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Genetic Estimates and Reproductive Traits of Two Local Turkey Variants and their Reciprocal Hybrids in Zaria, Nigeria

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Abstract

A two-generation experimental study was carried out to assess the reproductive performance of two indigenous turkey strains. From a foundational population composed of white, black, main cross (white male x black female), and reciprocal cross (black male x white female) birds, a total of 180 poults were generated. Each breeding group contained 45 poults, replicated three times. At eight weeks, the heaviest tom and two hens per replicate were chosen to record reproductive data, a process repeated for the second generation (G2). Data analysis employed the General Linear Model (GLM) in SAS, and differences among strains were evaluated using Duncan's Multiple Range Test. Heritability was estimated through variance component analysis. Results showed that egg production (5.15±0.16 and 4.66±0.16 eggs/week) and body weight at first lay (3632.88±48.98 g and 3532.53±48.98 g) were significantly higher ($p<0.05$) in G2 compared to G1 (first generation). Fertility (72.70% and 63.49%) and hatchability (56.76% and 41.09%) declined in G2. No significant strain effects were found in G1 reproductive traits except hatchability; however, in G2, white strain and main cross showed superior egg production and earlier age at maturity. Heritability estimates ranged from low to moderate, indicating stronger environmental influence.

Keywords: Genetic Parameters, Reproductive Traits, Indigenous Turkeys, Reciprocal Crosses, Poultry Breeding

Introduction

Turkey production is increasingly recognized as a profitable sector globally (Kabir *et al*., 2015). However, in Nigeria, it remains underdeveloped due to factors such as lack of detailed information on breeds, adaptability, disease susceptibility, and feed management (Shettima *et al*., 2023). Promoting indigenous turkey farming could enhance food security and alleviate poverty (Shettima *et al.,* 2022).

Key reproductive traits like egg production, fertility, and hatchability dictate the profitability of turkey operations (Adebiyi *et al*., 2014). Among these, egg production is the dominant income source, accounting

for nearly 90% of returns (Oluyemi and Roberts, 1979). Despite optimal conditions, turkey hens produce only 60-100 eggs annually, with moderate fertility and hatchability rates (Ozcelik *et al.,* 2009). Several factors influence these traits including mating systems, age, nutrition, health, and environmental conditions (King'ori, 2011).

Heritability describes the proportion of trait variance attributable to genetics (Aboul-Seoud, 2008) and informs breeding strategies. Reproductive traits often exhibit low heritability, suggesting a greater role of environmental factors and advocating for crossbreeding methods (Mcphee, 2001; Kosum *et al.,* 2004). Conversely, productive traits like body weight show higher heritability (Emamgholi Begli *et al.,* 2019).

Previous studies observed variations in growth performance linked to plumage color, with black turkeys typically outperforming white ones in weight gain (Ilori *et al.,* 2019; Shettima *et al.,* 2022). There is limited data on the reproductive traits across indigenous turkey strains in Nigeria, motivating this study to estimate heritability and assess the reproductive traits of selected strains and their hybrids.

Materials and Methods

Study Location

The experiment was conducted at the Teaching and Research Farm of the Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria. Zaria is situated in the Northern Guinea Savannah, at latitude 11° 9′ 45″ N and longitude 7° 33′ 8″ E, with an elevation of 610 meters above sea level. Annual rainfall ranges between 1100-1200 mm, while temperatures vary between 14°C and 39°C. The climate is categorized into three seasons: a hot dry season (March-May), a rainy season (June-October), and a cool dry season (November-February).

Experimental Design and Bird Management

The breeding stock comprised 36 adult turkeys, split equally among white and black strains, consisting of 12 males and 24 females. They were allocated into four mating groups: white strain, black strain, main cross, and reciprocal cross, each replicated thrice. Eggs collected from these groups yielded 180 poults (G1). At 8 weeks, 12 toms and 24 hens with superior body weights were selected for breeding, and the same selection criteria were applied to the next generation (G2).

Birds were fed ad libitum with formulated diets: starter (2800 kcal ME/kg, 28% crude protein CP), grower (2900 kcal ME/kg, 18% CP), and breeder rations (2900 kcal ME/kg, 15% CP), based on NRC (1994) recommendations. Standard vaccination and health management practices were maintained.

Data Collection

- **Egg Number:** Average eggs laid per hen weekly.
- **Age at First Lay:** Age in weeks at first egg laying.
- **Body Weight at First Lay:** Weight at first egg production.
- **Fertility (%):** (Fertile eggs/Total eggs) × 100
- **Hatchability (%):** (Hatched chicks/Fertile eggs) × 100

Statistical Analysis

The General Linear Model (GLM) procedure in SAS (2002) was employed. Duncan's Multiple Range Test was used to separate means. Variance components were calculated to estimate heritability using the mixed model:

$Y_{ijklm} = \mu + G_i + H_j + S_k + E_{ijklm}$

Where:

- Y_{ijklm} = observation
- μ = overall mean
- G_i = effect of the i^{th} generation

- H_j = effect of the j^{th} genotype
- S_k = effect of the k^{th} sire
- E_{ijklm} = random error term

Results and Discussion

Table 1 shows the effect of generation on reproductive traits of Nigerian local turkey. Significant differences ($p<0.05$) were recorded between G1 and G2 for egg number, fertility, hatchability, and body weight at first lay, but not for age at first lay. Egg production and body weight were significantly higher in G2, suggesting positive selection response. However, fertility and hatchability rates declined, possibly due to seasonal differences in data collection and storage conditions.

Table 2 shows the effect of genotype on reproductive traits in generation 1 and 2. In G1, significant differences ($p<0.05$) were only observed for hatchability, with the black strain outperforming others. In G2, white strain and main cross exhibited higher ($p<0.05$) egg production and earlier maturity, making them suitable for reproductive purposes.

Table 3 and 4 shows the heritability estimates for reproductive traits of black and white strain. The heritability estimates for reproductive traits were generally low to moderate across both strains and generations. Traits like age at first lay and body weight at maturity showed moderate to high heritability, indicating potential for improvement through selection, while traits like egg number, fertility, and hatchability were more environmentally influenced.

Discussion

Mean fertility (68.09%) observed in this study was less than the 95% fertility reported by Salim *et al*. (2014) in an improved breed of turkey eggs imported from France to Sudan, but is similar to the study of Ann Anandh *et al*. (2012) wherein they observed a fertility percentage of 68.85% in turkey. Hatchability (48.92 %) observed in this study was lower than 67.49, 62.30 and 59.38% observed during winter, summer and monsoon, respectively (Jahan *et al*., 2018). Similarly, Salim *et al*. (2014) observed higher hatchability of 79.26% in turkey eggs incubated artificially. Conversely, Asaduzzaman *et al*. (2017) observed a lower hatchability of 10.8, 18.9 and 27.0% from farmers that used turkey hen, chicken hen, both turkey and chicken hens, respectively to incubate eggs. The lower hatchability observed in this study might be as a result of factors of the hatchery. The higher egg number observed in generation two against generation one shows that there was positive response to selection in egg production. This is similar to the reports of Friars (1970), and Mukherjee and Friars (1970) who observed a significant increase in egg number in line selected for short-term increased Body Weight at either 8, 12, or 24 weeks of age. This is contrary to the report of Nestor and Noble (1995) who noticed an increase in mature body weight in line selected for 16-weeks increased body weight leads to a loss of three eggs per hen per generation. Heavier mature body weight observed in generation two is in accordance to the findings of Nestor and Noble (1995) where they recorded a significantly higher mature weight in line selected for 16 weeks increased body weight as generation of selection increases. Higher fertility and hatchability observed in G_1 over G_2 shows a negative response to selection. This corresponds with the study of Nestor and Noble (1995) who observed decrease in fertility and hatchability in the selected line compared to the Random Bred Control line even though the former (selected line) hens were artificially inseminated more frequently than Random Bred Control hens. Similarly, Friars, (1970), Mukherjee and Friars, (1970) as updated by (Nestor and Noble, 1995) reported that duration of fertility was reduced by selecting for increased growth rate. The author further opined that fertility in turkey is negatively correlated with body weight. The superiority of G_1 over G_2 in terms fertility and hatchability could be due seasonal variation during hatching. Fertile eggs from G_1 population were hatched in cold season, which was the favourable weather for hatching. This is in line with the report of King'ori (2011) and Jahan *et al*. (2018) who stated that climatic condition affects both fertility and hatchability.

The pattern of egg lay and the age at first egg lay observed in this study is in line with the study of Tadelle *et al.* (2000) who reported that egg were collected every alternate day from six month of age. Also, Siopes *et al*. (2010) observed age at sexual maturity in turkey to be 23-26 weeks of age. Contrarily, Adebiyi *et al*. (2014) reported that a turkey will start lay from the 30th weeks of age. Significant difference observed in hatchability among the different strains and their crosses In G_1, is in accordance with the study of King'ori *et al*. (2010) that hatchability is a traits that varies among strains and breeds. The differences observed is a character of the strain because other factors (flock age, storage condition, season of hatching, incubation environment and nutrition) that affect hatchability as reported by (Brah and Sandhu, 1989; Roque and Soares, 1994; Buhr, 1995; Permsak, 1996 and Jahan *et al.*, 2018) were controlled. Significantly higher egg number and early age at first egg lay observed in white strain and is similar to main cross shows that the strain and said cross are better for reproduction compared to the black and reciprocal cross.

Lower heritability estimates observed in egg number and moderate to low values observed in fertility and hatchability in both strain corresponds with the findings of some authors (Arthur and Abplanalp, 1975; Jankoski, 1989; Wawro *et al*., 1993; Wawro *et al*., 1996) who all observed a lower heritability estimates in reproductive traits of turkey. They concluded that reproductive traits (egg production, fertility and hatchability) are among low-heritable characters that are influenced by non-additive gene action (dominant and epistasis) or environmental factors. Similarly, Sapp *et al*. (2004) reported low heritability in fertility and hatchability of chickens. More so, moderate heritability estimates observed in fertility and hatchability in this study is in accordance with the study of Kranis *et al*. (2006) and Emamgholi Begli *et al*. (2019) who observed a range of 0.22 to 0.34 as heritability for reproductive traits in turkey. They concluded that variability due to additive genetic values was low compared to non-additive components, hence the trait is more influenced by environment. Furthermore, the higher estimates observed in age at first egg lay in both strains agrees with the report of Emamgholi Begli *et al*. (2018) where they reported higher heritability value (0.62) for age at first egg lay. Similarly, Wolc *et al*. (2012) and Tongsiri *et al*. (2015) observed a higher heritability estimate for age at first egg lay in chicken.

Table 1: Effect of generation on reproductive traits of turkey

Reproductive traits	Grand mean	Generation 1	Generation 2	LOS
Egg number (per week)	4.90±0.11	4.66±0.16^{b}	5.15±0.16^{a}	*
Fertility (%)	68.09±0.94	72.70±1.33^{a}	63.49±1.33^{b}	*
Hatchability (%)	48.92±1.14	56.76±1.61^{a}	41.09±1.61^{b}	*
BW at maturity (g)	3582.70±34.64	3532.53±48.98^{b}	3632.88±48.98^{a}	*
Age at maturity (weeks)	27.44±0.16	27.22±0.23	27.66±0.23	NS

^{ab} means with different superscript on the same row are significantly different at $p<0.05$; NS= Not significant; LOS= level of significant; Age= in week; BW= body weight.

Table 2: Effect of genotype on reproductive traits of turkey in generation 1 and 2

Gen	Reproductive traits	Main cross	White	Black	Reciprocal cross	LOS
1	Egg number (per week)	4.8333±0.47	5.3056±0.29	4.3056±0.40	4.1944±0.29	NS
	Fertility (%)	77.540±2.88	64.359±2.02	77.652±2.94	70.466±3.70	NS
	Hatchability(%)	58.929±4.18^{ab}	46.770±2.16^{b}	62.531±4.13^{a}	58.462±4.06^{ab}	*
	BW at Maturity (g)	3583.8±67.33	3552.6±121.87	3554.0±91.90	3841.1±108.67	NS
	Age at maturity (weeks)	27.500±0.33	27.7500±0.36	27.6250±0.26	27.7500±0.25	NS
2	Egg number	5.01±0.22^{ab}	5.38±0.22^{a}	4.60±0.22^{b}	4.63±0.22^{b}	*
	Fertility (%)	69.17±1.88	65.51±1.88	69.88±1.88	67.83±1.88	NS
	Hatchability (%)	49.77±2.27	47.75±2.27	48.58±02.28	49.59±2.28	NS
	BW at maturity (g)	3527.31±69.27^{bc}	3418.94±69.27^{c}	3630.25±69.27^{ab}	3754.31±69.27^{a}	*

Age at maturity(weeks)	27.0000±0.59[ab]	25.6250±0.65[a]	28.7500±0.37[c]	27.5000±0.63[b]	*

[abcd] means with different superscript on the same row are significantly different at $p<0.05$; NS= Not significant; LOS= level of significant; BW= body weight.

Table 3: Heritability (± SE) estimates of reproductive traits of white turkey in generations 1 and 2

Traits	Generation 1	Generation 2
Egg number	0.02±0.06	0.07±0.11
Fertility	0.25±0.07	0.11±0.02
Hatchability	0.23±0.05	0.13±0.12
Age at maturity	0.42±0.23	0.58±0.17
BW at maturity	0.42±0.04	0.54±0.03

BW= body weight.

Table 4: Heritability (± SE) estimates of reproductive traits of black turkey in generations 1 and 2

Traits	Generation 1	Generation 2
Egg number	-	0.05±0.10
Fertility	0.25±0.11	0.10±0.02
Hatchability	0.43±0.11	0.19±0.12
Age at maturity	0.25±23	0.42±0.27
BW at maturity	0.47±0.04	0.79±0.03

BW= body weight.

Conclusion

Selection for higher 8-week body weight enhanced egg production and body weight at first lay but led to reduced fertility and hatchability. Indigenous turkeys can be genetically improved through selection, especially for body weight traits, but environmental management should be prioritized to sustain fertility and hatchability rates. White strain and main cross are recommended for reproductive performance based on their superior egg production and earlier maturity.

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