



Study of Hatching Traits of Eggs of Local Chickens Raised in Basra Governorate

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Abstract

The aim of this study was to investigate the effect of feather color on hatchability parameters of three genetic groups of local chickens raised in Basra governorate. The study included field visits to local chicken flocks available to breeders in different areas of Basra governorate. This study was conducted to determine the effect of feather color on hatching parameters of three genetic groups of local chickens during initial period of egg production (24-28 weeks) and during peak egg production period (44-46 weeks). The results of hatching parameters during initial period of egg production showed no significant ($p \leq 0.05$) differences in eggs weights (g) between local chicken groups according to different feather colors (white, black and brown). A significant ($p \leq 0.05$) superiority was observed in fertility rate (%) of local white feather chicken group (LW) compared to local brown feather chicken group (LBR). The results showed that local black feather chicken group (LB) was significantly ($p \leq 0.05$) superior in hatchability rate (%) compared to the groups of local white (LW) and brown (LBR) chickens. The results also showed a significant ($p \leq 0.05$) increase in embryonic mortality rate (%) for the local white (LW) and brown (LBR) chicken groups compared to the local black (LB) chicken group. The local chicken genotypes did not differ significantly ($p \leq 0.05$) in the weight of the hatched chick during initial egg production period. The results of the hatching parameters during peak egg production showed no significant ($p \leq 0.05$) differences between local chicken groups in eggs weight (g), fertility rate (%), hatchability rate (%), embryonic mortality rate(%), and hatched chick weight (g). This study demonstrates the independence of genes responsible for feather color from genes related to egg weight and hatching chick weight.

Keywords: Fertility rate, hatchability rate, feather color, local chickens.

Introduction

Local chicken farming is widespread worldwide as an economic resource for low-income farmers, including in Asian, African, and Latin American countries. Its share of total poultry farming in Malaysia, Bangladesh, and Nigeria reached approximately 70%, 90%, and 94%, respectively (Aini, 1990). Local chickens constitute approximately 9.52% of the total chicken populations in Indonesia and contribute 4.44% of egg production and 8.33% of meat production (Bakrie et al., 2021). Local chickens in Iraq are a source of genetic diversity with varying feather colors, distinguished by their genetic adaptability to harsh environmental conditions and resistance to endemic diseases in Iraq (Al-Rekabi, 2015; Al-Jaryan et al., 2021), while natural selection factors during its development helped increase its physiological ability to withstand environmental stressors, it is characterized by slow growth, low body weight, and limited egg production due to poor nutrition (Wang et al., 2018). Several research institutions in Iraq, including the Scientific Research Council in 1986 and the Ibaa Agricultural Research Foundation from 1992 to 2003, contributed to the genetic improvement of local chickens and succeeded in producing six genetic lines for feather color (brown, black, white, striped, white naked-neck, and brown naked-neck), these lines showed improved body weight, age of sexual maturity, and egg weight (Tawfeq & Al-Neemy, 2022). This encouraged breeders to raise the chicken during that period, compared to commercial chicken strains that emerged with the development of the global poultry industry. Currently, some research institutions are still working on producing genetically improved lines of local chickens based on feather colors, with the aim of distributing the resulting chicks to breeders. However, these attempts did not include the study of improving local chickens from different regions of Iraq as a strategy for sustaining local chickens as an economic and national resource, at a time when global interest is growing in preserving the genetic diversity of local chickens, whether through genetic improvement, improving the administrative conditions of raising, or through both aspects. The importance of relying on hatching criteria such as fertility rate, hatchability rate, and embryonic mortality rate during the initial egg production period and during the peak egg production period is highlighted in studying the genetic potential of local chickens raised in Iraq with different feather colors. This is to determine the reproductive efficiency of hens and roosters and to determine the extent of their genetic contribution to the breeding values in the

resulting offspring. The results of many previous studies conducted on local Iraqi chickens have varied, but most of these studies have confirmed the general weakness of their productive ability due to differences in experimental conditions and local environmental conditions. Shaker et al. (2019) indicated no significant differences in egg weight among three genetic groups of local chickens in Kurdistan-Iraq. No significant differences were observed in weight of eggs produced by local gray, brown, red, white, and black chicken lines (Al-Anbari, 2020), this was due to the negative phenotypic correlation between egg weight and average body weight at sexual maturity. Al-Ardhi & Al-Hilali (2021) demonstrated the effect of genetic variation among three genotypes of Iraqi local chickens (black, brown, and white) on the qualitative characteristics of egg components, the results of this variation in egg qualitative characteristics were observed to be associated with the average egg weight across different genotypes during egg production period. On the other hand, the study of Shanaw & Ghani (2022) on Iraqi local chicken showed a significant ($p \leq 0.05$) superiority for the hybrid resulting from crossing Lohmann laying hens breed with Iraqi local naked-necked white roosters in fertility rate, which reached 90.00%, compared to fertility rate of the hybrid resulting from crossing Lohmann laying hens breed with the local brown roosters, which reached 85.33%, indicating that local chicken has the possible genetic potential for its genetic improvement by crossing it with genetically improved strains and benefiting from the naked-neck gene in improving its reproductive performance through hatching criteria if used as indicators in a comprehensive program for the genetic improvement of local chicken. Due to the scarcity of studies comparing local chicken groups spread in Basra governorate according to feather colors in hatching parameters and studying their genetic potential in order to preserve their genetic diversity and prevent a decline in their numbers, this study was conducted.

Materials And Methods

Location and management of experimental birds: The study was conducted at the poultry hatchery of the College of Agriculture, University of Basra, from November 1st, 2023 to March 1st, 2024. The aim was to investigate the effect of feather color on hatchability parameters of three genetic groups of local chickens raised in Basra governorate. The study included field visits to local chicken flocks available to breeders in different areas of Basra governorate. This was done to obtain accurate data on local chickens according to their feather colors: white (LW), brown (LBR), and black (LB). Based on this, (90) hens and (18) roosters were selected from all local chicken groups, with (30) hens and (6) roosters for each of the three groups. Their ages ranged between (20-22) weeks. The birds were raised by a breeder in a closed hall divided into 18 cages, each with an area of (2 x 2) m². (6) cages were allocated to each group of local chickens, representing the families of sires and dams flocks producing hatching eggs. The birds of each family were randomly distributed in each cage, with one rooster for every five hens. Throughout the experiment, the birds were fed 50% layer hen feed and 50% food scraps, with (17) % of crude protein and (2800) kilocalories/kilogram of feed. A lighting program was used, allocating 14 hours of lighting per day throughout the experiment. The temperature in the rearing hall ranged between (20-22)°C throughout the rearing period. A two-week period was set for the birds to acclimatize to the experimental conditions. The process of collecting hatching eggs from hens of local chicken groups according to families began during two periods. The first period was at the beginning of egg production at an age ranging between (24-28) weeks, the second period was when the parents of the three group families reached peak egg production at an age ranging between (44-46) weeks. The egg collection step was carried out in the first period until the age of 28 weeks, and the total number of eggs reached (180) eggs for all chicken groups, with (60) eggs for each group. Eggs were collected for the second period at the peak of egg production according to the families of the genetic local chicken groups, the total number of eggs was (180) eggs for all groups, with (60) eggs for each group. The hatching eggs collected were weighed daily during the two periods using a sensitive balance. Suitable conditions were prepared for storing the eggs collected at the beginning and peak of egg production in a refrigerated storage, where the temperature was maintained at (6-9)°C and the humidity level was maintained at (75%). The egg storage process continued for 7 days. The incubator used to incubate the hatching eggs was prepared and sterilized, and the eggs suitable for hatching were selected in terms of weight and shape before being placed in the incubator drawers. The temperature in the incubator was adjusted at (37.8)°C and the humidity level at (60)% until the 17th day of the egg incubation period. On the 18th day, the hatched eggs were transferred from the incubator to the hatchery, where the temperature was set at (37.5)°C and the humidity at (65%). The eggs were turned in the incubator starting from the fourth day of the incubation period at a rate of 4 times a day, and then the egg turning process was stopped during the last 3 days of the hatching period. The hatching criteria for eggs were calculated for the period of the beginning of egg production and the period of peak egg production according to the local chicken groups.

Fertility and Hatching parameters: The fertility rate (%), hatchability rate (%) and Embryo mortality rate (%) were calculated according to the following equations:

$$\text{Fertility rate (\%)} = \frac{\text{Number of total fertile eggs}}{\text{Total number of set eggs}} \times 100$$

$$\text{Hatchability rate (\%)} = \frac{\text{Number of hatched chicks}}{\text{Total number of set eggs}} \times 100$$

$$\text{Embryo mortality rate (\%)} = \frac{\text{Number of died embryos}}{\text{Total number of eggs}} \times 100$$

After completing the incubation and hatching period, the hatched chicks were confirmed to be viable, their numbers were recorded, and they were weighed using a scale sensitive. The average weights of the hatched chicks were then calculated for each group of local chickens according to their feather color (white, black, and brown).

Statistical Analysis: Hatching criteria data were analyzed to determine the significance of differences between genetic groups based on feather color using the Statistical Package for the Social Sciences program (SPSS., 2021). Significant differences between hatching parameters across genetic groups were determined using Duncan test at a probability level $P \leq 0.05$.

Results

Hatching Parameters During Initial Period of Egg Production: Table (1) shows the results of the effect of feather color on the hatchability parameters of eggs from genetic groups of local chickens during initial egg production period. The results indicate no significant differences ($p \leq 0.05$) in the egg weight (g) before incubation between the chicken groups according to plumage color (LW, LBR and LB) which amounted to (46.41, 46.75, and 47.21) g, respectively. As shown in the results of Table (1), the LW chicken group was significantly superior ($p \leq 0.05$) in fertility rate (%) compared to the LB chicken group, as their fertility rate reached (65.00, 56.60) % respectively. It is also noted that the LW and LB chicken groups were significantly superior ($p \leq 0.05$) in fertility rate (%) compared to the LBR chicken group, as its fertility rate reached (46.00 %).

Table (1): Effect of the genetic group of local chickens according to feather color on egg weight (g), fertility rate (%), hatchability rate (%), embryonic mortality rate (%), and hatching chick weight (g) during the period of initial egg production (mean \pm standard error).

Groups	Parameters				
	Egg weight (g)	Fertility rate (%)	Hatchability rate (%)	Embryonic mortality rate (%)	Hatching chick weight(g)
LW	46.41a \pm 0.422	65.00a \pm 1.154	55.33b \pm 0.881	44.66a \pm 0.881	32.44a \pm 0.589
LBR	46.75a \pm 0.205	46.00c \pm 0.577	58.16b \pm 0.440	41.83a \pm 0.440	32.78a \pm 0.650
LB	47.21a \pm 0.342	56.66b \pm 0.881	70.65a \pm 1.058	29.35b \pm 1.058	32.74a \pm 0.59
Significance	N.S	*	*	*	N.S

Different letters in the same column between the groups mean significant differences ($P \leq 0.05$). N.S: There are no significant differences between the groups. LW: local chicken group of the white feather. LBR: local chicken group of the brown feather. LB: local chicken group of the black feather.

The results (Table 1) also show that the LB chicken group significantly ($p \leq 0.05$) outperformed in hatchability rate (%), reaching 70.65%, compared to hatchability rate (%) of the LW and the LBR chicken groups, which did not differ significantly ($p \leq 0.05$) in hatchability rate, reaching 55.33% and 58.16%, respectively. The current results also indicate a significant increase ($p \leq 0.05$) in embryonic mortality rate (%) for the LW and LBR chicken groups, reaching 44.66% and 41.83%, respectively, compared to a significant decrease ($p \leq 0.05$) in embryonic mortality rate (%) for the LB chicken group, reaching 29.35% (Table 1). Regarding the effect of feather color on hatching chick weight during the initial egg production period, the results (Table 1) show that the LW, LBR, and LB chicken groups did not differ significantly ($p \leq 0.05$) in the average of hatching chick weight (g) at one day of age, reaching (32.44, 32.78, and 32.74) g, respectively.

Hatching Parameters During Peak Period of Egg Production: Table (2) shows the results of the effect of feather color on the hatching parameters across local chicken groups during the period of peak egg production. It is noted that the LW, LBR, and LB chicken groups did not differ significantly ($p \leq 0.05$) in egg weight (g) before incubation, reaching (46.26, 47.09 and 46.65) g, respectively. The results also showed no significant ($p \leq 0.05$) differences in fertility rate (%) between the groups of LW, LBR, and LB chicken, which reached (70.00, 68.86, and 66.66) %, respectively. The highest fertility rate (%) was achieved by the group of LW chicken compared to LBR and LB chicken groups. Table (2) also reveals no significant ($p \leq 0.05$) differences in hatchability rate (%) between LW, LBR, and LB chicken groups, which reached (59.23, 59.67, and 62.69) %, respectively. However, there was a significant ($p \leq 0.05$) increase in hatchability rate (%) for the LB group compared to LBR and LW chicken groups.

Table (2): Effect of the genetic group of local chickens according to feather color on egg weight (g), fertility rate (%), hatching rate (%), embryonic mortality rate (%), and hatching chick weight (g) during peak egg production period (mean \pm standard error).

Genetic groups	Parameters				
	Egg weight (g)	Fertility rate (%)	Hatchability rate (%)	Embryonic mortality rate (%)	Hatching chick weight(g)
LW	46.26a \pm 0.975	70.00a \pm 0.577	59.216a \pm 1.065	40.78a \pm 1.065	32.59a \pm 0.578
LBR	47.09a \pm 0.717	68.86a \pm 1.041	59.670a \pm 1.310	40.33a \pm 1.310	33.45a \pm 0.566
LB	46.65a \pm 0.945	66.66a \pm 0.881	62.693a \pm 0.906	37.31a \pm 0.906	32.89a \pm 0.474
Significance	N.S	N.S	N.S	N.S	N.S

Different letters in the same column between the groups mean significant differences ($P \leq 0.05$). N.S: There are no significant differences between the groups. LW: local chicken group of the white feather. LBR: local chicken group of the brown feather. LB: local chicken group of the black feather.

Regarding the embryonic mortality rate (%) during peak egg production period, Table (2) indicates no significant ($p \leq 0.05$) differences between the local chicken groups in this parameter, as it reached (40.78, 40.33, and 37.31) % for LW, LBR, and LB chickens groups, respectively. The embryonic mortality rate was mathematically lower for LB chicken group compared to LW and LBR chicken groups. Table (2) also shows no significant ($p \leq 0.05$) difference between the local chicken groups in weight(g) of hatched chicks during the peak egg production period. It is noted from the current results that the reason for the low average weights of hatched eggs for groups of local chickens according to feather colors, as well as the lack of variation in the weights of eggs produced during the initial egg production period and during the peak egg production period, may be due mainly to the fact that the local chicken groups in this study were belong to flocks raised by breeders, which are flocks that are not genetically improved for growth trait and are characterized by low body weights during the growth stage and low body weights upon reaching sexual maturity and even upon reaching the age of peak egg production, which may have an effect on the low average of egg weight, as a result of the phenotypic and genetic correlation between body weight at sexual maturity with egg weight (Bobbo et al., 2013; Osei-Amponsah et al., 2014). Previous studies have shown that egg weight is affected by several factors, including nutrition, genotypes of breeds, and age during egg production period, and that all of these factors are related to average body weight of hens during egg production stage (Msoffe et al., 2001; Yakubu et al., 2008). Regarding Iraqi local chickens, it was observed that hens of low average body weights during egg production period produced eggs of low average weights, and that a one-gram increase in average body weight at sexual maturity caused a 0.017 g increase in average egg weight (Al-Anbari, 2020). The current results are consistent with the results of a study by Shaker et al. (2019), which was conducted on three genetic groups of local chickens in Kurdistan-Iraq, as it showed no significant ($p < 0.05$) differences in egg weight between these groups. The current study results are also consistent with the study of Al-Anbari (2020), which showed that there was no significant difference in the weights of eggs produced during egg production period of gray, brown, red, white, and black local chicken lines, as they amounted to (41.08, 42.60, 43.04, 43.84, 43.61) g, respectively, and the average egg weights in that study (Al-Anbari, 2020) were lower compared to the average egg weights in the current study. On the other hand, the study of Al-Ardhi and Al-Hilali (2021), which was conducted on three types of Iraqi local chickens according to feather color (black, brown, white), showed that there is an effect of genetic variation in the genotypes of these lines on the qualitative

characteristics of eggs, as it indicated a significant ($p \leq 0.05$) increase in the concentration of total protein in blood plasma in the eggs of local chickens of black feathers, as it reached 7.78 g / 100 ml compared to the local chicken line of brown and white feather, which reached 5.45 and 6.04 g / 100 ml, respectively, as a result of the biological requirements for increasing the concentration of protein in the blood during the egg formation process, which varies and differs according to the genotypes, which ultimately affects the average weight of the egg. The current study results are consistent with the results of a study by Okoh et al. (2020) conducted on seven chicken lines in Nigeria, which showed that egg weights were not significantly ($p < 0.01$) affected by the different lines (black, white, black-white, brown, black-brown, gray and spotted). The average weights of the eggs were lower than in our study, reaching (39.31, 40.05, 38.25, 39.68, 39.28, 40.08, 38.06) g, respectively. In another study, three lines of Noiler local chicken breed in Nigeria were compared according to feather color (brown, black, striped). The average hatching egg weight was similar for the brown and black lines, and both lines were significantly ($p < 0.05$) superior in average hatching egg weight compared to the striped line. The average egg weight at 52 weeks of age was (60.23, 61.57, 58.35) g, respectively, for the brown, black, and striped lines (Adetunji and Ola, 2020). The results of our study did not agree with the results of the study by Gambo et al. (2022), which was conducted to evaluate the effect of feather color in four types of local chickens (black, gray, brown, and white) on egg production parameters during 3 months of egg production. The study showed that hens of the black feather line were significantly ($p < 0.05$) superior in average egg weight, which reached (41.44) g, compared to hens of the brown, gray and white feather lines, where the average egg weight was (38.91, 40.08, 36.83) g, respectively. While the black chicken line hens did not differ significantly ($p < 0.05$) compared to the yellow line hens in average egg weight, which reached 40.54 g. The study also showed that the superiority of the black chicken line in the egg shape index, which reached 79.91% compared to other lines, is considered an indicator of the quality of the internal qualitative characteristics of black feather chicken eggs and its superiority in the rate of egg weight. Our results were not consistent with the study of Gambo et al., (2022) which was applied to six ecological types of local chickens in Nigeria according to feather colors (grey, black, brown, light gray, white, yellow), as the results indicated that the brown chicken line was significantly ($p < 0.05$) superior in egg weight, which reached (42.20) g compared to white and yellow lines, as the average egg weight for them reached (39.93, 39.64) g, respectively, due to the superiority of brown chicken line in egg shape index, which reached (79.23)% compared to the other lines, and the gray chicken line recorded the lowest average egg weight, which reached 35.80 g. In a study conducted by Fathi et al., (2022) to evaluate the effect of six genetic compositions of local chickens in the Kingdom of Saudi Arabia according to feather colors (black, black-striped, brown, gray, naked-neck, curly-feathered) on hatching parameters, the results showed a significant ($p < 0.05$) increase in the weight of hatching eggs for chickens having the gene for the (neck naked of feathers (Na)) compared to the average weight of eggs for chickens with curly feathers with the gene (F), which reached 45.9 and 44.2 g, respectively. Both lines significantly ($p < 0.05$) outperformed local hens of black, black-striped, brown, and gray feathers, as the average weight of hatching eggs reached (39.9, 40.2, 39.6, 40.6) g, respectively. The results of our study did not agree with the results of Fulla and Gebresslassie (2024) which compared the productive performance of different genotypes of local chicken lines in Addis Ababa, Ethiopia, namely the genetically improved (Horro) chicken line, the (Cosmopolitan) chicken line, the (Koekoek) chicken line, the local chicken line, the hybrid resulting from genetic crossing between females of Horro line with males of Cosmopolitan line, the hybrid resulting from genetic crossing between males of Horro line with females of Cosmopolitan line. The study indicated effect of the variation of these genotypes on the average weight of hatching eggs, as the weight increased significantly ($P \leq 0.01$) in Koekoek chicken line, reaching (49.53) g compared to average egg weights of the two crossbreeds hybrids, Horro line, and local chicken line, reaching (46.49, 45.12, 44.90, 44.48, 37.05) g, respectively). The reason for these results was attributed to the differences in body weights of the females. Regarding fertility, the results of our study showed an increase in fertility rate of LW, LB, and LBR hens during peak egg production period (Table 2) compared to the fertility rate of chickens from these lines at initial period of egg production (Table 1). These results may be due to the variation in reproductive biological efficiency among these groups at the beginning of egg production compared to peak egg production period and the completion of sexual maturity. This is due to the physiological changes that females undergo, which affect their ability to be fertilized by males with age (Alsobayel & Albadry, 2012). The reason for the increase in fertility with age may also be attributed to the physiological improvement in the semen quality in males with age (Campbel and May., 2003). Furthermore, the sex ratio between males and females has been found to influence the variation in fertility rates (Alsobayel and Albadry, 2012). It is also likely that the significant ($p \leq 0.0$) increase in fertility rate of LW chickens during initial egg production period (Table 1) and mathematically during the peak egg production period compared to LB and LBR chicken groups may be due to their inherited reproductive efficiency and high genetic ability compared to LB and LBR chicken groups (Allanah et al., 2014). Differences in fertility rate may also increase at peak egg production due to increased genetic-environmental interaction. The genes responsible for the inheritance of white feather color in LW chicken group may have an interaction relationship in increasing the efficiency of energy utilization towards vital functions such as fertility at the beginning of egg production and at peak egg production, increasing the efficiency of the oviduct in the process of sperm storage in females, and improving the characteristics of semen in males. In this regard, Abbas et al. (2017) indicated relationship between feather color and reproductive efficiency in naked-necked chickens in Pakistan. The results showed a significant ($p \leq 0.05$) increase in the semen volume of male naked-neck chickens with black feathers compared to male bare-neck chickens with brown feathers. A positive correlation coefficient was also observed between the increase in semen volume and body weights of male naked-neck chicken

with black feathers. In the same vein, our results suggest that the variation in body weights of males and females across different local chicken lines at the initial and at peak of egg production may have influenced fertility rates. Galal, (2007) showed a positive correlation between body weight and semen quality in males. Furthermore, phenotypic differences in comb and wattle size across local chicken lines in our study may be significantly related to the development of the secondary sexual characters and androgen production, which determines the degree of female preference for males. Furthermore, the variations in body weights of males across different local chicken lines may be associated with testicle weights, semen quality, and androgen hormone levels (Riaz et al., 2006). In general, the current results indicate a low fertility rate for local chicken groups which may be due to the fact that the birds of these groups, based on feather colors, have not been subjected to genetic improvement of reproductive traits related to fitness, and the dams and sires flocks to which the birds of these groups belong have not been subjected to genetic improvement methods for traits related to reproductive efficiency. In this regard, the study by Shanaw and Ghani (2022), which was conducted on Iraqi local chickens, showed a significant ($p \leq 0.05$) superiority of the hybrid resulting from crossing females of the white Lohmann strain with males of the local white naked-neck chickens in the fertility rate, which reached (90.00) %, compared to the fertility rate of the hybrid resulting from crossing females of the white Lohmann strain with males of the local brown chickens, which reached (85.33) %. The reason for this result was attributed to the role of the naked-neck gene (Na) in reducing the effect of heat stress on birds, improving their physiological performance, and increasing reproductive efficiency of local white male naked-neck chickens. Our results are consistent with the results of the study of Fulla and Gebreslassie, (2024) which showed variation of fertility rate according to the genotypes of chickens in Ethiopia, as it showed the superiority of Horro line chickens significantly ($p \leq 0.01$) with a fertility rate of 96.25% compared to 93.75% for the hybrid resulting from crossing females of Horro line with males of Cosmopolitan line, which both outperformed the Cosmopolitan line as its fertility rate reached 92.50%, which in turn was significantly ($p \leq 0.01$) superior to the hybrid resulting from crossing males of Horro line with females of Cosmopolitan line as its fertility rate reached 91.67%, while the lowest fertility rate significantly ($p \leq 0.01$) for the local chicken line compared to other genotypes as it reached 90.42%. Regarding the hatchability results, the current results indicate a decrease in hatchability rate of the total eggs for the local chicken lines in general. However, it is noted that the group of LB group is significantly ($p \leq 0.05$) superior in hatchability rate during the initial egg production period compared to the groups of LBR and LW groups. It is also noted that the group of LB chickens is superior in hatchability rate during peak egg production period. The reason for these results may be due to the significant ($p \leq 0.05$) decrease in the embryonic mortality rate of LB group at the initial period of egg production (Table 1), as well as the numerical decrease in the embryonic mortality rate of LB group during the period of peak of egg production compared to LW and LBR groups, which were close in hatchability rate and in the embryonic mortality rate. The low hatchability rate in the local chicken groups in the current study may also be associated with the low average of hatching eggs weights, which was similar across all local chicken groups and falls within the small egg range, where hatchability rates are low. This result is consistent with the findings of Asuquo (1993), which showed that egg sizes falling within the medium to large range yielded the best hatchability compared to very large eggs. Furthermore, the discrepancy in hatchability among the local chicken groups in the current study may be attributed to the variation in the external and internal quality characteristics of eggs produced during the early egg production period and during peak egg production period (Anyachie, 2008). The results of the current study are consistent with the study by Allannah et al. (2014), which indicated that the genetically improved local Nigerian chicken significantly ($p < 0.05$) superior to achieve the best hatchability rate of fertilized eggs, reaching 77.33%, and of total eggs, reaching 63.34%, compared to the hatchability rate of fertilized eggs of non-genetically improved local chicken, reaching 73.35%, and of total eggs, reaching 62.78%. The hatchability rate of imported fertilized eggs decreased to 61.24%, and of total eggs, reaching 43.01%, due to the very large size of imported chicken eggs. Jesuyon (2024) showed that eggs produced during the early period of egg production, with an average weight of 53g, had a lower hatching rate compared to eggs with an average weight of 58g. The results of the current study are also consistent with those of Odah et al. (2019), which demonstrated variations in hatchability rates of local chickens in Nigeria, classified according to feather color and shape, comb color, and eye color. The reasons for these results were attributed to differences in egg weights, eggshell characteristics, management and feeding conditions, and genetic makeup affecting egg quality. The lack of genetic improvement of local chickens for reproductive traits related to parental fitness may result in a continued decline in fertility-related genes, leading to increased embryonic mortality and decreased hatchability (Ajayi and Agaviezor, 2016). In this regard, Jubril et al. (2019) indicated that improving Nigerian chickens by crossing them with Rhode Island Red and Rhode Island White chickens resulted in improved hatchability rates of 65.19% and 24.39% for the two hybrids. Regarding Iraqi local chicken, Shanaw and Ghani (2022) study indicated the superiority of the hybrid resulting from crossing males of local white naked-neck chickens with females of the white Lohmann strain in hatchability rate, which reached 84.00% compared to the hatchability rate of 76.00% for the hybrid resulting from crossing males of local brown chickens with females of the white Lohmann strain, despite the lack of significant differences in the percentage of fertilized eggs, the percentage of embryonic mortality, and the percentage of deformed embryos, explaining the positive effect of the naked-neck gene in improving the reproductive efficiency of females and males of the hybrid resulting from crossing males of local white naked-neck chickens with females of the Lohmann strain. On the other hand, the current results are consistent with the results of the study by Fathi et al. (2022), which confirmed that the hatchability rate was significantly ($p < 0.05$) affected by genotypes of local chickens in the Kingdom of Saudi Arabia, as the local black chicken group and the local gray chickens group recorded the

lowest hatchability rate, reaching 68.2 and 68.6%, respectively, compared to the local chickens with naked necks and the local chickens with curly feathers. This was attributed to the increased embryonic mortality rate of the local brown chickens compared to other genotypes, as well as the increased embryonic mortality rate of the local black chickens feathers due to the increased number of pecking eggs during the last week of the incubation period, reaching 18.1%, compared to the local chickens with naked necks and the chickens with curly feathers, which reached 4.5 and 5.5%, respectively. The results of the study by Jesuyon., (2024) also showed a strong relationship between body weight at 20 weeks of age and sexual maturity and the effect of this relationship on the hatching rate. The results of the study showed that the group of females with a low average body weight ranging between (1500-1600) g had a moderate sexual maturity age and achieved a better hatchability rate compared to the females with an average body weight ranging between (1601-1700) g, as the hatchability rate reached 71.20 and 67.82%, respectively. The highest hatching rate was for the group with a high body weight ranging between (1701-1800) g, as it reached 82.06%. The results of the current study also show that there is no difference between groups of local chickens according to feather color with regard to the weight of the hatched chick at the initial and at peak of egg production. This is likely due to the fact that these groups do not differ significantly in the average weights of hatched eggs, as the weight of the eggs is considered the main factor affecting the weight of hatched chicks at one day of age (Anandh et al., 2012; Egbeyale et al., 2013). This result is consistent with the study of Fulla and Gebresslassie (2024) which showed that the weight of the hatched chick is affected by the difference in genotypes of local chicken lines in Ethiopia, as it indicated the significant superiority ($p \leq 0.01$) of chickens of the Koekoek, Cosmopolitan lines, the hybrid resulting from crossing males of the Horro line with females of the Cosmopolitan line, compared to the average weight of the hatched chick from the eggs of Ethiopian local chicken, which reached (32.79, 28.63, 28.51, 25.77) g, respectively, indicating the effect of variation in egg size on the availability of yolk and Albumen for embryos and on the quality of hatched chicks.

Conclusions

Black feather color is considered a positive indicator that can be used to select the best males and females in selection programs for producing fertilized eggs with a lower embryonic mortality rate.

Author contributions

Arshad T. M. Sultan and Qutaiba J. Ghani were responsible for the experimental design and preliminary data analysis, with Q. J. Ghani specifically leading the on-farm trials. Sajida A. Al-Shaheen oversaw the experimental design, conducted the formal statistical analysis, interpreted the results, drafted the manuscript, and provided final approval for publication.

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Ethical Considerations

The authors followed ethical protocols for bird treatment and ensured high standards of scientific integrity throughout the stages of data collection and writing the research.

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Conflict of Interest

The study was conducted with total objectivity, ensuring that all findings and conclusions were derived strictly from scientific analysis.

References

1. Abbas, W., Jabbar, A., Riaz, A., Akram, M., & Ditta, Y.A. (2017). Effect of plumage colour and body weight on the semen quality of naked neck chicken. *Journal of worlds poultry research*, 7(3), 129-133. https://jwpr.science-line.com/index.php?option=com_content&view=article&id=42&Itemid=53
2. Adetunji, P.O., & Ola, S. I. (2020). Comparative productive performance among three plumage varieties. *Sarhad Journal of Agriculture*, 36(4), 1079-1087. <http://dx.doi.org/10.17582/journal.sja/2020/36.4.1079.1087>
3. Aini, I. T. (1990). Indigenous chicken production in south-east Asia. *World's Poultry Science Journal*, 46(1), 51-57. <https://doi.org/10.1079/WPS19900010>
4. Ajayi, F. O., & Agaviezor, B. O. (2016). Fertility and hatchability performance of pure and crossbred indigenous chicken strains in the high rainforest zone of Nigerian. *Journal of Livestock. Production*, 7, 141-144. <https://doi.org/10.5897/IJLP2016.0308>
5. AL-Anbari, E. H. (2020). Association of coat plumage colors (CPC) for Iraqi local chicken and some productive performance trait by using some analysis parameters. *Association of coat plumage CPC.*, 23 Issue S6. <https://doi.org/10.36295/ASRO.2020.23612>

6. Al-Ardhi, S.A., & Al hilali, A. H .KH. (2021). The effect of feather color and sex on the physiological characteristics of domestic chickens. IOP Conference. Series: *Earth and Environmental Science 910. Fourth International Conference for Agricultural and Sustainability Sciences*.
<https://iopscience.iop.org/article/10.1088/1755-1315/910/1/012051/meta>
7. AL-Jaryan, I. L. H., Hassan, W. S., & Al-Rekabi, M. M. (2021). Association of the melatonin receptor C gene with egg production traits in local Iraqi chicken. *Systematic Reviews in Pharmacy*, 12(4), 1406-13.
<https://www.sysrevpharm.org/archive/srp-volume-12-issue-4-year-2021.html>
8. AL-Rekabi, M. M. J. (2015). A study of growth hormone gene and its receptor polymorphisms and their relationship with some production traits in local Iraqi chicken. PhD. Thesis. Iraq. 280p.
9. Allanah, T.O., Okonkwo, J. C., & Omeji, S. I. (2014). Fertility and hatchability characterization of three strains of egg type chickens. *Scientific Journal of Biological Sciences*, 3(6), 59-68.
<https://sjournals.com/index.php/sjbs/issue/view/397>
10. Alsobayel, A. A., & Albadry, M. A. (2012). Effect of age and sex ratio on fertility and hatchability of Baladi and Leghorn laying hens. *Journal of Animal and Plant Sciences*, 22(1), 15-19.
[https://thejaps.org.pk/IssueDetails.aspx?IssueName=Volume%2022,%20No.%20\(1\),%202012%20\(March\)](https://thejaps.org.pk/IssueDetails.aspx?IssueName=Volume%2022,%20No.%20(1),%202012%20(March))
11. Anandh, M. A., Jagatheesan, P. N. R., Kumar, P. S., Rajarajan, G. & Paramasivam, A. (2012). Effect of egg weight on egg traits and hatching performance of turkey (*Meleagris gallopavo*) eggs. *Iranian Journal of Applied Animal Science*, 2, 391-395. <https://sanad.iau.ir/Journal/ijas/Issue/45239>
12. Anyaehie, A. A., (2008). Effect of environment on performance of layer chickens. *Journal of Animal Production*, 20, 102-104.
13. Asuquo, B. O., (1993). Optimum protein and energy levels for local and exotic egg type chickens in the humid tropics. *Nigerean Journal of Animal Production*, 9(1), 35-43. <https://njap.org.ng/index.php/njap/issue/view/78>
14. Bakrie, B., Rohaeni, E. S., Yusriani, Y., & Tirajoh, S. (2021). The development of a newly formed superior local chicken in Indonesia. A review. *Journal of Hunan University Natural Science*, 48(9).
<https://jonuns.com/index.php/journal/issue/view/78>
15. Bobbo, G. A., S.S. Baba & Yahaya, M.S. (2013). Egg quality characteristics of three phenotypes of local chickens in Adamawa State. *Journal of Agriculture and Veterinary Science*, 4, 13-21. https://scite.ai/reports/egg-quality-characteristics-of-three-y8w21Ml?utm_source=copilot.com
16. Campbell, M. L., & May, D., (2003). Animal Science the Biology, care and production of domestic animals. *Four Edition, Mc-Caraw Hill, New York.*, 2138-2144.
https://books.google.iq/books/about/Animal_Sciences.html?id=K0FgAAAACAAJ&redir_esc=y
17. Dodamani, S., Vidyasagar., Kumars, N., Waghmare, P., Biradar, S., Meenaxi., & Bhatambra, P. (2023). Relationship between plumage colour and egg production traits in native chicken. *Indian Journal of Animal Production Management*, 37(2), 114-117. <https://epubs.icar.org.in/index.php/IJAPM/issue/view/3777>
18. Egbeyale, L. T., Fatoki, H. O., & Adeyemi, O. A. (2013). Effect of egg weight and oviposition time on hatchability and post hatch performance of Japanese quail (*Coturnix coturnix japonica*). *Nigerian Journal of Animal Production*. 40, 102-108. <https://njap.org.ng/index.php/njap/issue/view/28>
19. Fathi, M., Abou-Emera, O., Al-Homidan, I., Galal, A., & Rayan, G. (2022). Effect of genotype and egg weight on hatchability properties and embryonic
20. mortality pattern of native chicken population. *Poultry Science*, 101(11), 102129
<https://www.sciencedirect.com/journal/poultry-science/vol/101/issue/11>
21. Fulla, Sh. T., & Gebreslassie, A. H. (2024). Evaluation of egg production, fertility, hatchability, embryonic mortality and chick quality of different chickens. *International Journal of Animal Science and Technology*, 8, 55-65.
<https://doi.org/10.11648/j.ijast.20240803.14>
22. Galal, A. (2007). Predicting semen attributes of Naked Neck and normally feathered male chickens from live performance traits. *International Journal of Poultry Science*, 6(1): 36-42.
<https://ijpsjournal.org/index.php/ijps/article/view/706>
23. Gambo, D., Kasim, Z. C., & Zanwa, M. (2022). Effect of plumage colour on egg characteristics of Fulani local chickens. *Nigerian Journal of Animal Science and Technology*, 5, 71-77.
<https://www.njast.com.ng/index.php/home/issue/view/17>
24. Jesuyon, O. M. A. (2024). The effect of 20-week pullet weight on full-sexual maturity characteristics in a parent-stock layer strain. *Ghana Journal of Agricultural Science*, 59(1), 55-67. <https://dx.doi.org/10.4314/gjas.v59i1.6>
25. Jubril, A. E., Fayeye, T. R., Ademola, A. A., & Gunn, H.H. (2019). Auto-sexing potential and growth performance in Rhode Island, Nigerian local chickens and their reciprocal crosses. *Nigerian Journal of Animal Production*, 46(5), 1-8. <https://njap.org.ng/index.php/njap/issue/view/10>
26. Msoffe, P. L. M., Minga, U. M., Olsen, J. E., Yongolo, M. G., Juulmadesen, H. R., Gwakisa, P. S. & Mtambo, M. M. A. (2001). Phenotypes including immunocompetence in scavenging local chicken genotypes in Tanzania. *Tropical Animal Health and production*, 33: 341-354. <https://link.springer.com/article/10.1023/A:1010544221028>
27. Odah, E. O, Daikwo, S. I, Mbap S.T & Okpanachi U. (2019). Phenotypic characterization of local chickens (*Gallus Gallus Domesticus*) in Bekwarra Cross River state, Nigeria. *JSM veterinary Medicine and Research*, 2,1-7.
<https://www.scirp.org/reference/referencespapers?referenceid=3742260>

28. Okoh, J. J., Mbap, S., Mancha, Y., & Ibrahim, T. (2020). Effects of plumage colour on measureable attributes of indigenous chicken in north central Nigeria. Scientific papers. Series D. *Animal Science*, *LXIII*(2), 30-35.
29. Osei-Amponsah, R., Kayang, B. B., Manu, H. & Naazie, A. (2014). Egg quality traits of local Ghanaian chickens and influence of storage period. *Animal Genetic Resources*. <https://doi.org/10.1017/S2078633614000290>
30. Riaz, A., Aleem, A., & Ijaz, A. (2006). Relationship of body weight, testes biometry and sperm production in broiler breeder. *Korean Journal of Poultry Science*, *33*(2): 165-169.
<https://www.cabidigitallibrary.org/doi/full/10.5555/20073117758>
31. Shaker, A. S., Mustafa, N. A., Amin, Q. A. & Hani, N. H. (2019). Egg traits uniformity comparison between Kurdish local chicken and two commercial strain using coefficient of variation. Proceeding of 170th the IRES. *International conference, Roma, Italy 20th-21st August*.
https://www.researchgate.net/publication/335402012_Egg_traits_uniformity_comparison_between_Kurdish_local_chicken_and_two_commercial_strain_using_coefficient_of_variation
32. Shanawa, KH. A. A. & Ghani, Q. J. (2022). Some physiological parameter for the first generation resulting from cross-breeding lohman classic chickens with two strains of Iraqi local roosters. *Biochemical and Cellular Archives*, *22*(1), 2893-2897. <https://connectjournals.com/03896.2022.22.2893>
33. SPSS. (2021). IBM SPSS statistics for Windows (Version 27.0). IBM Corp. <https://www.ibm.com/analytics/spss-statistics-software>
34. Tawfeq, E. M., & Al-Neemy, M. A. S. (2022). Productive performance and qualitative egg characteristics of two local lines chickens and laying brown Lohman. *Journal of Agricultural, Environmental and Veterinary Sciences* *6*(2), 109-116. <https://doi.org/10.26389/AJSRP.S060122>
35. Wang, y., Saelao, P., Chanthavixay, K., Gallardo, R., Bunn, D., Lamont, S. J., & Zhou, H. (2018). Physiological responses to heat stress in two genetically distinct chicken inbred lines. *Poultry Science Journal*, *97*(3), 770-780. <http://dx.doi.org/10.3382/ps/pex363>
36. Yakubu, A., Ogah, D. M. & Barde, R. E. (2008). Productivity and egg quality characteristics of free range naked neck and normal feathered Nigerian indigenous chickens. *International Journal of Poultry Science*, *7*(6), 579-588. <https://doi.org/10.3923/ijps.2008.579.585>