Morphometric Variation and Repeatability Estimates of Egg Quality Traits of Two Duck Breeds Raised in a Derived Savannah Zone of Nigeria

Yusuff[1], A. T., Adetola[1], M. A., Adeyemi[2], S. A., Ajao[1], B. H. and Fayeye[1], T. R.
[1]*University of Ilorin, Department of Animal Production, Ilorin, Nigeria*
[2]*Al-Hikmah University, Department of Animal Science, P.M.B.1601, Ilorin, Nigeria*
Corresponding author: yusuff.at@unilorin.edu.ng; +2348060132238

Abstract

This study examined early lay variation and repeatability estimates for egg weight (EW) and egg quality traits in Khaki Campbell (KC) and Ancona (AN) ducks raised in derived savannah zone of Nigeria. A total of 40 AN and KC ducks in equal ratio were reared for a period of 17 weeks during which the eggs laid by the ducks were measured for quality traits (weight, length, width, shell thickness (ST), Haugh unit, albumen height, yolk color and height) in the first 12 weeks of laying. The data collected were pooled on fortnight basis and were subjected to analysis of variance of Completely Randomized Design and Variance Components analysis. The KC duck laid relatively bigger eggs (59.17g and 61.93g) in the first and second fortnight period of lay (FPL) compared to AN ducks (52.17g and 55.34g), while AN produced bigger eggs (71.47g) than KC ducks (69.10g) in the 6th FPL. Within breed variation was observed for egg weight (EW) and egg length (EL) in the two breeds, with an increasing trend as the duck ages. Egg ST and Haugh unit declined across the FPL in a non-uniform pattern. Moderate repeatability estimates (0.46 to 0.67) were obtained for EW in KC, and for EL and ST in the two breeds. Repeatability estimates for egg width, yolk height, yolk color and albumen height were generally low. It is concluded that Ancona ducks possess higher repeatability for bigger and longer eggs than KC ducks. Improvement of EW and EL is likely to yield a faster result when individuals with better performance are selected. Utilization of relative records and improvement on non-genetic factors may lead to the improvement of other egg traits except shell thickness.

Keywords: Ducks, breeds, egg, variation, repeatability
Running Title: Repeatability of egg traits in ducks

Variation morphométrique et estimations de répétabilité des caractéristiques de la qualité des œufs de deux races de canards élevées dans une zone de savane dérivée du Nigéria

Résumé

Cette étude a examiné la variation de la ponte précoce et les estimations de répétabilité pour le poids des œufs (PŒ) et les caractéristiques de la qualité des œufs chez les canards Khaki Campbell (KC) et Ancona (AN) élevés dans la zone de savane dérivée du Nigéria. Un total de 40 canards AN et KC, répartis de manière égale, ont été élevés pendant une période de 17 semaines au cours de laquelle les œufs pondus par les canards ont été mesurés pour les caractéristiques de qualité (poids, longueur, largeur, épaisseur de la coquille (ST), unité Haugh, hauteur de l'albumen, couleur et hauteur du jaune) au cours des 12 premières semaines de ponte. Les données recueillies ont été regroupées sur une base quinzaine et ont été soumises à une analyse de variance selon un plan complètement randomisé et à une analyse des composants de variance. Les canards KC ont pondu des œufs relativement plus gros (59,17 g et 61,93 g) pendant les premières et deuxièmes périodes de ponte (DPP) comparativement aux canards AN (52,17 g et 55,34 g), tandis que les AN ont produit des œufs plus gros (71,47 g) que les KC (69,10 g) pendant la 6e période de ponte. Une variation au sein des races a été observée pour le poids des œufs (PŒ) et la longueur des œufs

(LŒ) dans les deux races, avec une tendance à l'augmentation à mesure que les canards vieillissent. L'épaisseur de la coquille (EC) et l'unité Haugh ont diminué de manière non uniforme au cours des différentes périodes de ponte. Des estimations de répétabilité modérées (0,46 à 0,67) ont été obtenues pour le PŒ chez les KC, et pour le LŒ et le EC dans les deux races. Les estimations de répétabilité pour la largeur des œufs, la hauteur du jaune, la couleur du jaune et la hauteur de l'albumen étaient généralement faibles. Il est conclu que les canards Ancona possèdent une plus grande répétabilité pour des œufs plus gros et plus longs que les canards KC. L'amélioration du PŒ et du LŒ est susceptible de donner des résultats plus rapides lorsque les individus avec de meilleures performances sont sélectionnés. L'utilisation de records relatifs et l'amélioration des facteurs non génétiques pourraient conduire à une amélioration des autres caractéristiques des œufs, sauf de l'épaisseur de la coquille.

Mots-clés : Canards, races, œufs, variation, répétabilité

Introduction

Poultry species are kept widely throughout the world, and have led to massive egg production which has become a vast global industry. For instance, upward trending of egg production and consumption has been documented, and with specific indicators of shortage of supply compare to demand (FAO, 2023). The advent of commercial egg-laying strains of chickens has contributed meaningfully to this abundance but this has relegated to the background, the relevance and relative contribution of other poultry species such as ducks. Ducks are domestic birds known to be water fowls but not completely restricted to water body (Babington and Campbell, 2022). Several breeds of duck are known for specific merits such as increased egg laying capacity and better nutritive value of their eggs (Babington and Campbell, 2022).Exotic ducks such as Khaki Campbell (KC) and Ancona (AN) have been documented to produce about 300 eggs per year compare to indigenous Muscovy ducks that lay less than 80 eggs per year (Yakubu, 2013; Kavitha *et al.*, 2017; Onbaşılar *et al.*, 2018).

Egg quality and grading are usually determined based on several internal and external parameters. Preference of most consumers is often hinged on indices such as, mass, yolk height and yolk color (Berkhoff *et al.,* 2020; Riemensperger, 2023), while most of farmers place emphasis on shell thickness and egg weight because of reduced transportation breakages and increased profits (Ketta and Tůmová, 2016; Cheng and Ning, 2023). However, combinations of these indices are important to animal breeders because of the existence of relationship between them (Sokołowicz *et al.,* 2019; Lu *et al.,* 2020).

Performance of any livestock species is tied to genetics and environment. If an environment is not favorable, genetic potential of a species may be masked, leading to a production capacity below expectations (Zamani *et al*., 2023). Therefore, evaluation of genetic parameters should not ignore the environment where the animals are raised. The AN and KC ducks are not commonly reared in the tropics and most especially Nigeria (Oguntunji and Ayorinde, 2015); hence, there is dearth of empirical studies on egg traits in these waterfowls. Thus, this study was designed to evaluate morphometric variation and repeatability estimates for egg quality traits in AN and KC ducks during early laying phase.

Materials and Methods

Experimental Site, Experimental Birds and their Management: This study was conducted in an experimental site situated between latitude 08°36'N of the equator and longitude 04°33'E of the Greenwich Meridian.

Experimental Birds and their Management: A total of 40 female ducks (KC: n=20; AN: n = 20) at 18 weeks of age and body weight range of 1.45 – 1.75kg were used for this experiment. The ducks were obtained from a reputable duck farm in Ibadan, Oyo state, Nigeria. The ducks were tagged and given anti-stress on arrival. This was followed by feeding and acclimatization for two weeks on a free range within fixed pens comprising deep litter housing units. In addition, the birds were provided with two wallow pits of 3.66m x 1.83m. The ducks were fed twice daily for a period of 17weeks (5 weeks rearing; 12 weeks laying) with a compounded feed with the compositions indicated in Table 1.

Ethical Approval: This research received the ethical approval of the University of Ilorin Ethical Review Committee and was assigned identification code: UERC/AGR/260 and Approval Number: UERC/ASN/2024/2720

Experimental Design: The experiment was laid out in a Completely Randomized Design to make separate comparison between breeds of duck and for the six fortnight egg collections. The experimental models were:

$y_{ij} = \mu+\beta_i + e_{ij}$………… equation 1; $y_{ij} = \mu + \text{Ɯ}_j + e_{ij}$………….. equation 2

Where: μ = Population mean; y_{ij} = Observation on egg parameters of i^{th} breed for fortnight period of lay; β_i= Fixed effect breed on egg parameters; Ɯ_i= Fixed effect fortnight period of lay on egg parameters; e_{ij}= Random error which is assumed to be normally distributed and with expectation equals to zero.

Table 1: Compositions of the feed for the experimental Ducks

Feed Ingredient		%				
Maize		47.00				
Soya bean meal		30.00				
Palm kernel cake		4.00				
Brewer's dried grain		10.40				
Bone meal		1.30				
Di Calcium Phosphate		0.50				
Limestone		5.85				
Common salt		0.25				
Vitamin Premix		0.25				
Methionine		0.12				
Lysine		0.14				
Baobab leaf meal		0.19				
Calculated Nutrient values	ME	CP	Ca	P	Lysine	Methionine
	2708.4	18.7	2.8	0.3	1.2	0.5

ME= Metabolizable Energy, CP= Crude Protein, Ca= Calcium, P= Phosphorus

Data Collection: Eggs were collected daily for a six consecutive fortnight period starting from onset of lay when the birds were 23 weeks old. The eggs were properly labeled before being subjected to weighing and morphometric measurements which were carried out within 24hours after egg collection. The parameters focused were:

Egg Weight (EW): Eggs collected at different production period were thoroughly cleaned prior weighing to ensure accuracy of the reading. An electronic sensitive scale was used to take weight of egg in grams.

Egg Length (*EL)* and Egg ***Width (EW)*****:** These were measured for in millimeters (mm) using a Vernier caliper.

Albumen Height: Albumen height (AH) was measured using tripod micrometer according to the method described by USDA (2020).

Eggshell Thickness (ET): Thickness was measured having removed the eggshell membrane of each egg and eggshell wiped dry. A micrometer screw gauge calibrated in millimeters (mm) was used to take measurement.

Yolk Color*:* A Roche fan scale was used to take reading for yolk color (YC) in eggs. This scale was determined using colorimetry as described by Dvořák *et al.* (2010).

Yolk Height: Yolk height (YH) was also measured using tripod micrometer.

Haugh Unit: This was calculated using the parameter indicated below as described by Haugh (1937).

$HU = 100 \log (H+7.57-1.7W^{0.37})$

where: HU= Haugh Unit; H= Observed Albumen Height in millimeters; W= Observed Weight of egg in grams.

Data Analysis

Data obtained were subjected to Analysis of Variance of Completely Randomized Design to establish within and between breed differences. Nested design was used to obtain variance components using Minitab Version 17 Statistical Software. The variance components obtained were used to estimate repeatability coefficient as indicated below:

$$\text{Repeatability} = \frac{\sigma_b^2}{\sigma_b^2 + \sigma_w^2}$$

Where: $\boldsymbol{\sigma}^2_b$ = variance component between fortnight records for each parameter; $\boldsymbol{\sigma}^2_w$ = variance component within fortnight records for each parameter.

Results

Descriptive statistics of egg weight and egg quality traits:

The descriptive analysis of EW and egg quality traits during early laying phase of KC and AN ducks are presented in Table 2. The overall mean values recorded for KC are numerically higher than that of AN duck in all the parameters studied except EW and ST. However, the EW of KC and AN ducks ranged from 51.50g to 69.95g and 44.60g to72.10g, respectively, while the two breeds were similar in minimum egg ST(0.398mm) but a fairly higher maximum ST was among AN compare to KC duck (0.529mm and 0.495mm, respectively). Coefficients of variation among the parameters studied were mostly less than 10% except EW in AN ducks which had 17.45%, and ST in the two breeds (AN: 14.11 vs KC: 12.09). Coefficients of variation for other parameters were generally higher in AN compared to KC except the yolk height of KC which was higher than that of AN with 1.77%. The YH of the eggs ranged from 12.30 to 21.30 and 15.50 to 21.00 among KC and AN ducks respectively, while AN duck had a higher mean HU range (22.46) compared to KC duck (11. 87). The YC was slightly higher in KC (10.12) compared to AN (10.04)**.**

Table 2: Descriptive statistics of egg weight and egg quality traits in Khaki Campbell and Ancona Ducks

	Egg parameters/ Breed															
Descriptive	EWT (g)		EL (cm)		EWD (cm)		AH (cm)		ST (mm)		YC		YH		HU	
Statistics	KC	AN	KC	AN	KC	AN	KC	AN	KC	AN	KC	AN	KC	AN	KC	AN
Mean	64.19	65.23	5.49	5.40	3.61	3.53	9.28	8.66	0.483	0.525	10.12	10.04	19.04	18.93	91.39	81.38
SEM	0.42	2.00	0.45	0.10	0.02	0.04	0.16	0.37	0.01	0.01	0.19	0.20	0.34	0.27	0.78	1.68
SD	2.01	9.81	0.22	0.52	0.11	0.23	0.79	1.84	0.06	0.07	0.94	0.96	1.67	1.33	3.86	8.24
CV	3.54	17.45	4.05	9.65	3.19	6.45	8.55	9.25	12.09	14.11	9.35	9.51	8.81	7.04	4.02	8.82
Minimum	51.50	44.60	5.00	4.10	3.40	2.90	7.00	4.80	0.39	0.39	9.00	9.00	12.30	15.50	84.34	71.00
Maximum	69.95	72.10	5.69	5.98	3.90	3.90	11..00	11.50	0.49	0.56	12.00	12.00	21.30	21.00	99.21	101.46
Range	18.45	25.50	0.90	2.00	0.50	1.00	4.00	6.70	0.17	0.29	3.00	3.00	9.00	5.50	11.87	22.46

EWT: Egg Weight; EL: Egg Length; EWD: Egg Width; AH: Albumen Height; ET: Eggshell Thickness; YC: Yolk Colour; YH: Yolk Height; HU: Haugh Unit; KC: Khaki Campbell; AN: Ancona; SEM: Standard Error of Mean; SD: Standard Deviation; CV: Coefficient of Variation.

Within and between breed phenotypic variation in egg weight and egg quality traits

Relative comparison of EW and egg quality traits between and within AN and KC ducks is presented in Table 3. Within breed variations were observed in the fortnight evaluation (FPL) of EW, EL, ET and HU for both KC and AN ducks. The mean EWT of AN duck within the 1stFPL (52.77g) was significantly smaller ($p<0.05$) compared to the mean EWT of subsequent fortnights which were also significantly different ($p<0.05$) from one another until the end of the 4th FPL. The 70.69g and 71.47g mean EWT respectively laid by AN ducks in their 5^{h} and 6th FPLwere not different ($p>0.05$) from each other. The mean EWT of KC duck during the 5th and 6th FPL were also not only significantly different ($p>0.05$) from each other but were significantly heavier ($p<0.05$) than the eggs laid during the preceding FPL. The egg of KC ducks in the 5th FPL was significant heavier ($p<0.05$) than that of 4th FPL with 2.34g, while there was no difference between 63.43g and 61.93g of eggs, respectively laid at 3rd and 2nd FPL. The EW of KC ducks in the first FPL (51.97g) was significantly smaller ($p<0.05$) compared to eggs of the other periods of coverage in the present study. The KC ducks laid relatively bigger eggs compared to AN in the 1st and 2nd FPL while there was no noticeable EWT difference in the two breeds from 3rdto5th FPL.

The AN ducks, however, produced a significantly bigger ($p<0.05$) egg than KC duck during their 6th FPL (71.47g vs. 69.10g). The EL increases as week-in-lay progresses but the trends were not uniform in the two breeds. The EL of KC ducks in the 1st (5.13cm) and 2nd (5.42cm) FPL were significantly different ($p<0.05$) from each other, while that of AN ducks (5.24cm and 5.42cm) were statistically the same. This similar trend was observed in the two breeds between 4th and the 5th FPL, while the egg length obtained during the 2ndand 3rd FPL in each of AN and KC ducks were not significantly different ($p>0.05$) from each other. The longest EL obtained in the 6th FPL in KC ducks (5.68cm) was not significantly different ($p>0.05$) from 5.65cm obtained at 5th FPL while AN ducks produced eggs that were statistically comparable in the 4th (5.72cm), 5th(5.80cm) and 6th (5.95cm) FPLs. Analysis of breed variation in the EL on fortnight basis reveals no statistical difference from the onset of egg production until the 6th FPL when the egg laid by AN ducks had a longer length compare to KC ducks (5.95cm vs. 5.68cm). There was no within and between breed statistical variation in AH across the periods of lay, though a uniformly descending trend was noticed in both AN and KC ducks with the highest AH obtained at 1st FPL as 9.50mm and 9.85mm in KC and AN respectively. Generally, a gradual reduction in ET was noticed in the two breeds as FPL progresses, though the trend is inconsistent. There was no breed difference in fortnight comparison of egg ST but the thickness of KC eggs was relatively more stable over a long period (1st to 3rd FPLs) compared to AN eggs which exhibited no thickness difference between the 1st and 2nd FPLs. The fortnight evaluation of the ST from 4th to 6th FPLs revealed a stable trend across the periods in both AN and KC ducks. The egg width, AH, YC and YH across the FPLs for the two breeds exhibited no significant difference ($p>0.05$). The albumen height descends as FPL progresses, while a non-uniform fluctuation was observed in the mean values of egg width, YC and YH. The egg HU of the two breeds significantly reduces ($p<0.05$) in a dissimilar trend with progression in FPL. The highest HU in KC (93.36) observed in the first FPL was not significantly different from 95.91 and 94.97 obtained in 2nd and 3rd FPLs respectively, while the HU of AN eggs in the 1st FPL (99.67) was significantly higher ($p<0.05$) compare to the subsequent FPLs. Eggs produced by AN ducks between 2^{nd,} and 5th FPLs were not significantly different in HU while that KC eggs has relatively similar HU units from the 4th and 6th FPLs.

Table 3: Fortnight mean egg weight and egg quality traits in Khaki Campbell and Ancona ducks during early production phase

FPL	Egg parameters / Breed																	
	Egg weight (g)		Egg length (cm)		Egg width (cm)		Albumen height (mm)		Eggshell thickness (mm)		Yolk colour		Yolk height		Haugh Unit			
	KC	AN	KC	AN	KC	AN	KC	AN	KC	AN	KC	AN	KC	AN	KC	AN		
1st	59.17$^{d(a)}$	52.77$^{e(b)}$	5.13^{d}	5.25^{d}	3.47	3.37	9.50	9.85	0.492^{a}	0.562^{a}	10.50	11.00	17.30	18.33	96.36^{a}	99.67^{a}		
2nd	61.93$^{c(a)}$	55.34$^{d(b)}$	5.42^{c}	5.42^{cd}	3.65	3.60	9.43	8.93	0.489^{a}	0.536^{a}	10.75	9.75	19.65	19.20	95.91^{a}	92.31^{b}		
3rd	63.43^{c}	62.57^{c}	5.51^{c}	5.52^{c}	3.68	3.62	9.35	8.70	0.484^{a}	0.465^{b}	10.25	10.00	19.65	18.30	94.97^{a}	91.62^{b}		
4th	66.55^{b}	65.64^{b}	5.55^{b}	5.72^{ab}	3.50	3.67	8.15	8.45	0.412^{b}	0.429^{c}	9.50	9.75	19.48	19.15	88.65^{b}	90.04^{b}		
5th	68.89^{a}	70.60^{a}	5.65^{a}	5.80^{a}	3.68	3.60	8.13	8.22	0.391^{b}	0.424^{c}	10.50	10.00	18.65	19.00	88.10^{b}	89.25^{b}		
6th	69.10$^{a(b)}$	71.47$^{a(a)}$	5.68$^{a(b)}$	5.95$^{a(a)}$	3.78	3.68	7.95	7.55	0.380^{b}	0.405^{c}	9.50	9.75	19.55	19.00	86.78^{b}	83.00^{c}		
SEM(±)	2.33	2.16	0.12	0.19	0.16	0.39	2.30	2.45	0.03	0.04	1.59	1.28	2.91	1.98	2.13	3.79		
P-value	0.02	0.00	0.00	0.02	0.21	0.11	0.21	0.33	0.00	0.00	0.32	0.42	0.30	0.43	0.026	0.045		

FPL: Fortnight period of lay; KC: Khaki Campbell duck; AN: Ancona duck. Superscripts within parenthesis compares the means between the breeds for each trait; superscripts without parenthesis compare the means between the FPL for each breed

Repeatability estimates

Repeatability estimates for EW and egg quality traits in Khaki Campbell and Ancona ducks are presented in Table 5. Estimates of repeatability for EW and egg quality traits in the two breeds ranged from 0.31 to 0.46 and 0.01 to 0.67, respectively. The repeatability estimates for EW in KC and AN ducks are (0.31 vs 0.46). The two duck breeds had moderate repeatability values for both EL and ST with KC exhibiting a relatively higher value than AN duck in the two parameters (EL: 0.48 vs. 0.55; ST: 0.50 vs. 0.67). Low repeatability estimates were obtained for the egg width, AH, YC, YH and HU of the two breeds.

Table 6: Repeatability estimates for egg weight and egg quality traits in Khaki Campbell and Ancona ducks

Breed	Repeatability estimates (%)							
	EWT	EL	EWD	AH	ET	YC	YH	HU
Khaki Campbell	0.46	0.55	0.28	0.13	0.67	0.06	0.08	0.10
Ancona	0.31	0.48	0.27	0.06	0.50	0.01	0.01	0.01

EWT: Egg weight; EL: Egg length; EWD: Egg width; AH: Albumen height; ET: Eggshell thickness; YC: Yolk colour; YH: Yolk height; HU: Haugh unit

Discussion

Although, previous reports on egg weight across breeds of ducks exhibit disparities but the average egg weights for the two duck breeds evaluated in the present study fall within the range of (45 – 89g) reported for ducks (Dzhus *et al.*,2021; El-Deghadi *et al.,* 2022). For instance, the report by El-Deghadi *et al.* (2022) indicated a slightly lower average egg weight (64.3g) for Khaki Campbell ducks while (Vishwavidyalaya *et al.*, 2014) reported 57.09g for the same breed. The coefficients of variation in the egg weight of the two breeds vary widely from 3.54% to 17.45%. The low CV in KC duck (3.54%) compared to 17.58 in AN duck depict breed differences in the consistency of egg size during the early laying phase of the ducks. Similarly, the genotype difference observed in the egg weight as laying progresses aligns with earlier findings by El-Deghadi *et al.* (2022) and (Vishwavidyalaya *et al.*, 2014), which indicated significant effect of genotype on EW of ducks. Decrease in ST as egg size increases in the present study aligns with the report of Boğa-kuru *et al.* (2023). Although, variation in egg ST has been attributed to be multi-factorial (Ketta and Tumova, 2016), but more relevant to the current study are age of birds and size of eggs which are highly interrelated (El-Ghareeb *et al.*; 2018; Boğa-kuru *et al.*, 2023). A decline in ST as week in lay progresses or as egg volume appreciates was reported to be caused by finite deposition of calcium during egg formation (Harrington *et al*., 2020). The observed influence of genotype on variation in avian ST (Lewko, 2021) was not directly observed in the fortnight comparison in the present study. Meanwhile, the mean ST of the two duck breeds exhibited different patterns of decline as weeks in lay progresses. This implies an indirect variation across FPL for the two breeds. Generally, the egg ST of the two breeds fall within the normal range of 0.35 to 0.56mm reported for ducks (Shoimah *et al.*, 2019) though, higher values were reported for KC by Vishwavidyalaya *et al.* (2014). This could be an indication of strains differences or likelihood of environmental effect on this egg parameter. The relatively low CV in HU and AH of the eggs of AN and KC ducks reveals a clear demarcation between these breeds compare to Mallard or Pekins which were asserted (Liu *et al*., 2021; Sulaiman *et al*., 2023) to have a high coefficient of variation of not less than 15% for the traits. Similarly, the mean HU for the two duck breeds, irrespective of laying duration, are generally outside the range of 78.31 to 81.58 reported for ducks by Shoimah *et al.* (2019). This variation might be due to age, rearing system, genotype and their interactions (Rakonjac *et al.*, 2021; Sözcü *et al.*,2021).The gradual reduction observed in the HU as the duck ages in the current study corroborates the findings of (Sulaiman *et al*., 2023), though a generally low HU ranging from 75.57 to 83.63 were reported for Alabio duck by these authors while Adamski *et al*. (2005) reported 69.8 HU for an unspecified duck breed. The reduction in the HU could be due to gradual reduction in AH and gradual elongation of egg length resulting from anatomical changes in the pelvic bones as the bird ages (Onbaşılar *et al.,* 2018). Observed similarity in the egg yolk colour of the two duck breeds affirms the assertion that egg yolk pigmentation is chiefly dietary related than other factors (Bovšková *et al.*, 2014; Rostinia *et al.*, 2021), since the ducks were fed similar ration. The β-carotene in poultry diets is almost completely converted to vitamin A or xanthophylls towards playing a major role in egg yolk pigmentation (Lokaewmanee *et al.*, 2011). A contrary finding was reported by Sözcü *et al*. (2021) in the egg yolk of two chicken genotypes fed similar diet and range exposure. Differences in foraging ability of the breeds might account for this variation among the chickens as compared to the present study.

Different estimates of repeatability for egg traits have been documented across poultry species with more reports on chicken (John-Jaja *et al.*, 2016; Ni *et al*., 2023), and to a lesser extent on quail (Ahmed, 2021; Udoh *et al.*, 2020) rather than duck (Lin *et al.*, 2016). High estimate of repeatability for EW among KC ducks in the current study aligns with the reports (John-Jaja *et al.*, 2016; Ahmed, 2021; Ni *et al*., 2023; Udoh *et al.*, 2020) in which high repeatability estimates ranging from 0.42 to 0.89 for egg weight were reported. However, a moderate estimate of repeatability for EW in AN ducks might be an indication of influence of factors that are non-genetic on the breed (Bovšková *et al.*,2014) with respect to the trait. Although, most of the earlier reports on egg weight repeatability estimates are high but the report by (Ahmed, 2021) indicating a low repeatability estimate for this traits in quail which contradicts the moderate range obtained for AN in the current study. Contrary to high estimates of repeatability for shell thickness for both KC and AN ducks in the current study, Lin *et al.* (2016) and Udoh *et al.* (2020) reported a low estimate for this trait. This might be as a result of breed peculiarity and variation in dietary calcium components which constitutes the bulk of shell contents (Chen *et al*., 2015). On the other hand, the low and high estimates (respectively) obtained for egg width and EL in the two duck breeds highly corroborate the report of Lin *et al.* (2016).

Conclusion

Khaki Campell and Ancona ducks vary slightly in their egg traits with Ancona ducks possessing a higher tendency for bigger and longer eggs than KC ducks while the repeatability estimates were generally low for yolk color, yolk height and Haugh unit. Improvement of egg length and egg weight are likely to yield a faster result when individuals with better performance are selected while utilization of relative records and improvement on non-genetic factors are recommended for the improvement of other measured traits except shell thickness.

Conflict of Interest Statement

The authors of this article hereby declare that there exists no potential conflict, be it personal, financial, cultural or what so ever, with respect to the objectivity of the manuscript.

References

Adamski, M., Bernacki, Z. and Kuniacka J. 2005. Changes in the biological value of duck eggs defined by egg quality. *Folia biol. (Kraków),* 53 (Suppl.): 107-114

Ahmed, L. 2021. Repeatability Estimates of egg number and egg weight under various production periods in three lines of local quail. *Advances in Animal and Veterinary Sciences*, 9(12): 2216-2220. DOI: 10.17582/journal.aavs/2021/9.12.2216.2220

Babington, S. and Campbell, D.L.M. 2022. Water for Domestic Ducks: The Benefits and Challenges in Commercial Production. *Front. Anim. Sci.*, 3: 1. doi.org/10.3389/fanim.2022.782507

Berkhoff , J., Alvarado-Gilis, C., Keim, J.P., Alcalde, J.A., Vargas-Bello-Pérez, E. and Gandarillas M. 2020. Consumer preferences and sensory characteristics of eggs from family farms. *Poult Sci.*, 2020 Nov; 99(11): 6239–6246. doi: 10.1016/j.psj.2020.06.064

Boğa-kuru, B.B., Kirmizibayrak, T., Cengiz, M.M. and Adigüzel, I.S. 2023 The effect of egg weight on egg external quality characteristics and hatching performance in Pekin ducks. *Kafkas Univ Vet Fak Derg* 29 (4): 415-422. doi: 10.9775/kvfd.2023.29657

Bovšková, H., Mikova, K. and Panovska, Z. 2014. Evaluation of egg yolk colour. Czech. *Journal of Food Sciences*, 32(3):213-217. DOI: 10.17221/47/2013-CJFS

Chen, W., Zhao, F., Tian, Z.M., Zhang, H.X., Ruan, D., Yan, L.Y., Wang, S., Zheng, C.T. and Lin, Y.C. (2015). Dietary calcium deficiency in laying ducks impairs eggshell quality by suppressing shell biomineralization. *J Exp Biol.*,218(Pt 20):3336-43. doi: 10.1242/jeb.124347

Cheng, X. and Ning, Z. (2023). Research progress on bird eggshell quality defects: a review. *Poultry Science*, 102(1): 102283. DOI: 10.1016/j.psj.2022.102283

Dvořák, P., Suchý, P., Straková, E. and Doležalová, J. 2010. Variation in egg yolk colour in different systems of rearing laying hens. *Acta Veterinaria Brno*,79: S13–S19; Doi:10.2754/avb201079S9S013

Dzhus, P., Sydorenko, O., Chen, B. and Liumeng, Li. 2021. Analysis of morphometric parameters of duck eggs of local breed Shaoxing. AGROFOR 6(1):2021. doi: 10.7251/AGRENG2101014D

El-Deghadi, A.S., Ali, W.A.H. and Gharib, M.G. 2022. Study for some body weight and egg traits in Domyati and Khaki-Campbell ducks. Open Journal of Agricultural Research 2(1): 29–36

El-Ghareeb, M.M., Abu –Heakal, N., Yousef, S.A., Seady, Y. and El-Shhat, A.M. 2018. Effect of Dumyati duck breeders age on productive performance, egg traits and their offspring duckling performance. *Mansoura Vet. Med. J*., 19(1):441 - 455

FAO, 2023. Food and Agriculture Organization. *Production: Crops and livestock and products*. In: FAOSTAT Rome. https://www.fao.org/faostat/en/#data/QCL

Harrington, D., Hall, H., Wilde, D. and Wakeman, W. 2020. Application of aromatic plants and their extracts in the diets of laying hens. *Feed Additives*, 2020: 187-203

Haugh, H. (1937). The haugh unit for measuring egg quality. *The U.S. Egg & Poultry Magazine*, 43, 552-555, 572-573

John-Jaja, S.A., Udoh, U.H. and Nwokolo, S.C. 2016. Repeatability estimates of egg weight and egg-shell weight under various production periods for Bovan Nera Black laying chicken. *Beni-Suef University Journal of Basic and Applied Sciences*, 5(4):389-394

Kavitha, K., Manohar, G. and Ramamurthy, N. 2017. Comparative study of egg quality traits In White Pekin and

Indigenous ducks of Tamil Nadu. *Int. J. Sci. Environ. Technol.*, 6, 3520-3523 .

Ketta, M. and Tůmová, E. 2016. Eggshell structure, measurements, and quality-affecting factors in laying hens: a review. *Czech J. Anim. Sci*. 61(7):299-309. doi: 10.17221/46/2015-CJAS

Lewko, L., Krawczyk, J. and Calik, J. 2021. Effect of genotype and some shell quality traits on lysozyme content and activity in the albumen of eggs from hens under the biodiversity conservation program. *Poultry Science*, 100(3): 100863. DOI: 10.1016/j.psj.2020.11.040

Lin, R.L., Chen, H.P., Rouvier, R.and Marie-Etancelin, C. 2016. Genetic parameters of body weight, egg production, and shell quality traits in the Shan Ma laying duck (*Anas platyrhynchos*). *Poultry Science*,95(11): 2514-2519

Liu, H., Zhou, Z., Hu, J., Guo, Z., Xu, Y., Li, Y., Wang, L., Fan, W., Liang, S., Liu, D., Zhang, Y., Xie, M., Tang, J., Huang, W., Zhang, Q. and Hou, S. 2021. Genetic variations for egg internal quality of ducks revealed by genome-wide association study. *Anim. Genet.*,52(4):536-541

Lokaewmanee, K. Yamauchi, K., Komori, T. andSaito, T. 2011. Enhancement of egg yolk color by paprika combined with a probiotic. *Journal of Applied Poultry Research*, 20(1): 90- 94. DOI: 10.3382/japr.2009-00140

Lu, L., Xue, Y., Asiamah, C.A., Zou, K., Liu, Y. and Su, Y. 2020. Evaluation of egg-laying performance, egg quality traits, and nutritional values of eggs of Leizhou Black Duck. *Europ. Poult. Sci.,* 84. 2020, DOI: 10.1399/eps.2020.319.

Ni, A., Calus, M.P.L., Bovenhuis, H., Yuan, J., Wang, Y., Sun, Y. and Chen, J. 2023. Genetic parameters, reciprocal cross differences, and age-related heterosis of egg-laying performance in chickens. *Genet. Sel. Evol.* 55: 87. DOI: 10.1186/s12711-023-00862-7

Oguntunji, A.O. and Ayorinde, K.L. 2015. Duck production in Nigeria: flock characteristics, management and mortality. Archiva Zootechnica 18:1, 27-40, 2015 27

Onbaşılar, E.E., Ünal, N. and Erdem, E. 2018. Some egg quality traits of two laying hybrids kept in different cage systems. *Ankara. Univ. Vet. Fak. Derg*,65:51–55

Riemensperger, A. 2023.*Economic upside of maintaining eggshell quality*. Agromed Poultry World Digital Magazine, June 2023 Edition

Rakonjac, S., Dosković, V., Bošković, S.B., Škrbić, Z., Lukić, M., Petričević, V. and Petrović, D. M. 2021. Production Performance and Egg Quality of Laying Hens as Influenced by Genotype and Rearing System. *Braz. J. Poult. Sci.* 23: 02. doi.org/10.1590/1806-9061-2019-1045

Rostinia, T., Biyatmokob, D. and Wahdib, A. 2021. Productivity of laying Alabio duck and its eggs quality under exposure of different intensity and color of led light. *Tropical Animal Science Journal*, June 2021, 44(2):205-212. DOI: 10.5398/tasj.2021.44.2.205

Shoimah, D., Djunaidi, I.H. and Sjofjan, O. 2019. Quality of duck eggs maintained using a different maintenance system in the Malang Raya area. *International Research Journal of Advanced Engineering and Science,* 4(4): 273-277

Sokołowicz, Z., Dykiel, M., Krawczyk, J. and Augustyńska-Prejsnar, A. 2019. Effect of layer genotype on physical characteristics and nutritive value of organic eggs. *CyTA J. Food.*17:11–19. doi: 10.1080/19476337.2018.1541480.

Sözcü, A., İpek, A., Oguz, Z., Gunnarsson, S. and Riber, A.B. 2021. Comparison of performance, egg quality, and yolk fatty acid profile in two Turkish genotypes (Atak-s and Atabey) in a free-range system. *Animals (Basel)*, 11(5): 1458. doi: 10.3390/ani11051458

Sulaiman, A., Wahdi, A., Suwanda, T.A., Hanafi, I. and Iqbal, A. 2023. Performance and egg quality of the Alabio ducks (Anas platyrhynchos borneo) on different ages of flocks during the first-laying period. IOSR *Journal of Agriculture and Veterinary Science*, 16(2): 12 -19. doi: 10.9790/2380-1602021219

Udoh, U.H., Ukana, U.M. and Isaac, U.C. 2020. Repeatability estimates of external and internal egg quality traits in Japanese quail. *Nigerian J. Anim. Sci.*, 22(1): 19-26.

USDA2020. United States Department of Agriculture. Egg Grading Manual, Agricultural Handbook, Number 75

Vishwavidyalaya, G.K., Sahoo, S.K., Karna, S.K., Saran, S., Sastry, K.V.H. and Kandi, N. 2014. Production performance of ducks under extensive system of management in tribal districts of Odisha. *Indian Journal of Poultry Science*, 49(1): 97-100

Yakubu, A. 2013. Characterisation of the local Muscovy duck in Nigeria and its potential for egg and meat production, *World's Poultry Science Journal*, 69(4):931 - 938. DOI: 10.1017/S0043933913000937

Zamani, P., Abdoli, R.A. and Ferdosi, M.H. 2023. Genetics of Reproduction for Livestock Species. *Front. Genet.*, 14 – 2023. Doi: 10.3389/fgene.2023.1210904

Date received: 1st October, 2024

Date accepted: 3rd March, 2025