Global Scientific and Academic Research Journal of Multidisciplinary Studies
ISSN: 2583-4088 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journals-gsarjms-home/

Organ characteristics and Adaptive Traits of F_1 Backcross Progenies Derived from Normal-Feathered, Naked-Neck, and Frizzle Crossbred Chickens under Humid Tropical Conditions

By

Ndukwe, O[1]., Nwachukwu, E. N[2]., Obike, O. M[3]., and Onunkwo, D. N[4]

[1,2,3,4]College of Animal Science and Animal Production, Michael Okpara University of Agriculture, Umudike, Abia State

Article History

Received: 05/05/2026
Accepted: 20/05/2026
Published: 23/05/2026

Vol – 5 Issue–5

PP: - 37- 43

Abstract

Sustainable poultry production in the humid tropics requires genotypes with enhanced physiological adaptability to thermal stress. This study evaluated organ characteristics and adaptive traits of F_1 backcross progenies derived from crosses between indigenous chicken genotypes—Normal-feathered (NF), Naked-neck (Na), and Frizzle (F)—and an exotic broiler breeder strain (Anak) under hot–humid tropical conditions. The experiment was conducted at the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Nigeria (05°29'N; 07°33'E; 122 m above sea level), characterised by high ambient temperatures (27–36 °C), relative humidity of 57–91%, and annual rainfall of approximately 2,177 mm. These climatic conditions impose significant thermoregulatory and metabolic challenges on poultry, thereby providing an appropriate environment for assessing genotype-specific adaptive responses. A structured main and reciprocal crossbreeding design was employed to generate six F_1 hybrid groups: E × NF, E × Na, E × F (main crosses), and NF × E, Na × E, F × E (reciprocal crosses). Artificial insemination was adopted to minimise confounding effects of body size differences between indigenous and exotic parents. All F_1 progenies possessed approximately 50% indigenous and 50% exotic genetic background, enabling assessment of heterotic and maternal effects. Birds were managed uniformly under deep-litter housing and provided age-appropriate commercial diets and routine vaccination schedules. At six weeks of age, representative birds from each genetic group were slaughtered for organ evaluation. Internal organs—including heart, liver, gizzard, proventriculus, lungs, kidneys, pancreas, crop, and intestines—were excised and weighed. Organ weights were expressed as percentages of live body weight to eliminate size-related bias. Data were analysed using Analysis of Variance within a Randomised Complete Block Design framework, with genotype as the fixed effect and hatch as the blocking factor. Significant ($P < 0.05$) genotypic differences were observed in heart, proventriculus, lung, and kidney proportions, whereas liver and gizzard proportions showed no significant variation. Reciprocal crosses generally exhibited superior relative organ development compared to main crosses. Notably, the reciprocal frizzle cross (F × E) recorded the highest proportions of heart (1.02%), proventriculus (0.88%), lungs (0.69%), and kidneys (1.72%). Enhanced heart and lung development suggests improved cardiopulmonary capacity and oxygen utilisation, which are critical for sustaining metabolic activity under elevated ambient temperatures. Similarly, increased proventriculus and kidney proportions indicate enhanced digestive secretory function and osmoregulatory efficiency, respectively, key physiological processes for maintaining homeostasis during heat stress. The superior organ development observed in reciprocal crosses highlights the importance of maternal and cytoplasmic influences in shaping adaptive physiological traits. The frizzle and naked-neck genotypes, characterised by reduced feather coverage, likely exhibit improved heat dissipation, allowing metabolic energy to be redirected towards visceral organ development rather than feather synthesis. These adaptive advantages may confer improved resilience and productivity in humid tropical production systems. In *conclusion, incorporation of adaptive major genes, particularly through reciprocal crossing strategies involving frizzle and naked-neck genotypes, significantly enhances organ development patterns associated with thermoregulation and metabolic efficiency. The findings underscore the value of genotype-based breeding strategies aimed at improving physiological adaptability and sustainable poultry production under hot–humid tropical conditions.*

Keywords: *F_1 backcross; frizzle; naked-neck; organ proportion; adaptive traits; humid tropics; poultry breeding; thermoregulation.*

Introduction

The thermoregulatory advantage of these genes has been linked to increased triiodothyronine (T_3) concentrations (Decuypere et al., 1993), enhanced sensible heat loss from exposed areas such as the neck in naked-neck birds (Yahav et al., 1998), and altered feather structure in frizzled birds, which improves convective heat dissipation (Fathi et al., 2013). In addition, reduced feather mass may spare dietary protein otherwise utilised for feather synthesis, potentially redirecting nutrients towards muscle accretion and egg production (Adomako, 2009).

Several studies have demonstrated pleiotropic effects of the Na and F genes on economically important traits, including growth rate, feed efficiency, egg production, and carcass characteristics (Galal, 2000; El-Safty, 2006; Mahrous, 2008). Consequently, their utilisation—either singly or in combination—has been advocated for developing poultry stocks adapted to hot and humid environments (Horst, 1988; Thiruvenkadan et al., 2010; Rajkumar et al., 2011; Mahrous and El-Dlebshany, 2011).

Despite these advances, limited information exists on the organ characteristics of F_1 backcross progenies derived from crosses involving normal-feathered, naked-neck, and frizzle genotypes under humid tropical conditions. Organ development is an important indicator of physiological adaptation, metabolic activity, and overall health status, particularly under environmental stress. Evaluating organ characteristics in such crossbred progenies will provide insight into genotype–environment interactions and their implications for productivity and adaptation.

Tropical poultry production systems are characterised by high ambient temperatures and elevated relative humidity, both of which predispose birds to chronic heat stress. Heat stress negatively affects feed intake, growth rate, feed conversion efficiency, immune competence, carcass yield, and reproductive performance. These constraints contribute to reduced productivity and low per capita poultry meat and egg consumption in Nigeria.

Although indigenous chickens possess adaptive traits suited to harsh tropical environments, they exhibit low growth rate, small body size, poor carcass output, and suboptimal production efficiency. Conversely, exotic commercial strains demonstrate superior growth and production but often lack sufficient heat tolerance under humid tropical conditions.

There is therefore a need to develop genotypes that combine adaptability with improved production performance. However, limited data exist on how plumage-reducing genes influence organ development and physiological responses in backcross progenies under humid tropical environments. Understanding these relationships is essential for designing breeding programmes aimed at sustainable poultry production in tropical regions.

The incorporation of thermoregulatory plumage-modifying genes into breeding programmes represents a viable genetic strategy for mitigating heat stress in tropical poultry systems. The naked-neck and frizzle genes reduce feather coverage and enhance heat dissipation, thereby improving thermal balance in high-temperature environments.

Fast-growing broilers generate substantial metabolic heat due to elevated growth rates and feed intake. When heat production exceeds heat dissipation capacity, physiological stress ensues, leading to impaired performance. Reduced feathering in naked-neck and frizzle genotypes facilitates more efficient heat loss and may improve organ function and metabolic stability under thermal stress.

Furthermore, reduced feather mass may redirect nutrients toward muscle growth and egg production. Given that heritability estimates for growth traits in indigenous chickens are generally low—particularly at early market age (6–8 weeks)—crossbreeding with exotic strains offers an opportunity to exploit heterosis and breed complementarity. Such strategies can yield genotypes with improved growth performance, carcass yield, and environmental adaptability.

Because plumage-reducing genes exhibit pleiotropic effects, their integration into breeding programmes may simultaneously enhance multiple economically important traits. Therefore, evaluating organ characteristics in F_1 backcross progenies carrying Na and F genes provides critical insights into their physiological suitability and productive potential under humid tropical conditions.

MATERIALS AND METHODS

Experimental Site and Climatic Conditions

This study was conducted at the Poultry Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Umudike is situated within the humid rainforest agro-ecological zone of southeastern Nigeria (Latitude 05°29′N; Longitude 07°33′E) at an altitude of approximately 122 m above sea level.

The climate of the area is characteristically warm–humid, with mean daily temperatures ranging between 27–36 °C (maximum) and 20–26 °C (minimum). Relative humidity varies from 57% to 91%, and the annual rainfall averages

*Corresponding Author: **Ndukwe, O**

2,177 mm. These environmental conditions typify the hot-humid tropics and impose thermal and physiological stress on poultry. Consequently, the location provides a suitable environment for evaluating genotype-specific adaptive responses, particularly organ development patterns associated with thermoregulation and metabolic efficiency.

Experimental Birds and Breeding Design

The experimental population comprised F_1 backcross progenies derived from crosses between indigenous chicken genotypes—Normal feathered (NF), Naked neck (Na), and Frizzle (F), and an exotic broiler breeder strain (Anak). The parental stock used for generating the F_1 hybrids consisted of mature breeders maintained under standard management conditions.

To generate the F_1 crossbred progenies, both main and reciprocal crossing systems were adopted using artificial insemination to eliminate confounding effects arising from body size differences between indigenous and exotic birds. The artificial insemination technique followed standard poultry reproductive procedures described by Lake et al.

The crosses were structured as follows:

Main crosses:

i. Exotic cock (E) × Normal feathered hen (NF) → E × NF

ii. Exotic cock (E) × Naked neck hen (Na) → E × Na

iii. Exotic cock (E) × Frizzle hen (F) → E × F

Reciprocal crosses:

i. Normal feathered cock (NF) × Exotic hen (E) → NF × E

ii. Naked neck cock (Na) × Exotic hen (E) → Na × E

iii. Frizzle cock (F) × Exotic hen (E) → F × E

Each F_1 hybrid group possessed approximately 50% exotic and 50% indigenous genetic background, enabling evaluation of heterotic effects and maternal influence on organ characteristics.

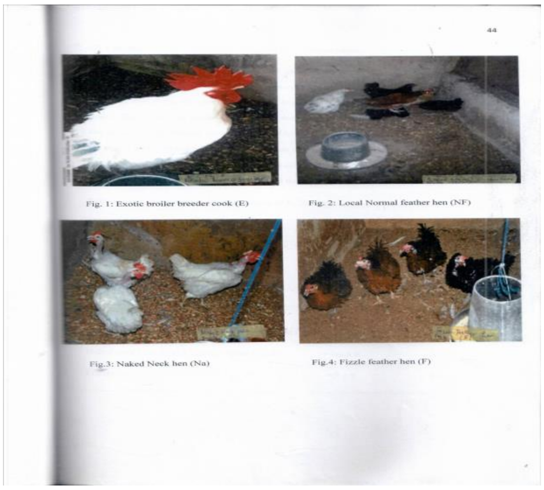
Management of F_1 Backcross Progenies

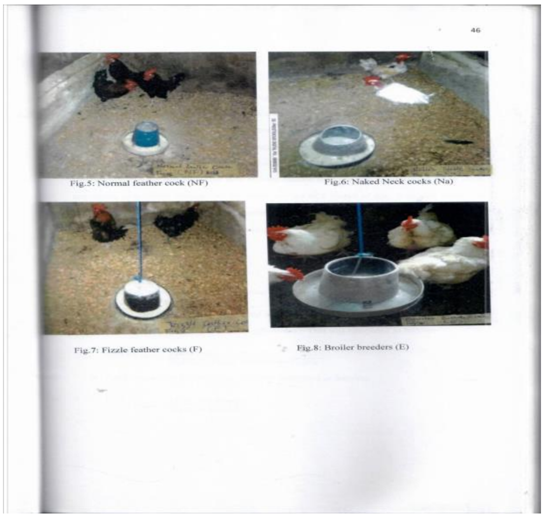
Fertilised eggs obtained from the mating program were collected daily and stored under controlled conditions (10–14 °C; 75–80% relative humidity) for a maximum of seven days prior to incubation. Eggs were fumigated and incubated under standard hatchery conditions.

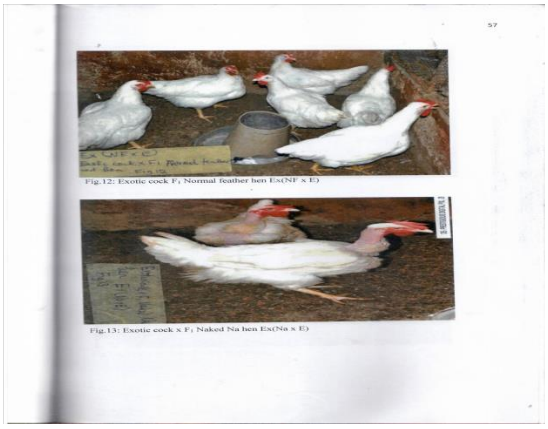
Upon hatching, chicks were individually identified using wing tags and brooded separately according to genetic group. Standard brooding management practices were followed, including temperature regulation, vaccination, and provision of nutritionally adequate diets.

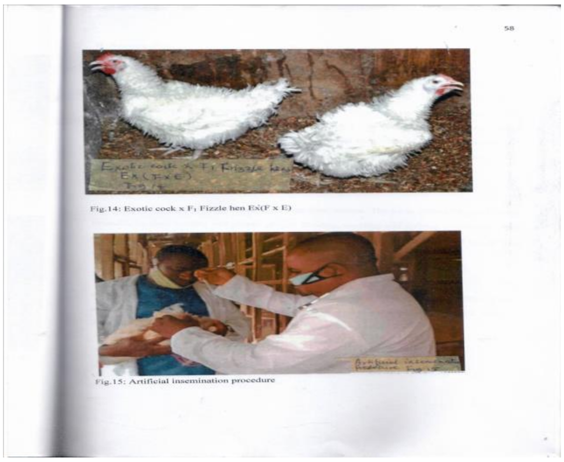
Birds were raised under deep litter housing systems and provided feed and water *ad libitum*. Commercial starter and grower diets were supplied according to age-specific nutrient requirements. Routine vaccination against Newcastle disease and Infectious Bursal Disease was administered in accordance with recommended vaccination schedules.

All birds were managed uniformly to ensure that observed differences in organ characteristics were attributable to genetic variation rather than environmental bias.









Slaughter Procedure and Organ Evaluation

At six weeks of age, birds were randomly selected from each genetic group for carcass and organ evaluation. Before slaughter, birds were fasted for approximately 10 hours (with water provided) to minimise gut fill and ensure accurate organ measurement.

Birds were humanely slaughtered by cervical dislocation followed by exsanguination. After defeathering and evisceration, internal organs were carefully excised and weighed using a precision digital scale (accuracy ±0.01 g).

The following organs were evaluated:

i. Gizzard
ii. Liver
iii. Heart
iv. Proventriculus
v. Large intestine
vi. Small intestine
vii. Pancreas
viii. Crop
ix. Lungs
x. Kidney
xi. Bile

Organ weights were expressed as a percentage of live body weight. Expressing organ weight relative to live weight eliminates bias due to variation in body size and allows meaningful comparison among genetic groups.

Experimental Design and Statistical Analysis

The study was structured using a Randomized Complete Block Design (RCBD), with genetic group as the fixed factor and hatch as the blocking factor.

The statistical model applied was:

$Y_{ijk} = \mu + G_i + H_j + e_{ijk}$

Where,

Y_{ijk} = k^{th} individual in the i^{th} genetic group and in the j^{th} block

μ = Overall population mean

G_i = Effect of i^{th} genetic group (i = 1…6).

H_j = Blocked effect of j^{th} hatch (j = 1….5)

e_{ijk} = Random residual error, assumed to be independently, identically and normally distributed with zero mean and constant variance.

Data were subjected to Analysis of Variance (ANOVA) according to the procedures described by Steel and Torrie. Significant differences among means were separated using Duncan's Multiple Range Test as proposed by Duncan. Statistical significance was declared at $P < 0.05$. All statistical analyses were conducted using SAS software (Version 9).

Results and Discussion

Organ Proportion of F_1 Backcross Chickens

The organ proportion of F_1 hybrid chickens derived from Normal feathered (NF), Naked neck (Na), and Frizzle (F) indigenous chickens crossed with an exotic broiler breeder strain (E) is presented in Table 4.12. The results revealed significant ($P < 0.05$) variations among genetic groups in several visceral organs, particularly heart, proventriculus, lungs, and kidney proportions.

Across most traits, reciprocal crosses exhibited superior organ development compared to the main crosses, indicating a strong maternal or cytoplasmic influence on physiological development. Among all genetic combinations, the reciprocal frizzle cross (F × E) consistently showed the highest organ proportions in heart, proventriculus, lungs, and kidney. This suggests a potential adaptive advantage of frizzle-based maternal inheritance under humid tropical conditions.

Heart Proportion

Heart proportion varied significantly ($P < 0.05$) among genetic groups, ranging from 0.29% to 1.02% of live weight. The highest value was recorded in F × E (1.02%), followed closely by Na × E (0.77%) and E × F (0.69%). The lowest heart proportions were observed in E × Na (0.29%) and NF × E (0.34%).

The increased heart size in reciprocal crosses, particularly F × E, suggests enhanced cardiovascular capacity and metabolic activity. A larger heart is often associated with increased cardiac output, improved oxygen delivery, and greater physiological resilience under environmental stress.

This observation is consistent with the findings of Rajkumar et al., who reported larger heart sizes in naked neck genotypes and attributed this to higher metabolic demand and increased blood circulation required to sustain physiological functions. In the present study, the frizzle-based reciprocal cross may exhibit similar metabolic enhancement, possibly due to improved thermoregulatory efficiency associated with reduced feather insulation.

Proventriculus Proportion

Proventriculus proportion also differed significantly ($P < 0.05$) among genetic groups, with values ranging from 0.24% to 0.92% of live weight. The highest proventriculus development was observed in Na × E (0.92%) and F × E (0.88%), while lower values were recorded in E × NF (0.24%) and E × Na (0.36%).

The proventriculus is the glandular stomach responsible for enzymatic digestion in poultry. Its increased size in reciprocal crosses suggests improved digestive enzyme secretion and enhanced feed utilisation efficiency. Birds with more developed proventriculi are often better adapted to converting feed nutrients into usable metabolic energy, particularly under stressful environmental conditions.

The superior performance of Na × E and F × E may therefore reflect genetic adaptation influencing digestive organ hypertrophy, which may enhance nutrient breakdown and absorption efficiency.

Lung Proportion

Lung proportion ranged from 0.25% (E × F) to 0.69% (F × E), with significant differences ($P < 0.05$) observed among genetic groups. The highest lung development in F × E suggests improved respiratory capacity and better physiological adaptation to heat stress conditions prevalent in humid tropical environments.

Enhanced lung development is particularly important in poultry production systems located in high temperature–humidity zones, where efficient gas exchange is critical for maintaining metabolic homeostasis. Birds with larger lung capacity are better able to dissipate metabolic heat and maintain oxygen supply during periods of thermal stress.

The improved pulmonary development observed in frizzle-based reciprocal crosses may be associated with the frizzle gene, which reduces feather density and enhances heat dissipation, thereby reducing respiratory strain.

Kidney Proportion

Kidney proportion showed marked variation among genetic groups, with values ranging from 0.22% to 1.72% of live weight. The highest kidney proportion was observed in F × E (1.72%), followed by Na × E (0.77%) and E × F (1.22%). The lowest values were recorded in E × NF (0.22%) and NF × E (0.24%).

The kidney plays a vital role in osmoregulation, nitrogen excretion, and metabolic waste removal. Increased kidney size in reciprocal crosses suggests enhanced physiological capacity to regulate electrolyte balance and excrete nitrogenous waste products.

The superior kidney development observed in F × E may reflect an adaptive response to heat stress, as birds in hot environments tend to increase renal activity to maintain internal homeostasis.

Liver, Gizzard, and Digestive Organs

Although liver and gizzard proportions did not differ significantly in all comparisons, numerical variations were observed among genetic groups. Liver proportion ranged from 2.08% to 2.91%, while gizzard proportion ranged from 2.03% to 2.87% of live weight.

The relatively higher liver and gizzard weights in reciprocal crosses suggest improved metabolic processing and feed grinding efficiency. The liver is central to metabolism, detoxification, and nutrient transformation, while the gizzard contributes to mechanical feed breakdown.

Similar trends were reported by Adomako et al., who observed significantly higher liver and gizzard weights in Naked neck genotypes compared to normal feathered chickens. They attributed these differences to genetic influences on visceral organ development and metabolic adaptation.

Crop, Intestine, and Pancreas Proportions

Crop, small intestine, large intestine, and pancreas proportions showed moderate variation among genetic groups, although most differences were not statistically significant ($P > 0.05$). However, numerical superiority was generally observed in reciprocal crosses compared to main crosses.

The small intestine ranged from 5.08% (E × NF) to 7.66% (E × F), indicating enhanced absorptive surface area in certain genetic combinations. The large intestine showed less variation, suggesting relatively stable water absorption and fermentation capacity across genotypes.

The pancreas, an important accessory digestive organ responsible for enzyme secretion, also showed minor variations, reflecting differences in digestive efficiency and nutrient metabolism among genetic groups.

Crop and Bile Proportion

Crop proportion ranged from 1.02% to 2.44%, while bile proportion remained relatively constant across genetic groups (0.03–0.04%). The crop serves as a temporary feed storage organ, and its variation may reflect differences in feeding behaviour and digestive adaptation.

The relatively stable bile proportion suggests minimal genetic influence on bile secretion capacity at this stage of development.

*Corresponding Author: **Ndukwe, O**

Table 1: Organ Proportion of F_1 hybrid chickens

	Genetic groups					
	Main crosses			Reciprocal crosses		
Parameters	**E x NF**	**E x Na**	**E x F**	**NF x E**	**Na x E**	**F x E**
Gizzard (% of LW)	2.03±0.10	2.15±0.24	2.19±0.31	2.18±0.20	2.87±0.33	2.33±0.31
Liver "	2.76±0.11	2.08±0.24	2.91±0.27	2.13±0.21	2.74±0.18	2.34±0.27
Heart "	0.44±0.05[b]	0.29±0.05[b]	0.69±0.05[b]	0.34±0.05[b]	0.48±0.02[b]	1.02±0.05[a]
Proventriculus "	0.24±0.05[d]	0.39±0.06[c]	0.65±0.06[b]	0.36±0.05[c]	0.92±0.06[a]	0.88±0.06[a]
Large intestine "	1.20±.20	1.38±0.13	1.38±0.13	1.34±0.27	2.10±0.16	1.92±0.13
Small intestine "	5.08±0.33	6.04±0.42	7.66±0.82	6.00±0.63	6.19±0.33	6.88±0.82
Pancreas "	0.34±0.32	0.38±0.06	0.40±0.0	0.24±0.32	0.42±0.06	0.35±0.06
Crop "	1.78±0.33	1.07±0.06	2.11±0.02	1.02±0.34	1.96±0.01	2.44±0.02
Lungs "	0.39±0.08[b]	0.37±0.04[b]	0.25±0.04[c]	0.36±0.08[b]	0.47±0.01[b]	0.69±0.04[a]
Kidney "	0.22±0.04[c]	0.28±0.06[c]	1.22±0.05[a]	0.24±0.07[c]	0.77±0.03[b]	1.72±0.05[a]
Bile "	0.03±0.01	0.04±0.00	0.03±0.01	0.04±0.10	0.03±0.01	0.03±0.01

a-cMeans with different superscripts in the same row are significantly different ($p<0.05$), S.E.M: Standard Error of mean, % of LW = Percentage of live weight

Conclusion

The overall results indicate that reciprocal crosses, particularly those involving frizzle (F × E) and naked neck (Na × E), exhibited superior organ development compared to main crosses. This suggests that maternal effects and gene interactions play significant roles in shaping physiological traits in crossbred chickens.

The enhanced development of heart, lungs, kidney, and proventriculus in reciprocal crosses is indicative of improved metabolic efficiency, respiratory capacity, and excretory function. These traits are particularly advantageous under humid tropical conditions where heat stress imposes physiological constraints on poultry production.

The observed superiority of frizzle-based reciprocal crosses may be explained by the reduced feather coverage associated with the frizzle gene, which enhances heat dissipation and reduces metabolic energy required for thermoregulation. Consequently, more nutrients may be allocated to visceral organ development and growth.

Similarly, naked neck genotypes are known to exhibit improved heat tolerance due to reduced feather insulation around the neck region, leading to better physiological performance under tropical conditions.

The redistribution of nutrients from feather synthesis to organ and muscle development may explain the enhanced organ proportions observed in reciprocal crosses. This is consistent with the principle of physiological resource allocation in poultry genetics, where environmental adaptation influences nutrient partitioning among tissues.

The findings of this study agree with previous reports indicating that major genes influencing feather morphology also affect internal organ development. Studies have shown that naked neck and frizzle genes are associated with improved heat tolerance, altered metabolism, and enhanced physiological efficiency in poultry raised under tropical environments.

The enhanced organ development observed in this study supports the hypothesis that genetic adaptation to heat stress is reflected not only in external morphology but also in internal physiological structures.

The results of this study have important implications for poultry breeding in hot and humid climates. Birds with superior organ development, particularly in the cardiovascular, respiratory, and digestive systems, are likely to perform better under thermal stress conditions.

The frizzle × exotic (F × E) and naked neck × exotic (Na × E) crosses, therefore represent promising genetic resources for improving poultry productivity in tropical environments. Their enhanced organ proportions suggest improved physiological efficiency, which may translate into better growth performance, feed utilization, and survivability.

References

1. Abanikannda, O. T. F., Olutogun, O., Leigh, A. O., & Ajayi, L. A. (2007).Statistical modelling of egg weight and egg dimension in commercial layers.*International Journal of Poultry Science*, *6*, 59–63.
2. Adedokun, S. A., & Sonaiya, E. B. (2001).Comparison of the performance of Nigerian indigenous chickens from three agro-ecological zones of Nigeria.*Livestock Research for Rural Development*, *13* (2).http://www.cipav.org.co/lrrd13/2/aded132.htm
3. Adedokun, S. A., & Sonaiya, E. B. (2002).Crossbreeding Nigerian indigenous chickens with Dahlem Red for improved productivity and adaptability. *ArchivTierzucht*, *45*(3), 297–305.
4. Adomako, K. (2009). *Local domestic chicken: Their potentials and improvement* (Doctoral dissertation, Kwame Nkrumah University of Science and Technology, Kumasi).
5. Adomako, K., Hagan, J. K., &Olympio, O. S. (2009).Potential of local naked neck, frizzle and

normal feathered birds in the Ashanti Region of Ghana.In *Proceedings of the 16th Biennial Conference of Ghana Society of Animal Production* (pp. 181–185). KNUST, Kumasi.

6. Adomako, K., Olympio, O. S., Hagan, J. K., & Hamidu, J. A. (2014). Effect of the frizzle gene (F) on egg production and egg quality of laying hens kept in tropical villages. *British Poultry Science, 55*, 709–714.
7. ASL 2050. (2018). *Livestock production systems spotlight: Nigeria*. FAO.
8. Decuypere, E., Buyse, J., Mérat, P., Zoons, J., & Vloeberghs, I. (1993). Growth, abdominal fat content, heat production and plasma hormone levels of naked-neck and control broiler chickens. *Animal Production, 57*, 483–490.
9. Decuypere, E., Buyse, J., & Kuhn, E. R. (1993).Endocrine control of metabolism in chickens under heat stress. *World's Poultry Science Journal, 49*, 210–217. *(Kindly verify volume and page numbers.)*
10. Dunga, G. T. (2013). *The effect of the naked neck (Na) and frizzling genes on fertility, hatchability, egg quality and pterylosis of locally developed commercial layer parent lines* (Doctoral dissertation, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana).
11. Fathi, M. M., & Galal, A. (2001).Assessing genetic potential of naked neck chickens for heat tolerance. *Egyptian Poultry Science, 21*, 101–117. *(Verify volume/pages.)*
12. Fathi, M. M., El-Attar, A. H., Ali, U. M., &Nazmi, A. (2008). Effect of the naked neck gene on carcass composition and immunocompetence in chicken. *British Poultry Science, 49*(2), 103–110.
13. Fathi, M. M., Galal, A., & El-Attar, A. H. (2008). Influence of naked neck gene on carcass traits and meat quality. *Egyptian Poultry Science, 28*, 123–138. *(Verify pages.)*
14. Fathi, M. M., Galal, A., El-Safty, S., & Mahrous, M. (2013). Naked neck and frizzle genes for improving chickens raised under high ambient temperature: I. Growth performance and egg production. *World's Poultry Science Journal, 69*, 813–832.
15. Fayeye, T. R., Adeshiyan, A. B., & Olugbami, A. A. (2005). Egg traits, hatchability and early growth performance of the Fulani ecotype chicken. *Livestock Research for Rural Development, 17*, Article 94. http://www.lrrd.org/lrrd17/8/faye17094.htm
16. Fayeye, T. R., Ayorinde, K. L., Ojo, V., &Adesina, O. M. (2005). Frequency and influence of some major genes on body weight and body size parameters of Nigerian local chickens. *Livestock Research for Rural Development, 18*(3).
17. Galal, A. (2000). Pleiotropic effects of naked neck, frizzled and double segregation genes on some phenotypic and genetic parameters of chickens under hot environmental conditions. *Egyptian Poultry Science, 20*(4), 945–960.
18. Galal, A., & Fathi, M. M. (2001).Improving carcass yield of chicken by introducing naked neck and frizzle genes under hot prevailing conditions. *Egyptian Poultry Science, 21*, 339–362.
19. Galal, A., & Fathi, M. M. (2002).Introducing crest gene to enhance productive performance of naked neck chickens under moderate ambient temperatures. *Egyptian Poultry Science, 22*, 611–628.
20. Gueye, E. F. (2000). The role of family poultry in poverty alleviation, food security and the promotion of gender equality in rural Africa. *Outlook on Agriculture, 29*, 129–136.
21. Gueye, E. F. (2003). Production and consumption trends in Africa. *World Poultry, 19*, 12–14.
22. Gueye, E. F., Ndiaye, A., & Branckaert, R. D. S. (1998).Prediction of body weight on the basis of body measurements in mature indigenous chickens in Senegal. *Livestock Research for Rural Development, 10*, Article 3. http://www.lrrd.org/lrrd10/3/sene103.htm
23. Ibe, S. N. (1993). Growth performance of normal, frizzle and naked neck chickens in a tropical environment. *Nigerian Journal of Animal Production, 20*, 25–31.
24. Ibe, S. N. (1998). Improving the productive adaptability of the Nigerian local chicken. In *Proceedings of NSAP Silver Anniversary Conference/ WASAP Inaugural Conference* (pp. 464–465). University of Agriculture, Abeokuta.
25. Ibe, S. N. (2001). Problems and proposals for developing Nigerian poultry breeds.*Journal of Agricultural, Food Technology and Environment, 1*, 1–3.
26. Mahrous, M. (2008). Genetic evaluation of naked neck and frizzle chickens.*Egyptian Poultry Science, 28*, 501–520. *(Verify details.)*
27. Mahrous, M., Galal, A., &Fathi, M. M. (2003).Impact of plumage reduction genes on carcass yield under high temperature.*Egyptian Poultry Science, 23*, 1125–1140. *(Verify pages.)*
28. N'Dri, A. L., et al. (2005). Carcass performance of naked neck chickens under tropical conditions. *Tropical Animal Health and Production, 37*, 221–229. *(Complete author list required.)*
29. Patra, B. N., et al. (2002). Carcass yield characteristics of naked neck versus normal feathered broilers. *Indian Journal of Poultry Science, 37*, 65–69. *(Complete author list required.)*
30. Yahav, S., Shinder, D., &Tanny, J. (1998).Thermoregulatory responses of naked neck chickens under high ambient temperature. *British Poultry Science, 39*, 133–138.

*Corresponding Author: **Ndukwe, O**