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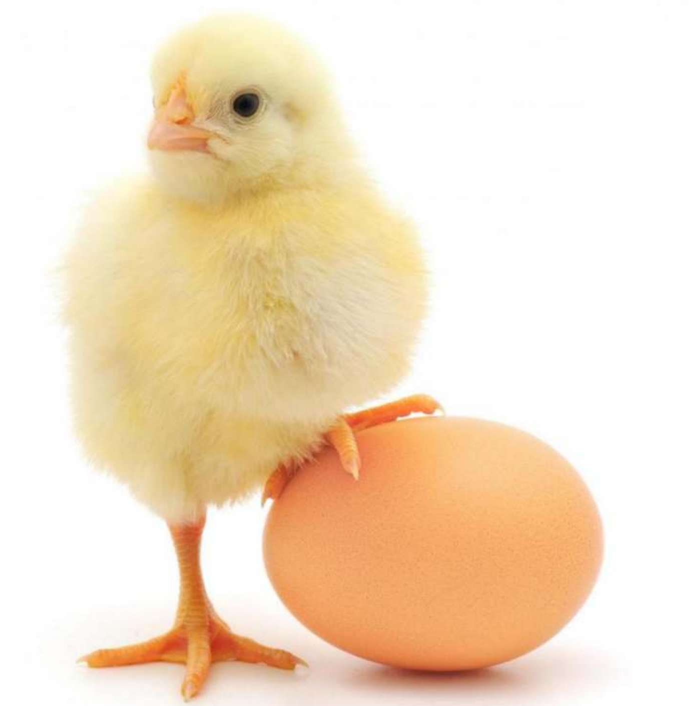

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Productivity and Egg Quality Characteristics of Free Range Naked Neck and Normal Feathered Nigerian Indigenous Chickens

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Abstract: A study was conducted in Nasarawa State, North Central Nigeria to determine the productivity and egg quality traits of free range naked neck and full-feathered chickens. A total of one hundred and two smallholder farmers were randomly selected. Information was obtained on average eggs per clutch, hatchability and mortality, while hen's body weight was measured directly on the day of egg collection. One hundred and two freshly laid eggs (51 eggs from each genotype) were used to evaluate external and internal egg qualities. Body weight and average eggs per clutch were significantly ($p<0.05$) higher in naked neck genotype compared to the normal feathered birds (1.30 vs. 1.16kg; 11.63 vs. 9.71 respectively). Normal feathered genotype recorded higher mortality (36.85%) than naked neck birds (28.60%). No significant ($p>0.05$) difference was found between the two genotypes in hatchability. Mean values for egg weight, egg length, egg width, egg shape index, shell thickness, albumen weight, albumen height, yolk weight, yolk height, yolk width and haugh unit were significantly ($p<0.05$) higher in naked neck hens than their normal feathered counterparts. There was no superiority in shell weight and yolk index. The association between egg weight and other egg biometrical traits were found to be positive and significant ($r = 0.22$-0.79; $p<0.05$). Other egg parameters were either positively or inversely correlated with each other. Egg weight was better predicted ($R^2 = 34.44\%$) using a combination of egg length and egg width. The estimation of shell weight from egg length, egg width and egg weight gave lower values ($R^2 = 2.86$-3.91%). The incorporation of allometry improved the prediction accuracy of shell thickness, albumen weight and yolk weight from egg weight ($R^2 = 44.16, 43.89$ and 49.89%). It is concluded that the introgression of the naked neck gene into poultry could play a pivotal role in the genetic improvement of traditionally managed flocks.

Key words: Productivity, egg parameters, relationships, indigenous chickens, Nigeria

Introduction

The Nigerian local chickens appear to be generally heterogeneous with no specific colour pattern and non-descriptive both in phenotype and genotype. The native chickens constitute about 80 percent of the 120 million poultry birds. They are known for their adaptation superiority in terms of their resistance to endemic diseases and other high environmental conditions (Nwakpu *et al.*, 1999). The local birds seen in villages may have been crossed with exotic cocks in earlier years through the cockerel exchange programme amongst others, but such gene may have been dispersed and lost in the population because of unplanned breeding programme and absence of selection (Njue *et al.*, 2002). One way of overcoming challenges posed by past strategies in improving sustainable productivity is through genetic selection and development of sustainable indigenous parent stock. Among the major genes of interest that can be considered for this purpose is the naked neck. The naked neck gene is incompletely dominant with Na/na birds showing an isolated tuft of feathers on the ventral side of the neck above the crop, while Na/Na birds either lack this tuft or it is reduced to just a few pin feathers or small feathers. The resulting bare skin becomes reddish, particularly in males as they approach sexual maturity (Somes, 1990). The reduction in feather coverage in naked neck birds permits convectional heat loss from the animal surface, thereby leading to improved thermo-regulation under the prevailing conditions. Mohammed *et al.* (2005) reported the superiority of Bare-neck indigenous chickens over two other Sudanese local fowls in terms of live weight. Similarly, Merat (1990) reported that in high temperatures near 30°C or higher, naked neck birds had a better laying rate, mean egg weight, egg shell strength and carcass yield than normal feathered birds.

In many developing countries, the local gene pool still provides the basis for the poultry sector. The genetic resource base of the indigenous chickens could form the basis for genetic improvement and diversification to produce breeds adapted to local conditions. However, there is paucity of information about existing or potential levels of productivity and production characteristics of indigenous chickens managed under extensive systems (Hoffman, 2005). In Nigeria, previous characterization attempts on indigenous chickens with major genes have been concentrated on on-station performance at the expense of on-farm testing.

The present investigation therefore, was designed to determine the productivity and egg quality characteristics of both full-feathered and naked neck birds under farmers' management. It equally established phenotypic relationships among the egg quality traits; and developed prediction equations using egg weight and other egg quality parameters.

Materials and Methods

Study site: The study was carried out in five randomly selected villages in each of the three agricultural zones (Nasarawa South, Nasarawa Central and Nasarawa West) of Nasarawa State, Nigeria from September 2006-June 2007. A pre-survey was done to identify households keeping naked neck and full feathered indigenous chickens which were at the laying stage.

Sampling of households: One hundred and two households were selected using random sampling. This corresponded to thirty four households per agricultural zone. Farmers who possessed village chickens and were keen to release eggs for quality analysis were considered. Each household was regarded as an experimental unit.

Data collection: Data on productivity (apart from hen's body weight) was collected using structured questionnaires; the productivity parameters taken were hen's body weight (measured directly with a scale on the day of egg collection), average eggs per clutch, hatchability and mortality. A total of one hundred and two freshly laid eggs, one from each of the experimental units were subjected to quality analysis in the laboratory. The external egg quality traits investigated were, egg weight (g), egg length (cm), egg width (cm) and egg shape index (%). Similarly, internal egg parameters were measured. They include, shell weight (g), shell thickness (mm), albumen weight (g), albumen height (mm), yolk height (cm), yolk width (cm), yolk weight (g), yolk index (%) and haugh unit. Egg quality traits were measured following standard procedures (Reddy *et al.*, 1979; Monira *et al.*, 2003; Fayeye *et al.*, 2005). Egg weight was determined using an electronic scale, while egg length and width were measured with a vernier caliper. Egg shape index was calculated as a ratio of the egg width to the egg length as follows:

$$\text{Egg shape index} = \frac{\text{Egg width} \times 100}{\text{Egg length}}$$

Each egg was later carefully opened around its sharp ends, large enough to allow the passage of both albumen and the yolk through it without mixing their contents together. The yolk and the albumen were then placed in separate Petri dishes, which had initially been weighed. The difference in the weight of each Petri dish after and before the introduction of the yolk and albumen was taking as the weight of the yolk and albumen respectively. The yolk and albumen heights were determined using a tripod micrometer. The yolk width was measured around the widest horizontal circumference using vernier caliper. Yolk index was determined as ratio of the yolk height to the yolk width. Shell weight (shell membrane inclusive) was obtained by weighing on the electronic scale. The thickness of each shell was determined using a micrometer screw gauge. Accuracy of shell thickness was ensured by measuring shell sample at the broad end, middle portion and narrow end of the shell. Individual Haugh unit (Haugh, 1937) score was calculated using the egg weight and albumen height as follows:

$$Hu = 100 \log (H + 7.6 - 1.7W^{0.37})$$

Where,

Hu = Haugh unit

H = observed height of the albumen in millimeter.

W = weight of egg in grams.

Statistical analysis: Analysis of variance was done for all recorded parameters using the appropriate sub-routine of SAS (1999) statistical packages to find out the differences between the two genotypes. Means separation was carried out using Least Significant Difference (LSD) method on the level $p<0.05$.

Pearson's coefficients of correlation among the various egg parameters (pooled data) were estimated. Prediction of egg weight and shell weight (dependent variables) using egg length, egg width and egg weight (independent variables) individually (simple linear regression), collectively (multiple regression) and the use of allometry in different cases was effected. Allometry was also used to show the relationship existing individually between albumen weight, yolk weight and shell thickness (dependent variables) and egg weight (independent variable).

The following regression models were employed as applicable to each case:

$Y = a + bX$ ----- simple linear regression

$Y = a+b_1X_1+b_2X_2+b_3X_3+\cdots b_k X_k$ ----- multiple regression

$Y = aX^b$ ----- allometric equation.

Where,

Y = dependent or response variable

a = intercept (the value of the dependent variable when the independent is zero)

b = regression coefficient

X = the independent variable.

Results and Discussion

Productivity parameters of indigenous chickens: Productivity parameters of naked neck and normal feathered indigenous chickens are shown in Table 1.

Table 1: Production data of naked neck and normal feathered indigenous chickens

Traits	Naked neck (NaNa)	Normal feathered (nana)	SEM
Body weight (kg)	1.30[a]	1.16[b]	0.02
Average eggs per clutch	11.63[a]	9.71[b]	0.25
Hatchability (%)	71.49	72.13	0.95
Mortality (%)	28.66[b]	36.85[a]	0.61

SEM: Standard error of means; Means within the same row bearing different superscripts are significantly different (p < 0.05)

There was a significant difference (p<0.05) in the body weights of the two genotypes, with higher mean value (1.30kg) recorded for naked neck hens compared to their normal feathered counterparts (1.16kg). This superiority was also confirmed by Njenga (2005), although slightly higher values were reported for mature body weights (1.40 and 1.30kg for NaNa and nana birds respectively). The present result on naked neck birds compares with the value of 1.30kg reported for native hens under the management of farmers in a selected area of Bangladesh (Ershad, 2005). The average of 1.16 and 1.30kg obtained in this study are higher than the range of 1.06-1.12kg recorded elsewhere for Nigerian local chicken type (Wekhe and Uku, 2006). However, they fall below the average live weights of 1.55 (naked neck) and 1.49kg (Baladi) reported for Sudanese indigenous chicken types (Mohammed *et al.*, 2005). In a similar fashion, El-Safty *et al.* (2006) reported values of 1.58 and 1.45kg as mature body weights for naked neck and normal feathered birds under low ambient temperature in Egypt. These disparities might not be unconnected with the fact that hens used in the earlier two countries were selected and subjected to better feeding and environmental conditions. This might have positively impacted on their superior performance. The favourable effect of the Na gene on body weight in the present study might be attributed to its association with pronounced heat tolerance. The gene, according to Ikeobi *et al.* (2004), causes bare skin on the chicken neck, leading to 30-40% reduction in the plumage, thereby giving the birds a better heat dissipation. This would in turn preserve more energy that could have been used for thermal homeostasis and this energy is subsequently directed to productive functions including body weight gain. Significantly higher (p<0.05) mean eggs per clutch was obtained in naked neck (11.63) than fully feathered birds (9.71). These result compare favourably with the findings of Mapiye and Sibanda (2005) where on average, village chickens laid and incubated 10±2 and 8±1 eggs per clutch. The better performance of naked neck birds is not unexpected as the Na gene could limit the negative effect of long-time heat stress (Chen *et al.*, 2004), which is a characteristic feature of tropical environment However, the values obtained are lower than the range 12. 70-14.72 reported by Njenga (2005).

There was no significant difference (p>0.05) observed in hatchability, although their was a tendency towards higher hatchability in normal feathered than the naked neck birds (72.13 vs. 71. 49%). The present results are comparable to the value of 69 and 74% recorded for village chickens between communal and small-scale commercial farming areas in Zimbabwe (Maphosa *et al.*, 2004). They are, however, higher than the mean value of 61.2% recorded for backyard chicken in Charsadda, Pakistan (Farooq *et al.*, 2002). The present finding is not in consonance with the earlier report on indigenous Fulani-ecotype chickens, where percentage hatchability was 48, although the extremely low value obtained according to Fayeye *et al.* (2005) might not be a true reflection of the genetic potential of this ecotype, as most of the embryo died few days before hatching. Such a late embryonic mortality may be due to non-genetic factors. Naked neck birds had significantly lower mortality than their full-plumage counterparts (28.66 vs. 36.85%; p<0.05). The mortality estimated was collectively based on diseases and weather effect, outside of that engendered by predation, theft and accidents. The values obtained in the present study are lower than the 74.40 and 45.10% reported for normal-plumage and naked neck genotypes by Njenga (2005); but higher than the 17. 5% observed in Desi chicken (Farooq *et al.*, 2002). The association of the Na gene with a higher disease resistance has also been reported (Kitalyi, 1998). Similarly, El-Safty *et al.* (2006) reported that naked necks have a better ability to secrete Acute Phase Protein (APP) produced in the liver cells, which gives protection to birds against infection or any invasion. Additionally, the lowest incidence of pathologies (cloacal cysts, prolapse, Marek's disease, coccidiosis, osteodystrophy and salmonellosis) were observed in naked neck birds compared to their normal-plumage counterparts; and these results, together with direct challenge and indirect immunity tests, suggest a greater disease resistance associated with the Na gene (Fraga *et al.*, 1999).

Egg quality traits of indigenous chickens: Mean values for external and internal traits of the eggs are presented in Table 2. Significant differences (p<0.05) were observed between naked necks and normal feathered birds in egg weight (43.04 vs. 40. 83g), egg length (5.15vs.4.87cm), egg width (3.84 vs.3.54 cm), egg shape index (74.68 vs. 72.60), shell thickness (0.38 vs. 0.34 mm), albumen weight (20.53 vs. 17.61g), albumen height (4.65 vs. 4.29 mm), yolk weight (16.95 vs.16.05 g), yolk height (1.19 vs. 1.05 cm), yolk width (2.35 vs. 2.16 cm) and haugh unit (73.22 vs. 71.40). However, the two genotypes were found not to be significantly different (p>0.05) in shell weight (4.48 vs. 4.65g) and yolk index (50.60 vs. 48.77).

Table 2: Mean values of egg quality characteristics of naked neck and normal feathered indigenous chickens

Traits	naked neck (NaNa)	Normal feathered (nana)	SEM
External qualities			
Egg weight (g)	43.04[a]	40.83[b]	0.33
Egg length (cm)	5.15[a]	4.87[b]	0.03
Egg width (cm)	3.84[a]	3.54[b]	0.09
Egg shape index (%)	74.68[a]	72.60[b]	0.49
Internal qualities			
Shell weight (g)	4.48	4.65	0.08
Shell thickness (mm)	0.38[a]	0.34[b]	0.006
Albumen weight (g)	20.53[a]	17.61[b]	0.33
Albumen height (mm)	4.65[a]	4.29[b]	0.05
Yolk weight (g)	16.95[a]	16.05[b]	0.22
Yolk height (cm)	1.19[a]	1.05[b]	0.02
Yolk width (cm)	2.35[a]	2.16[b]	0.03
Yolk index (%)	50.60	48.77	0.72
Haugh unit	73.22[a]	71.40[b]	0.31

SEM: Standard error of means; Means within the same row bearing different superscripts are significantly different ($p < 0.05$)

The mean egg weights in the present study are higher than values of 37.95, 38.46 and 39.89 reported for Sudanese indigenous chicken types (Mohammed *et al.*, 2005). They are also close to the values obtained for naked necks and normal feathered birds in coastal Kenya (Njenga *et al.*, 2005). Although egg weight is largely affected by environmental factors, feed restriction (Cary *et al.*, 1993) and parental average body weight; evidence of genetic involvement could equally be observed. The Na gene seems to have higher egg length than the Fulani-ecotype chicken (Fayeye *et al.*, 2005). It also compares with the values recorded for commercial layers by Abanikannda and Leigh (2007); however, they reported higher average egg width. Genetic difference in egg length and egg width were also elucidated and accentuated by Monira *et al.* (2003). Egg shape index is a good indicator of external egg quality. The higher value obtained in naked necks further consolidated their superiority over the normal plumage birds. The mean shell weights obtained in the present study are comparable to that reported for the two genotypes in a similar study (El-Safty *et al.*, 2006) and higher than that reported by Ershad (2005). This suggests their significance for adaptability and suitability to the sub-humid tropical environment. Shell quality particularly shell thickness, is an important bio-economic trait that primarily breeder of egg laying flock incorporate in their breeding programmes to reduce egg shell breakages. However a different trend was realized for shell thickness, where the Na genotype had an edge over the fully feathered birds. This is inconsistent with the finding of El-Safty *et al.* (2006). Ikeobi *et al.* (2004) also reported a higher average shell thickness value in normal plumage genotype, although the difference was not significant. The mean albumen weight and albumen height of naked necks are in agreement with those reported by Fayeye *et al.* (2005) for Fulani ecotype chicken. They are lower than that obtained in layer breeders (Olawumi *et al.*, 2006), but with a higher yolk weight. The naked necks equally outperformed their Fulani-ecotype in yolk weight. Yolk index and haugh unit have been reported to be the best indicators of internal egg quality (Ihekoronye and Ngoddy, 1985). The present values obtained suggest that eggs of both genotypes are of good quality.

Phenotypic correlations of egg parameters: Phenotypic correlation coefficients of egg quality traits (pooled data) are presented in Table 3. Positive and significant ($p<0.05$) correlations were observed between egg weight and other egg biometrical traits (r = 0.22-0.79). Egg length was highly and significantly ($p<0.05$) correlated (r = 0. 71) with egg width. The relationship between egg shape index and width was also high (r = 0.68). However, shell weight had a very weak positive association with yolk width, haugh unit, albumen weight, egg length, albumen height, egg shape index, yolk height and yolk index. On the other hand, the relationship between shell thickness and other egg quality parameters ranged from low to high values (r = 0.03-0.65). Albumen weight was moderately and highly correlated with haugh unit, yolk width, yolk height, yolk weight and albumen height respectively (r = 0. 40-0.60). The highest positive correlation was found between albumen height and haugh unit (r = 0.80) while the lowest was observed between egg shape index and yolk index (r = 0.02). However, inverse relationships existed between egg length and egg shape index (r = -0.02), shell weight and yolk weight (r = -0.02) and yolk width and yolk index (r = -0.27). The present positive relationship between egg weight and other egg quality indices is in concordance with the observations of Abanikannda and Leigh (2007). The strong association between egg weight and albumen height, yolk height, yolk weight, albumen weight, shell thickness and yolk width indicate that improvement on any of these traits through artificial breeding could result in concomitant improvement of the other traits. In other words, their action could more or less be additive in nature, suggesting an integrated manner of influence. The low value recorded for egg weight and shell weight concurs with the submission of El-Safty *et al.* (2006), although there was disparity in the correlation estimates of shell thickness where they reported negative and extremely low coefficients. The negative relationship between egg length and egg shape index confirms the finding of earlier workers (Ewa *et al.*, 2005). This is an indication that the determinant of egg shape index is more of the function of egg width. Conversely, the estimate of correlation in the present study is higher than the 0.27 reported by Dauda *et al.* (2006).

Table 3: Correlation matrix of egg quality characteristics

Egg weight	Egg length	Egg width	Egg shape index	Shell weight	Shell thickness	Albumen weight	Albumen height	Yolk weight	Yolk height	Yolk width	Yolk index	Haugh unit
Egg weight	0.55	0.55	0.23	0.22	0.65	0.66	0.79	0.69	0.79	0.64	0.30	0.48
Egg length		0.71	- 0.02	0.12	0.43	0.52	0.39	0.32	0.50	0.44	0.15	0.26
Egg width			0.68	0.19	0.33	0.57	0.38	0.32	0.45	0.41	0.13	0.26
Egg shape index				0.16	0.03	0.26	0.14	0.12	0.14	0.15	0.02	0.10
Shell weight					0.25	0.07	0.15	-0.02	0.18	0.03	0.18	0.04
Shell thickness						0.53	0.58	0.56	0.53	0.56	0.06	0.41
Albumen weight							0.60	0.57	0.54	0.47	0.19	0.40
Albumen height								0.57	0.67	0.54	0.26	0.80
Yolk weight									0.54	0.53	0.10	0.40
Yolk height										0.64	0.56	0.37
Yolk width											-0.27	0.31
Yolk index												0.06
Haugh unit												

Significant at $p<0.05$ for all correlations $\geq$ 0.19

Table 4: Prediction equations of selected egg variables

Functions	R^2 (%)	Significance
$Y_1 = 14.89 + 5.40\ X_1$	29.70	*
$Y_1 = 22.21 + 5.34\ X_2$	30.10	*
$Y_1 = 14.71 + 3.10\ X_1 + 3.17\ X_2$	34.44	*
$Y_1 = 15.30\ X_1^{0.63}$	29.58	*
$Y_1 = 23.60\ X_2^{0.44}$	28.63	*
$Y_2 = 2.77 + 0.49\ X_2$	2.86	*
$Y_2 = 2.15 + 0.06\ X_3$	3.90	*
$Y_2 = 2.13 + 0.05\ X_3 + 0.007\ X_1$	2.90	*
$Y_2 = 1.82 + 0.04\ X_3 + 0.26\ X_2$	3.72	*
$Y_2 = 2.79\ X_2^{0.37}$	3.38	*
$Y_2 = 0.74\ X_3^{0.48}$	3.91	*
$Y_3 = -0.17 + 0.01\ X_3$	41.20	*
$Y_3 = 0.001\ X_3^{1.55}$	44.16	*
$Y_4 = -9.43 + 0.68\ X_3$	42.60	*
$Y_4 = 0.06x_3^{1.54}$	43.82	*
$Y_5 = -1.37 + 0.43\ X_3$	47.73	*
$Y_5 = 0.23\ X_3^{1.14}$	49.89	*

Y_1 = Egg weight; Y_2 = Shell weight; Y_3 = Shell thickness;
Y_4 = Albumen weight; Y_5=Yolk weight; X_1= Egg length;
X_2 = Egg width; X_3 = Egg weight;
R^2 = Coefficient of determination; *p < 0.05

Prediction equations of selected egg parameters: Prediction equations involving selected egg variables are presented in Table 4. Egg weight was predictable from egg length and egg width singly with sufficient reliability (R^2 = 29.70 and 30.10%; $p<0.05$). However, a better and more reliable estimate was obtained when both egg length and egg width were fitted into the model (R^2 = 34.44%). The use of allometry did not improve the prediction accuracy. The results of the present study agree with the findings of Farooq *et al.* (2001) on the positive estimation of egg weight from egg length and egg width. The prediction of shell weight from egg width and egg weight singly; and linear combinations of egg weight and egg length and egg weight and egg width recorded low values (R^2 = 2.86-3.90%), although significance was exerted. Similarly, the allometric measures gave weak values (R^2 = 3.38 and 3.91%). This might have informed the negative allometric exponent (b). Comparatively, these findings are in line with the reports of Khurshid *et al.* (2003) who observed low R^2 values from the prediction of eggshell weight from egg weight, egg length and egg width. Shell thickness, albumen weight and yolk weight were predicted with sufficient accuracy from egg weight (R^2 = 41. 20-47. 73%). However, the use of allometry improved the reliability of the regression equations (R^2 = 43.82-49.89%). The present result is inconsistent with the submission of Khurshid *et al.* (2003) where extremely low R^2 values were obtained from the linear estimation. It is in agreement with the findings of Abanikannda and Leigh (2007) where there was positive allometry in the regression of albumen weight on egg weight, although they reported negative allometry for yolk weight.

Conclusion: This study has shown that naked neck hens were superior to their normal feathered counterparts in body weight, average eggs per clutch and mortality. No significance difference was observed in hatchability. Although genotype did not influence shell weight and yolk index, means values for other egg parameters were higher in naked neck birds. Positive and significant correlation coefficients were observed between egg weight and other egg variables. With the exception of egg length and egg shape index, shell weight and yolk weight and yolk index and yolk width, other egg indices associated positively with each other. The prediction of egg weight from both egg length and egg width gave better result. However, lower R^2 values were obtained when shell weight was predicted from egg length, egg width and egg weight singly or jointly. The use of allometric equations improved the estimation of shell thickness, albumen weight and yolk weight from egg weight.

Recommendations: In spite of the fact that naked necks possess the ability to survive, perform and reproduce under harsh conditions, their potentials have not been fully exploited in North Central Nigeria. Therefore, it is recommended that:

(1) The naked neck birds should be included in the breeding strategies involving the mating of selected indigenous birds with desirable qualities.
(2) More genetic progress could be made if local stock is crossed with appropriate exotic breeds.

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