($p<0.0001$) all parameters measured during the experimental periods. However, birds hatched from large sized eggs were suitable for better hatchling weight, survival, hen day egg production and egg weight whereas chickens hatched from small egg sizes were relatively better for hatchability, feed efficiency during growing stage and between 40-50 weeks. Chickens hatched from medium egg sizes were principally better for weight gain during brooder and grower stages with minimum feed efficiency. In conclusion; egg weight significantly effected the overall characteristics of chickens from day old to 50 weeks of age and the effect of egg weight only diminish for mortality after brooder stage.

Keywords: Age, Chicken, Egg weight, Egg size, White leghorn

Received: 25.04.2018 **Accepted:** 07.09.2018

INTRODUCTION

Egg weight and chick weight at hatching are positively related (1). Many agree that it is preferable to have eggs of medium weight to achieve good hatchability as far as chicken, turkey, ducks and ostriches are concerned (2-3). There are many factors which influence hatchability of eggs and these include storage time (4), fertility, temperature, relative humidity, ventilation, position of the egg, turning of the egg, candling and feed variation (5). Other factors that affect hatchability of a breeding hen include genetic constitution of the embryo, disease, egg size, age and shell quality (6). Some researchers reported that performance in chickens in terms of hatchability and chick hatch-weight may be closely related to the weight of the eggs because the main effect of egg size lies in the mass of the residual yolk sac that the chick retains at hatching (6, 7, 8). Wondmeneh et al. (9) showed that breed had a significant effect on the hatchability and weights of the day-old chicks whereas Islam et al. (10) reported that breed have little effect on the hatchability and fertility. The performance potentiality of the chicken depends, in part, on egg quality which is an important parameter for embryogenesis as well as for one-day old chick quality and growth (4). Improved quality of day-old chicks as starting material ensures greater survivability and better growth potential during the first days or first week of life (11). Alabi et al. (12) reported the effect of egg weight on hatchability and subsequent performance of white leghorn chicks from one to seven weeks of age and found that eggs weight influenced all parameters measured except the mortality rate. The study conducted by Ewonetu (4) on Fayoumi Chicken for eight weeks reported that medium-sized eggs were better in hatchability and feed efficiency whereas large sized eggs for better hatchling weight, weight gain and survivability. The effect of egg size on hatchability and subsequent growth performance of chicks from day old to seven or eight weeks of age were extensively studied and reported by many scholars. However; there is a little research information evaluated the effects of egg size on chick post-hatch growth performance and egg production later than brooder and grower age, therefore; this study is designed to evaluate the effect of egg size on post-hatch performance from day-old to laying age of White Leghorn breed.

MATERIALS and METHODS

Study Area

The experiment was conducted at the poultry farm of Haramaya University, located at 505 km east of Addis Ababa. The site is situated at an altitude of 1980 meter above sea level, 9° 26 ' N latitude and 42° 3' E longitude. The area has an average annual rainfall of 741.6 mm. The mean annual minimum and maximum temperatures are 8.25°C and 23.4°C, respectively.

Experimental Egg Collection and Selection

A total of five hundred and seventy six hatching eggs of different sizes from White Leghorn breed were used from Haramaya University Poultry Farm. The eggs were selected based on shape, free of shell cracks and stored in cold room for three days until the required amounts were obtained. The eggs were individually weighed, marked and purposively arranged into three groups of small (40.00 - 46.99g), medium (47.00-53.99g) and large (54.00 - 60.00g). Each treatment group contained one hundred ninety two eggs which were randomly sub-divided into three replicates of sixty four eggs in a completely randomized design (CRD).

[1]School of Animal and Range Sciences, College of Agriculture and Environmental Sciences, Haramaya University, Dire Dawa, Ethiopia
*Corresponding Author: Kebede Senbeta Ewonetu, e-mail: ewonetu2011@gmail.com

Egg Incubation and its Managements

Eggs were individually placed into a tray with the broad ends pointing upwards and incubated at 37.5°C and 70% relative humidity for eighteen days. On the 18th day of incubation, the eggs were transferred at once into the same hatchery and incubated for three days at 36.0°C and 80% relative humidity. The day old chicks hatched on the same day were counted, weighed on a sensitive balance and the percentage hatchability was calculated using the formulas described by Sahin et al. (13).

Management of Experimental Birds

In the second part of study, all normal chicks hatched from each treatment were used for subsequent growth trial. Pens, watering and feeding troughs were thoroughly cleaned, disinfected and sprayed before placing the experimental chicks in the pen. Chicks hatched from similar egg size were grouped in to the same treatment, and the chicks were intensively raised on deep litter system for fifty weeks. The litter materials used was wood shavings and saw dust. On the first day of hatching, chicks were provided water with vitamin premix (15 gm vitamin premix in 10 litter water). On the second day of hatching, the birds were vaccinated against new castle disease and medications were provided using broad spectrum antibiotics. The birds in each treatment were reared on same diet composed of ground corn, soybean meal, peanut meal, wheat short, salt, limestone and vitamin premix, but the proportion of the diet formulated for different stages (brooder, pullet and layer) were different. Feed and water were given to the birds *ad libitum.*

Body Weight Measurements

The body weight were taken at hatching and recorded as initial weight then the average body weight was measured every fourteen days by weighing the chicks in each pen and the total weight was divided by the total number of birds in each pen. These body weights were used to calculate growth rate. The overall average body weight for each treatment was then computed by taking the average values for the replication.

Feed Intake and Feed Efficiency

A weighed amount of feed was offered once daily at 08:00 am every day and refusal was collected the next morning and weighed. The feed offered and refused were recorded for each replicate. The amount of feed consumed was determined as the difference between the feed offered and refused. Feed conversion ratio is measured by dividing feed consumed into live weight gain within two consecutive weeks.

Egg Production and Egg Weight

Egg weight was measured individually every day for each group using electronic weighing balance and average was taken for two weeks. The mean daily egg production was recorded every two weeks for each experimental unit by using following formula:

$$\text{MHDEP}=\frac{\text{Number of egg produced on each day}}{\text{Number of hens alive on each day}}\times 100$$

MHDEP: Mean Hen Day Egg production (%)

Mortality

Mortality was recorded daily during the study. Deaths after the onset of the experiment were recorded as mortality and expressed as percent mortality at the end of the experiment.

Statistical Analysis

Effects of egg weight on hatchability, hatchling weight and subsequent growth performances and egg production of the birds were analysed using the general linear model procedure of the statistical analysis system (SAS). A P-value of <0.05 was considered for significant differences among groups, and the comparison of means was made by using Fisher's LSD test. The statistical model used was: $Yijk=\mu + Ti + \sum ijk$, Where, Yijk is the overall observation (hatchability, body weight, weight gain, mortality, egg production), Ti is effect of different egg weights (small, medium and large), $\sum ijk$ is residual effects.

RESULTS and DISCUSION

There is a significant difference among the egg weight incubated to determine post-hatch performances and it had also significant effect on hatchability (Table 1). The small size eggs were better in hatchability compared to medium and large size eggs, which was in contrast to the findings reported (4, 12, 14), the medium size eggs of chickens have higher hatchability while (15, 16) recorded higher hatchability for large eggs in New Hampshire, Red Rhode Island, and indigenous Venda chicken breeds. Farooq et al. (17) found negative correlations between egg weight and hatchability in crossbred chickens that is heavier eggs resulted in lower hatchability. In contrary to this study finding, Wilson (18) also reported that large-sized eggs had a higher hatchability value than medium and small-sized eggs. These inconsistent results may be due to certain factors like breed (9), age of flock, or incubation conditions.

Egg weight influenced the post-hatch weight of chicken throughout the rearing periods (Table 1). Similarly, Alabi et al. (12) reported the effect of egg weight on subsequent weight performance of White Leghorn chickens from one to seven weeks of age. This study reported that small chicks were hatched from small eggs while large chicks hatched from large eggs which is in agreement with the reports of (19) for Japanese quail, (20) for rock partridges, (21) for chicken and (22) for geese and they indicated in their study as the day old (hatchling) weight has function of egg weight regardless of strain difference. Javid et al. (23) also reported as egg size had a significant effect on chick weight in his study conducted on broiler breeder. Chicks hatched out from the heavy eggs have greater day old weight which is consistent to Ulmer-Franco et al. (24) and this 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. Similarly, Caglayan and Inlal (25) observed that chick weight increased with the increasing egg weight. Egg weight and chick weight at hatching are positively related as reported by Khurshid et al. (1). Ramaphala and Mbajiorgu (26) also indicated that large-size eggs produced chicks with higher chick hatch-weight than medium and small sized eggs. A heavier chick from heavier eggs is a result of more yolk attachment at hatching (14, 27) and also known that heavier eggs contain more nutrients than small or medium sized eggs

(4). Wondmeneh et al. (9) also reported as breed had a significant effect on weight of the day-old chicks. The current results suggest selection of hatching eggs of proper size to produce quality chicks of better hatchling weight. The first twenty weeks, chicks hatched from medium sized eggs had higher average live weight whereas from twenty to thirty weeks chicks hatched from large sized eggs had possessed higher weight (Table 1). However, the chicks hatched from the small-sized eggs attained numerically maximum weight at 40 and 50 weeks of age period compared to medium and large-sized eggs. This implied that chickens hatched from small egg sizes late to achieve their growth maturity. In this study, the average live weight of chicks hatched from medium sized eggs was heaviest during brooding and growing phase (1-20 weeks) than chicks hatched from the other group which is in contrast to Abiola et al. (28), who reported heavier body weight for chicks hatched from big size-egg from one to seven weeks of age. Besides, the study conducted by Ewonetu (4) on Fayoumi Chicken for eight weeks reported that birds hatched from large-sized eggs were better in live weight than those hatched from medium and small sized eggs all over the brooding periods. Contrary to this study, Ramaphala and Mbajiorgu (26) reported that as the yolk attachment is utilized by the chick after hatching and the potential performance of day-old chicks may depend on the quality and quantity of this yolk. As cited by Jiang and Yang (29), many researchers have shown that day-old chick weight is an important factor affecting brooder performances and similar conclusion was also obtained by Hartmann et al. (30) in a White Leghorn. However, some studies have found that the advantage of chick weight at hatch diminishes rapidly after hatching (29). The increase in body weight represents growth and development of farm animals (31). The chicken weight increased with advancing of age (Figure 1) which is consistent to the study reported by (32, 33).

As reported by Egbeyale et al. (34), egg size had significant effect on the means of day old weight. This finding approved that egg weight has a significant impact on live weight of chickens throughout the brooder, grower and layer stages. Chicks hatched from medium sized eggs had gain better body weight during brooder and grower stages whereas chicks hatched from small sized eggs were gain better body weight from week 20-30 (Table 1). In agreement to this study, Ewonetu (4) reported the significant effect of egg weight on post-hatch body weight gain performance of Fayoumi Chickens and better weight gain for chickens hatched from medium sized eggs during the brooder stage. Similarly, Egbeyale et al. (34) reported as egg size had significant effect on daily weight gain. This study is not in agreement with Ng'ambi et al. (35), reported that the performance of Potchefstroom Koekoek chicks (1 to 7 week of age) hatched from large-sized eggs had higher daily live weight gain than those hatched from medium and small-sized eggs.

Table 1. Effect of egg size on post-hatch performances of White Leghorn (mean ± SE)

Parameters	Age (Weeks)	Egg size			P value
		Small	Medium	Large	
Incubated egg weight (g)	-	44.26±0.21^{c}	50.39±0.11^{b}	55.39±0.23^{a}	<0.0001
Hatchability (%)	-	72.92±0.32^{a}	65.63±0.23^{c}	72.40±0.18^{b}	<0.0001
Body weight (g/bird)	Day-old	30.02±0.08^{c}	34.07±0.11^{b}	36.34±0.33^{a}	<0.0001
	10	257.9±0.41^{c}	330.80±0.39^{a}	305.80+0.57^{b}	<0.0001
	20	620.0±0.09^{b}	654.17±0.12^{a}	604.35±0.03^{c}	<0.0001
	30	1004.0±0.32^{c}	1020.0±0.61^{b}	1044.0±0.19^{a}	<0.0001
	40	1161.0±0.51^{a}	1092.0±0.28^{c}	1158.0±0.29^{b}	<0.0001
	50	1166.0±0.43^{a}	1159.63±0.36^{b}	1102.12±0.27^{c}	<0.0001
Body weight gain (g/bird)	0-10	45.57±0.14^{c}	59.35± 0.09^{a}	53.9±0.11^{b}	<0.0001
	10-20	78.59±^{b}0.01	81.52± 0.05^{a}	76.47±0.24^{c}	<0.0001
	20-30	61.29± 0.24^{a}	45.57± 0.31^{c}	50.4±0.31^{b}	<0.0001
	30-40	13.69± 0.35^{a}	1.08± 0.40^{c}	5.39±0.30^{b}	<0.0001
	40-50	1.12±0.19^{b}	2.0±0.22 ^{a}	0.28±0.18^{c}	<0.0001
Feed intake (g/bird)	0-10	44.01±0.33^{c}	49.91±0.34^{b}	51.56±0.26^{a}	<0.0001
	10-20	89.40±0.42^{c}	98.30±0.61^{b}	106.6±0.47^{a}	<0.0001
	20-30	114.60±0.04^{c}	127.80±0.062^{b}	133.10±0.05^{a}	<0.0001
	30-40	141.20±0.17^{c}	145.50±0.19^{b}	150.10±0.16^{a}	<0.0001
	40-50	187.5±0.06^{c}	194.5±0.20^{b}	205.4±0.31^{a}	<0.0001
Feed efficiency (g/bird)	0-10	0.56±0.01^{a}	0.41±0.03^{c}	0.50±0.06^{b}	<0.0001
	10-20	1.20±0.07^{c}	1.38±0.04^{b}	1.52±0.02^{a}	<0.0001
	20-30	0.83±0.08^{c}	2.42±0.06^{a}	1.13±0.05^{b}	<0.0001
	30-40	4.92±0.13^{a}	1.35±0.09^{b}	1.07±0.14^{c}	<0.0001
	40-50	3.37±0.04^{c}	9.92±0.02^{a}	4.21±0.07^{b}	<0.0001
Mortality (%)	0-10	5.22±0.07^{a}	3.93±0.10^{b}	2.09±0.21^{c}	<0.0001
	10-20	1.14±0.03^{a}	0.79±0.11^{b}	0.00+0.00^{c}	<0.0001
Hen-day egg production (HDEP) (%)	22-30	40.89±0.32^{c}	49.86±0.41^{b}	53.59±0.44^{a}	<0.0001
	30-40	69.73±0.14^{c}	74.12±0.24^{b}	74.84±0.17^{a}	<0.0001
	40-50	84.44±0.08^{c}	85.73±0.15^{b}	86.59±0.11^{a}	<0.0001
Egg weight (g)	22-30	48.77±0.06^{c}	50.18±0.13^{b}	53.64±0.21^{a}	<0.0001
	30-40	51.53±0.20^{c}	52.95±0.14^{b}	55.57±0.19^{a}	<0.0001
	40-50	53.05±0.31^{c}	55.57±0.22^{b}	58.38±0.16^{a}	<0.0001

^{abc}, Means with the same letter are not significantly different.

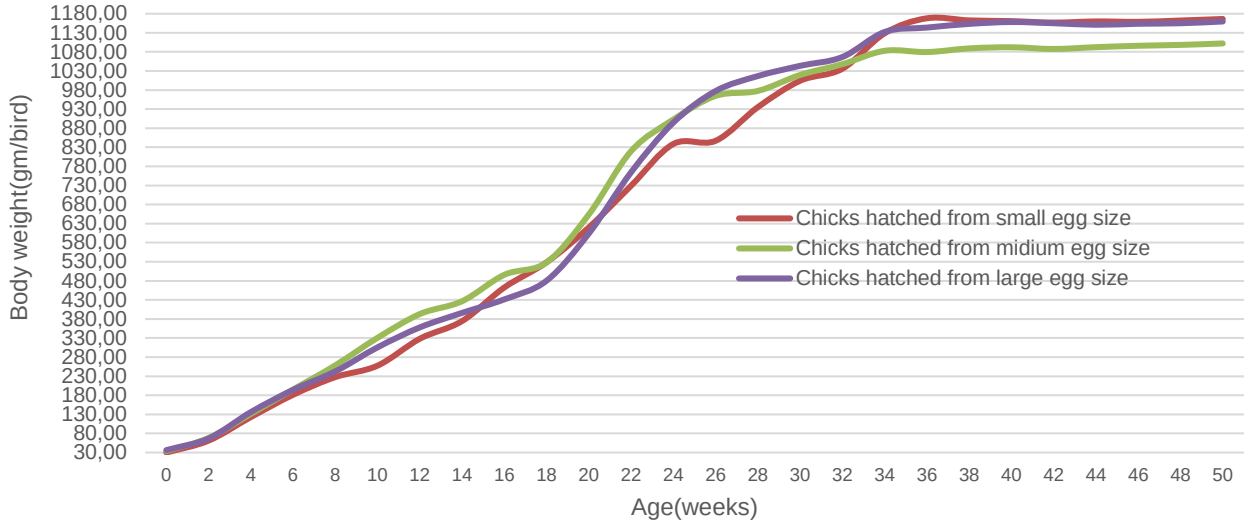

Figure 1. Effect of egg size on body weight performance

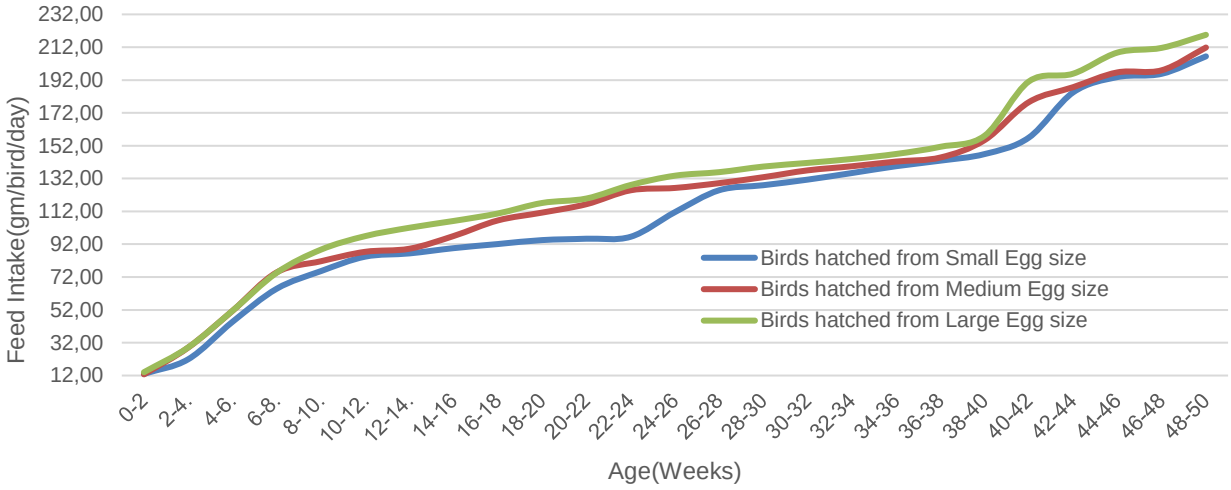

Figure 2. Effect of egg size on feed intake

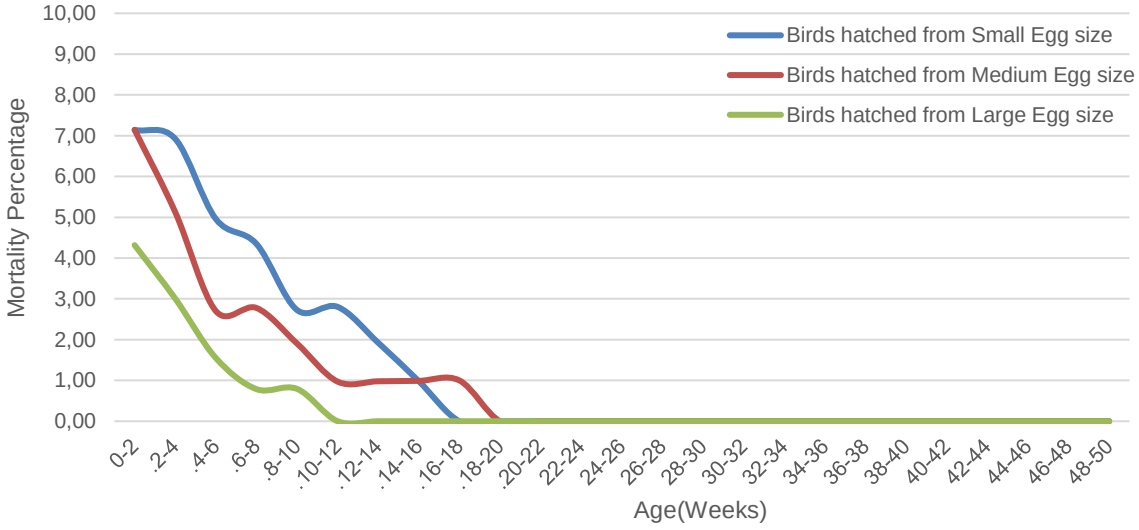

Figure 3. Effect of egg size on mortality

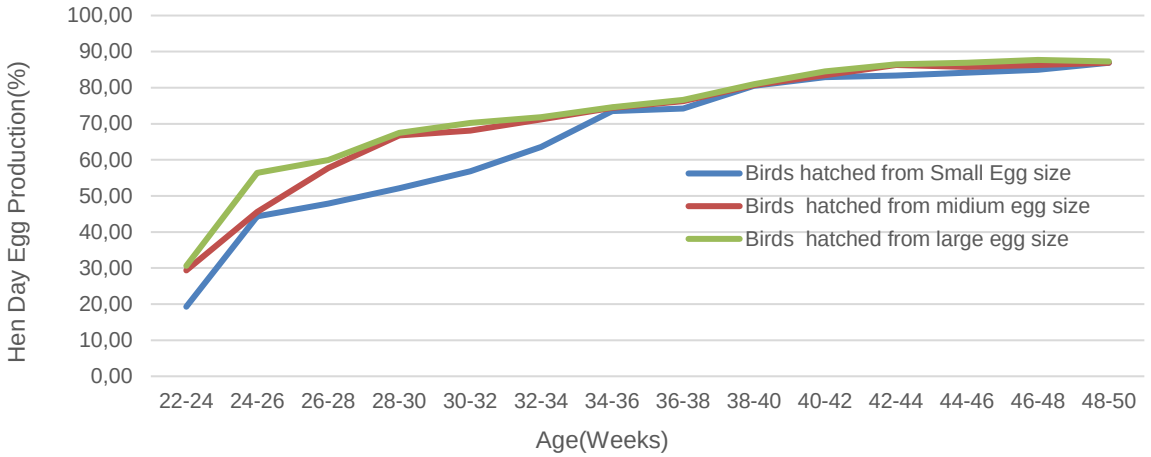

Figure 4. Effect of egg size on hen day egg production

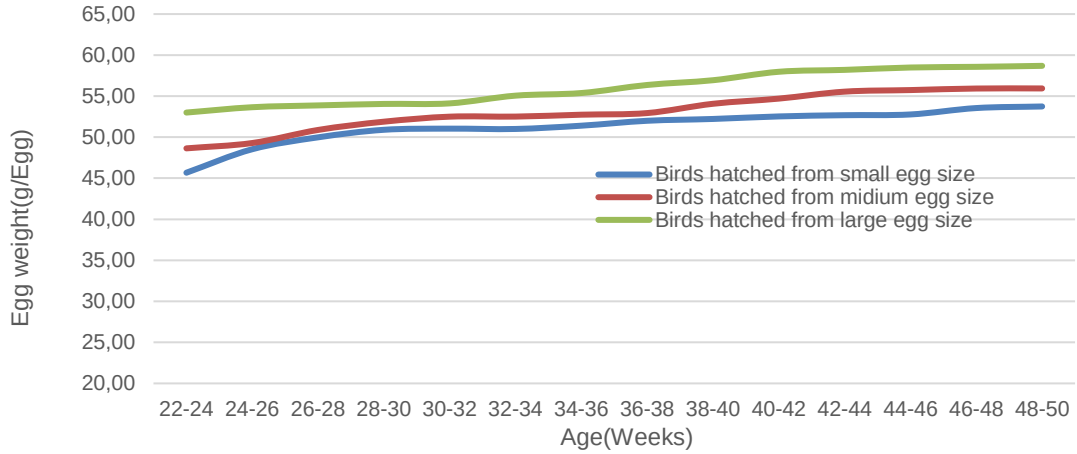

Figure 5. Effect of egg size on egg weight

Egg weight has a significant effect on average feed intake of chickens hatched from different egg sizes ($p<0.0001$) (Table 1). It is common knowledge, the higher the size of an animal the higher the intake in order to maintain the body processes and productivity, thus it is expected that the larger chicken will require higher feed intakes which is in accordance with the current research. This result is similar to the findings of Abiola et al. (28) observed that daily feed intake of chickens increased with increase in the weight of chickens. This study is disagreed to Javid et al. (36) reported that egg size had non-significant ($p>0.05$) effect on chick feed intake during growth period. Increase in feed intake as birds grew is due to the increasing demand for protein and energy needed for growth (37). The increase in feed intake as birds grew (Figure 2) is consistent with Nsoso et al. (31).

The average feed efficiency in the brooder phase (0-10 weeks) was better for chickens hatched from medium sized eggs; nevertheless, chickens hatched from small sized eggs were better during the grower ages (10-30 weeks) (Table 1). This result is contrary to Ulmer-Franco (24) and Javid et al. (36) reported that egg size had non-significant effect on chick feed efficiency during growth period. Similarly, De Witt and Schwalbach (15) found that feed conversion ratio was better in chicks hatched from medium New Hampshire and Rhode Island Red eggs than in those hatched from larger eggs. Contrary to this study, Ewonetu (4) reported the significant effect of egg weight on post-hatch feed conversion ratio of Fayoumi Chickens and reported better feed efficiency for chickens hatched from large sized eggs during the brooder stage (0-6 weeks). The feed efficiency increases with subsequent growth for all chicken groups hatched from different egg weight (Table 1). This result is contrary to Mwale et al. (37) noted that decreasing feed efficiency with age could be due to increasing feed quantities needed for growth. This study reported lower feed efficiency than the result (5.8%) obtained by Akbas and Takma (40) for the same breed raised under intensive management conditions in Ethiopia.

The birds hatched from small eggs were less survives than other group of birds hatched from medium and large egg weight groups during the brooder (0-10 weeks) and grower period (10-20 weeks) (Table 1). This might be due to small yolk attachment in small eggs which is utilized by the chick after hatching and passed lesser short lived immunity or antibodies which fight infection. Mortality rate decreased with advanced age (Figure 3) and not observed in any treatment group after 20 weeks of age. It means that the egg weight had no detrimental effect on the bird's health and overall mortality. In agreement to the present study, some experiments showed significant effect of egg weight on the subsequent broiler mortality (38). The result is also in agreement to (4) who reported as egg weight affected the survival of Fayoumi chickens during the brooder stage; however, contrary to this finding, Javid et al. (36) and Singh et al. (39), reported that the egg size had no effect on mortality rate in chicken. Besides, the

study conducted by Alabi et al. (12) on White Leghorn eggs for seven weeks reported that egg weight had no effect on mortality rate. The mortality rates obtained from present study were lower than 8.1% for the brooder phase the result obtained by Solomon (40) for the same breed raised under intensive management conditions in Ethiopia.

The effect of egg weight on mean hen-day egg production and egg weight from week 22-50 laying period was found significant ($p<0.0001$) (Table 1), in which chickens hatched from large egg size consistently produced higher daily egg production percentage (Figure 4) and bigger egg weight (Figure 5) than other chicken groups hatched from medium and small egg sizes from the beginning of laying periods to the end of experiment. This might be due to the higher feed consumption of chickens hatched from large egg sizes. The increased in egg production and egg weight as age and body weight of birds increased is in agreement to (41,42,43). It is well recognized that there is a strong relationship between breeder age and egg weight such that older hens produce larger eggs (44).

CONCLUSION

Birds hatched from large sized eggs were suitable for better hatchling weight, survival, hen day egg production and egg weight whereas chickens hatched from small egg sizes were relatively better for hatchability, feed efficiency during grower stage and from week 40-50. Chickens hatched from medium egg sizes were principally better for weight gain during brooder and grower stages with minimum feed usage per weight gain for brooder age. Egg weight significantly affected the overall characteristics of chickens from day old to 50 weeks of layer stage and the effect of egg weight only diminish for mortality after brooder age. Therefore; eggs selected for the purposes of hatching and replacement should consider appropriate egg size that positively influenced characteristics of chickens at different stages such as brooder, grower and layer stages.

ACKNOWLEDGEMENTS

This study was made possible by financial support from Haramaya University, enterprise directorate and the authors thanked the University for Financial Support and staff working in University Poultry Farm for any assistance during experimental works.

REFERENCES

1. **Khurshid, A., Farooq, M., Durrani, F.R., Sarbiland, K. and Chand, N.** 2003. Predicting egg weight, shell weight, shell thickness and hatching chick weight of Japanese quails using various egg traits as regressors. International Journal of Poultry Science, 2:164-167.
2. **Brah, G.S., Chaudhary, M.L., and Sandhu, J.S.** 1999. Analysis of relation of egg weight with embryonic mortality, hatching time, chick weight and embryonic efficiency in chickens. Indian Journal of Poultry Science, 34: 308 – 312.
3. **Gonzalez, A., Satterlee, D.G., Moharer, F. and Cadd, G.G.** 1999. Factors Affecting Ostrich Egg Hatchability. Poultry Science 78:1257–1262.
4. **Ewonetu, K.S.,** 2017. Effect of egg size on hatchability and subsequent growth performance of Fayoumi Chicken. Journal of Agricultural Science, 9: 116-122.
5. **Mussadideq, Y., Daud, S., and Akhtar, K.** 2002. A study on the laying performance of cross (FAY+ RIR) chickens under different plans of feeding. International Journal of Poultry Science, 1: 188-192.
6. **King'ori, A.M.** 2011. Review of the factors influence egg fertility and hatchability in Poultry. International Journal of Poultry Science, 10: 483-492.
7. **Donald, D., Bell, W.D., and Weaver, J.R.** 2002. Commercial meat and egg production. 5th ed. Norwell (MA): Kluwer Academic Publishers, 641–643.
8. **Rashid, M.M., Islam, M.N., Roy, B.C., Jakobsen, K. and Lauridsen, C.** 2005. Nutrient concentrations of crop and gizzard contents of indigenous scavenging chickens under rural conditions of Bangladesh, 17. Livestock Research for Rural Development, Web.http://dx.doi.org/10.3382/ps.2009-00069.Accessed on January 11.2018.
9. **Wondmeneh, E., Dawud, I. and Adey, M.,** 2011. Comparative evaluation of fertility and hatchability of Horro, Fayoumi, Lohmann Silver and Potchefstroom Koekoek Breeds of Chickens. Asian Journal of Poultry Science, 5 124-129.
10. **Islam, M.S., Howlider, M.A., Kabir, R.F. and Alam, J.** 2002. Comparative assessment of fertility and hatchability of Barred Plymouth Rock, White Leghorn, Rode Island Red and White Rock hen. International Journal of Poultry Science, 1:85-90.
11. **Christensen, V.L.** 2001. Development during the first seven days post-hatching. Pages 31–36 in Perspectives in Fertilisation and Embryonic Development in Poultry. G. K. Baggott, M. R. Bakst, R. Bellairs, V. L. Christensen, G. M. Fasenfko, and J. M. Starck, ed. Ratite Conference Books, Oxford.
12. **Alabi, O.J., Ngambi, J.W., and Norris, D.** 2012. Effect of egg weight on physical egg parameters and hatchability of indigenous Venda chickens. Asian Journal of Animal and Veterinary Advances, 7: 166-172.
13. **Sahin, E.H., Sengor, E., Cetingul, I.S., and Yardimci,** M. 2009. Relationship between pre-incubation egg parameters from old breeder hens, egg hatchability and chick weight. Journal of Animal and Veterinary Advances, 8: 115-119.
14. **Hassan, S.M., Siam, A.A., Mady, M.F. and Cartwright, A.L.** 2005. Eggs storage, period and weight effects on hatchability of ostrich (Struthio camelus) eggs. Poultry Science, 84: 1908-1912.
15. **De Witt, F. and Schwalbach, L.M.J.** 2004. The effect of egg weight on the hatchability and growth performance of New Hampshire and Rhode Island Red chicks. South African Journal of Animal Science, 34: 62-64.
16. **Mbajiorgu, C.A.** 2011. Effect of hatching egg size on hatchability and chick hatch- weight of indigenous Venda chickens. Indian Journal of Animal Science, 45: 300-304.
17. **Farooq, M., Aneela, K., Durrani, F.R., Muqarrab, A.K., Chand, N. and Khurshid, A.** 2001. Egg and shell weight, hatching and production performance of Japanese broiler quail. Sarhad Journal of Agriculture, 17: 289-293.

18. **Wilson, H.R.** 1999. Interrelationship of egg size, chick size, post-hatching growth and hatchability. World's Poultry Science Journal, 47: 5-20.
19. **Garip, M. and Dere, S.** 2011. The effect of storage period and temperature on weight loss in quail eggs and the hatching weight of quail chicks. Journal of Animal and Veterinary Advances, 10: 2363-2367.
20. **Çaglayan, T., Garip, M., Kirikçi, K. and Günlü, A.** 2009. Effect of egg weight on chick weight, egg weight loss and hatchability in rock partridges (A. graeca). Italian Journal of Animal Science, 8: 567-574.
21. **Raju, M.V.L.N., Chawak, M.M., Praharaj, N.K., Rao, S.V.R. and Mishra, S.K.** 1997. Interrelationship among egg weight, hatchability, chick weight, post-hatch performance and rearing method in broiler breeders. Indian Journal of Animal Science, 67: 48-50.
22. **Saatci, M., Kirmizibayrak, T., Aksoy, A.R. and Tilki, M.,** 2005. Egg weight, shape index and hatching weight and interrelationships among these traits in Native Turkish Geese with Different Coloured Feathers. Turkish Journal of Veterinary and Animal Science, 29: 353-357.
23. **Javid, I., Sohail, H.K., Nasir, M., Tanveer, A. and Riaz, A.P.** 2016. Effects of egg size (weight) and age on hatching performance and chick quality of broiler breeder, Journal of Applied Animal Research, 44:1, 54-64, DOI: 10.1080/09712119.2014.987294.
24. **Ulmer-Franco, A.M., Fasenko, G.M. and O'Dea Christopher, E.E.** 2010. Hatching egg characteristics, chick quality, and broiler performance at 2 breeder flock ages and from 3 egg weights. Poultry Science, 89:2735–2742.
25. **Caglayan, T. and Inlal, S.** 2006. Effect of egg weight on hatchability, growth and survival rate in Japanese quail, Vet. Bil. Deeg., 22:11-19.
26. **Ramaphala, N.O. and Mbajiorgu, C.A.** 2013. Effect of egg weight on hatchability and chick hatch-weight of COBB 500 broiler chickens. Asian Journal of Animal and Veterinary Advances, 8: 885-892.
27. **Woanski, N.J., Renema, R.A., Robinson, F.E., Carney, V.L. and Fancher, B.I.** 2006. Relationship between chick conformation and quality measures with early growth traits in males of eight selected pure or commercial broiler breeder strains. Poultry Science, 85: 1490-1497.
28. **Abiola, S.S., Meshioye, O.O., Oyerinde, B.O. and Bamgbose, M.A.** 2008. Effect of egg size on hatchability of broiler chiks. Archiva zootechnica, 57: 83 -86.
29. **Jiang, R.S. and Yang, N.** 2007. Effect of day-old body weight on subsequent growth, carcass performances and levels of growth-related hormones in quality meat-type chicken. European Poultry Science, 71: 93–96.
30. **Hartmann, C., Strandberg, E., Rydhmer, L. and Johansson, K.** 2003. Genetic relations of yolk proportion and chick weight with production traits in a White Leghorn line. British Poultry Science, 44: 186-191.
31. **Nsoso, S.J., Mareko, M.H.D., Manyanda, S. and Legodimo, P.P.** 2008. The effect of housing type on body parameters, feed intake and feed conversion ratio of guinea fowl (Numida meleagris) keets andchemical composition of their meat during growth, 36-40.
32. **Yildirim, I. E.** 2005. Effects of breeder age and pre incubation storage of eggs on hatchability, time of hatch and relative organ weight of quail chicks at hatch. South African Journal of Animal Science, 35:135–142.
33. **Christensen, V.L., Wineland, M.J., Fasenko, G.M. and Donaldson, W.E.** 2002. Egg storage alters weight of supply and demand organs of broiler chicken embryos. Poultry Science, 81:1738–1743.
34. **Egbeyale, L.T., Abiola, S.S., Sogunle, O.M. and Ozoje, M.O.** 2011. Effect of egg size and strain on growth performance of cockerel. Agriculture and Biology Journal of North America, 2:1445-1453.
35. **Ng'ambi, J.W., Alabi, O.J., Norris, D. and Mabelebele, M.** 2012. Effect of egg weight on hatchability and subsequent performance of potchefstroom koekoek chicks. Asian Journal of Animal and Veterinary Advances, 7:718–725.
36. **Javid, I., Nasir, M., Zaib, U.R., Sohail, H.K., Tanveer, A., Muhammad, S.A., Riaz, H.P. and Sajid, U.** 2017. Effects of egg weight on the egg quality, chick quality, and broiler performance at the later stages of production (week 60) in broiler breeders. Journal of Applied Poultry Research, 26:183–191.
37. **Mwale, M., Mupangwa, J.F. and Mapiye, C.** 2008. Growth performance of guinea fowl keets fed graded levels of baobab seed cake diets. International Journal of Poultry Science, 7: 429-432.
38. **Ambi, J., Thamaga, M., Norris, D., Mabelebele, M., and Alabi, O.** 2014. Effects of egg weight on hatchability, chick hatch-weight and subsequent productivity of indigenous Venda chickens in Polokwane, South Africa. South African Journal of Animal Science, 43:69–74.
39. **Singh, B.P., Taparia, A.L., Tailor, S.P. and Jain, L.S.** 2003. Factors affecting mortality pattern in chicken. Indian Journal of Poultry Science, 38:168-173.
40. **Solomon, D.** 2004. Growth performance and survival of local and white Leghorn chicken under intensive management system. Ethiopian Journal of Science, 27:161–164.
41. **Akbas, Y. and Takma, C.,** 2005. Canonical correlation analysis for studying the relationship between egg production traits and body weight, egg weight and age at sexual maturity in layers. Czech Journal of Animal Science, 50:163-168.
42. **Lacin, E., Yildiz, A., Esenbuga, N., Macit, M.** 2008. Effects of differences in the initial body weight of groups on laying performance and egg quality parameters of Lohmann laying hens. Czech Journal of Animal Science, 53: 466–471.
43. **Malik, H.M., Haq E.U. and Ahmad, F.** 2008. Effect of age and body weight at molting on the performance of broiler breeder hens under environment control house in Pakistan. Pakistan Veterinary Journal, 28: 189-193.
44. **Lourens, A., Molenaar, R., Van Den Brand, H., Heetkamp, M.J.W., Meijerhof, R. and Kemp, B.** 2006. Effect of egg size on heat production and the transition of energy from egg to hatchling. Poultry Science, 85:770–776.