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Influence of the Naked Neck Gene on the Productivity of Meat Type Chickens under Humid Tropical Conditions

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Abstract: *This study was conducted to determine the effect of the naked neck gene on the growth performance and carcass characteristics as well as plasma concentrations of thyroid hormones and their precursor in F1 crossbred broilers. The experiment involved crossing seventy normal feathered Hubbard Flex 15 broiler breeder females and seven locally developed naked neck males to obtain 320 chicks from four batches of hatch. The design was RCBD with the two phenotypes (normal feathered birds and naked neck birds) being the treatments. The results showed that the naked neck birds had higher ($p \leq 0.05$) weight gain than the normal feathered birds. There were however no differences ($p \geq 0.05$) in feed intake, feed conversion ratio and plasma concentrations of thyroid hormones T_3, T_4 and their precursor, TSH. The live weight, bled weight, defeathered weight, dressed weight, head, back, breast and drumstick were heavier ($p \leq 0.05$) in the naked neck birds than the normal feathered birds. The thigh, abdominal fat, neck, shank and the internal organs showed no ($p \geq 0.05$) difference in the two phenotypes. The naked neck gene has a positive effect on meat type chickens and may therefore be the best phenotype for broiler production under humid tropical conditions.*

Key words: *chickens, genotype, meat- type, naked neck, tropical.*

I. INTRODUCTION

Poultry production is endowed with a wide range of benefits. [1], has indicated that besides the fact that the livestock sub-sectors main contribution to the national economy is food and nutrition security, it offers prospects for wealth creation, income enhancement, coping mechanism against crop failure, financial security and improvement in rural livelihoods. Other advantages of poultry production include high feed efficiency, fast returns on investment, spreading income throughout the year, high returns compared to feed cost (when on a very large scale), less land requirement, adaptability to both small part time and large commercial enterprises, highly mechanised farm operations with high output per hour of labour. According to [2], poultry contributes about 1.3% of gross domestic product (GDP) in developing countries. In Ghana, [3] reported that as at 2010 agriculture was contributing about 30.2% GDP, whilst the livestock subsector including poultry contributed only about 6.1% of the 30.2% GDP from agriculture as against the crop subsector which contributed 66.2% GDP out of the 30.2% contributed by agriculture to the nations GDP. [4] therefore concluded that the livestock and poultry industry in Ghana has not been fully harnessed. [5] indicated that the accelerating pace of climate change coupled with increasing population is a threat to food security all over the world. They further indicated that developing countries are more vulnerable to climate change and food insecurity and are likely to be the most affected with the change. [6] observed that when temperature humidity index exceeds 32^{o}C, the performance of birds declines. The prevailing high temperatures in the tropics is thus of a major concern to our food security. Heat stress is seen as one of the most critical problems affecting poultry production throughout the world [7]. [7]; [8]; [9]; [10] have reported that heat stress negatively affects the welfare and productivity of broilers and laying hens. [6] stated that heat stress in poultry can be attributed to a number of factors like the components of a birds ration as well as the metabolic reactions that go on within a bird. [7] also indicated that heat stress results from a negative balance between the net amount of energy flowing from the animal's body to its surrounding environment and the amount of heat energy produced by the animal. [11] observed that birds subjected to heat stress conditions spend less time feeding, more time drinking and panting, as well as more time with their wings elevated, less time moving or walking, and more time resting. According to [12] there is an economic effect of heat stress in tropical and subtropical poultry production. [13] made it clear that even in temperate developed regions where high ambient temperature is experienced once a while, the high cost of energy used in cooling broilers is gradually being seen as a political and economic burden. [11] listed some of the strategies that can combat heat stress as the following: using birds that have thermoregulatory genes , inclusion of dietary thyroid hormones in the feed of birds (T3 and T4 and their balance are known to regulate body temperature and metabolic activities), early age thermal conditioning, reducing fat content of feed, the use of vitamins C as an antioxidant, avoiding direct sunshine on birds' drinking water and sometimes cooling the water, reducing the stocking density of birds in a pen, sighting pens to allow enough ventilation and using electric fans to cool the pens. Birds that have been domesticated show diverse morphologies of their integument and its appendages as a result of mutations (or mutant genes) and intense selective breeding [14]. He indicated that the mutant genes may affect the distribution of feathers on the skin as in naked neck birds, structure of the feathers, as in frizzle birds or the size of the bird as in dwarf birds. The characteristics expressed by these mutant genes have been continually investigated due to their economic benefits in the tropics. One of such genes is the naked neck gene. [15] indicated that, the integration of naked neck gene in chicken breeds enhances the resistance of birds to heat stress. They disclosed that the gene is characterised by a reduction in the feathers on the neck of birds possessing the gene. According to [16], homozygous (*NaNa*) and heterozygous (*Nana*) naked neck birds have 40% and 20% less feather respectively around the neck region. At high temperatures, [17] observed a higher yield in breast muscle especially in the homozygotes while [13] observed an extra weight gain in naked neck birds making it advantageous over the normal feathered birds. The presence of a single dose of ' *Na*' allele reduces the feather mass of the birds by 1.25g per 100g body weight [16]. [18] indicated that thyroid hormone plays a critical role in the homeothermic status of birds because they regulate basal metabolism and help in the regulation of high and constant body temperature. As scientists continually develop broilers with high growth potential, these birds tend to face the problem of high ambient temperature [19]. The intake and metabolism of food have a thermogenic effect and since there is a limitation on the amount of heat the bird can dissipate due to their feather coverage, birds are not able to function well within high ambient temperatures [9]. When birds are exposed to temperatures above 31^{o}C their heat production is increased [20]. High ambient temperatures results in a reduction of body weight due to energy demands through thermoregulation and decline in feed intake [21]. The objectives of this study were to access the effect of the naked neck gene on the growth performance of broilers, their carcass characteristics and the plasma concentration of thyroid hormones and their precursor.

II. MATERIALS AND METHODS

Study location and duration of the experiment

The studys location was the Poultry Section of the Department of Animal Science, Kwame Nkrumah University of Science and Technology, Kumasi Ghana. The entire experiment lasted for a period of eleven months.

Experimental birds

The birds used were the offspring obtained from seven heterozygous naked neck males crossed with seventy Hubbard flex 15 normal feathered females to obtain normal feathered and naked neck birds.

Experimental procedure and design

The first filial generation (F1) from the mating were grouped into naked neck birds and normal feathered birds and studied for twelve weeks. The two phenotypes represented the treatments and each treatment was replicated eight times. The experimental design was a randomised complete block design (RCBD). There were four batches of hatch, each serving as a block. A total of 320 day old naked neck and normal feathered chicks were used for the study, with 80 birds per block and 20 birds per replicate/ pen.

Housing

Each pen measured 1.8 m x 1.2 m, giving a floor space of 2.16 m^2. All the 16 pens were used for brooding during the first two weeks of the study and heat was supplied by means of two 100-watt incandescent bulbs per pen. Brooding temperatures ranged from a minimum of 27^0C to a maximum of 39°C. Temperature in the poultry house after the brooding period depended on the temperature of the outside air.

Feeding

The birds were fed with starter diet containing 22% crude protein and a metabolizable energy (ME) of 2940.8 kcal/ kg for the first 28 days (4 weeks). During the finishing period (5-12 weeks of age), all birds received a diet that contained 20% crude protein and a metabolizable energy (ME) of 3150.64 kcal/ kg. Water was provided *ad libitum* throughout the experimental period.

Table 1: Nutrient composition of starter and grower mash fed to the F1 generation

Starter diet		Grower diet	
Crude Protein (%)	21.6	Crude Protein (%)	20.34
Fat (%)	7.78	Fat (%)	8.94
Moisture (%)	10.6	Moisture (%)	10.30
Crude Fibre (%)	3.6	Crude Fibre (%)	3.4
Ash (%)	2.28	Ash (%)	2.61
NFE (%)	53.59	NFE (%)	54.419
Metabolizable Energy (kcal/kg)	2940.8	Metabolizable Energy (kcal/kg)	3150.6.4

Source: Agricare Feed Limited, Ghana

Disease and Parasite control

Vaccination was carried out against Newcastle and Gumboro diseases. Coccidiostats such as Amprocox and Amprolium (KEPRO, Netherlands) were added to drinking water of birds occasionally to control Coccidiosis whilst Penstrip Plus (KEPRO, Netherlands) was given to treat bacterial infections. Treatment against worms was also done using Levasol (KEPRO, Netherlands).

Traits measured on the first filial (F1) generation

The data collected on the birds during the experimental procedure included the following: initial weight, feed intake, weight gain, feed conversion ratio, temperature and humidity, carcass yield and hormonal analysis.

Temperature and humidity

Right from day one till maturity of each block, ambient temperature and humidity were recorded. The temperature and humidity readings were taking three times a day. The average reading for each block was calculated weekly. The readings were made by a digital thermo- hygrometer.

Carcass Yield Measurements

At the end of the 12 weeks experimental duration, 3 birds from each of the 16 replicates were randomly selected and deprived of feed for 10 hours in order to empty the crop. Birds were weighed before slaughter in order to obtain the live weight after which they were individually slaughtered and bled in order to obtain the bled weight. The birds were defeathered to obtain the defeathered weight. Data taken were head weight, neck weight, wing weight, thigh weight, breast weight, back weight, leg weight, shank length, full gizzard weight, empty gizzard weight, heart weight, lung weight, abdominal fat, spleen and crop.

Hormonal analysis

Blood samples were drawn from two birds from each phenotype to assess their hormonal levels at 12 weeks of age. The blood samples were taken from veins in the wings by means of a needle and syringe. The blood was then put into gel test tubes and transferred to the laboratory. This procedure was done in the early hours of the morning to avoid coagulation by direct sunshine.

Statistical analysis

All data collected on the first filial (F1) generation were subjected to the analysis of variance procedure of the GenStat statistical package version 11.1 (2009) and differences were deemed significant at $p<0.05$.

III. RESULTS AND DICUSSION

Growth performance

The weight gain in the naked neck birds was higher ($P \leq 0.05$) than that of the normal feathered birds. There was however no significant ($P \geq 0.05$) difference between the two phenotypes with respect to initial weight, feed intake and feed conversion ratio (Table 2). Higher weight gain in naked neck birds within humid tropical conditions is in line with research findings by [2], who indicated that the body weight gain of both heterozygous and homozygous naked neck birds were significantly greater than their normal feathered counterparts. [22] also showed that the negative effect of high ambient temperature on broilers could be reduced by the use of the naked neck phenotype. [23] also considering growth performance, observed that both the homozygous and heterozygous naked neck were superior to normal feathered birds at ambient temperatures of around 30^{o}C or more. The observed increase in weight gain in the naked neck could be due to the fact that less feather coverage on the naked neck birds allows it to dissipate internal heat efficiently even under high ambient temperatures [10] thus enabling it to consume more feed and increase its weight gain. The result is again in line with the observation by [13], who indicated that the protein which would have been used for feather production is rather used for muscle production and other reproduction processes. The non-significant difference in the feed intake of the birds could be because the temperature was not high enough. This is so because the higher the temperature the more obvious the positive effect of the naked neck gene [24]. As birds increase their feed intake there is an increase in their endothermic temperature and if this heat is not efficiently dissipated the birds decrease their feed intake and thereby reducing their growth rate. In the naked neck however, heat dissipation is not a problem so it can still feed well and grow effectively within high ambient temperatures.

Table 2: Growth performance of naked neck and normal feathered broilers

	Parameters			
Phenotype	**Initial weight (Kg)**	**Feed intake (Kg)**	**Feed conversion ratio**	**Weight gain (Kg)**
Normal feathered	0.041	6.63	3.239	2.05^{b}
Naked neck	0.042	7.04	3.065	2.30^{a}
SED	0.00037	0.363	0.0997	0.0643
F.Pr	0.099	0.314	0.156	0.017

CARCASS YIELD

Phenotype Versus Carcass Yield

Phenotype significantly (P≤ 0.05) influenced bled weight, back weight, breast weight, dressed weight, defeathered weight, drumstick weight, head weight and live weight, with the naked neck recording higher means in these traits than their normal feathered counterparts (Table 3). No significant difference was observed for carcass traits such us abdominal fat weight, crop weight, empty gizzard weight, empty intestine weight, full gizzard weight, full intestine weight, heart weight, live weight, liver weight, lung weight, neck weight, shank length, spleen weight and thigh weight (Table 3). Upon analysis of the yield from all parts of the four blocks, it was realised that in almost all the economically important parts, birds carrying the naked neck gene performed better than the normal feathered birds. The study is consistent with the work by [17], as well as [10], who observed that the breast yield in naked neck birds was heavier than that of the normal feathered birds especially in tropical environment. Increase in the yield of the breast muscle is as a result of increase in protein deposition, a characteristic of the naked neck gene which is likely due to less subcutaneous fat deposition or increased blood flow in the breast area which is cool due to less feather coverage [10]. Among the live weight, bled weight, defeathered weight, back, drumstick, and the thigh, all of them with the exception of the thigh were significantly higher (P ≤ 0.05) in the naked neck birds than their normal feathered counterparts. This also confirmed the findings of [2] since it was observed from the carcass parameters of the F_1 in their experiment that the heterozygote naked neck (*Nana*) had a significantly higher (P≤0.05) defeathered weight, dressed weight, drumstick weight, breast muscle weight, than their normal feathered counterparts, whilst the weight of the intestines, heart and liver were not significantly affected by the phenotypes. The head of the naked neck was significantly heavier than that of the normal feathered birds, this is of much economic importance in cases where leftovers from chicken carcass are processed into animal feed (eg. dog feed).

Sex / Carcass Yield

Concerning sex, significant (P≤ 0.05) differences were observed in the response parameters measured with male recording the maximum means relative to the female sex in almost all the economically important part with the exception of the thigh (Table 3). This confirms the finding of [25], who said that the ability of the naked neck to increase in weight gain is higher in males than in females. No significant (P ≥ 0.05) differences were however observed for response parameters like crop, empty gizzard, full gizzard, shank, spleen and thigh (Table 4). There was no significant difference between the carcass yield of the phenotype by sex interactions. When carcass yield was compared between the two sexes the males were seen to be significantly ($P \leq 0.05$) heavier in all the carcass characteristics with the exception of the crop, full and empty gizzard, lungs, shank and spleen. This confirms the assertion by [16] that the superiority of the naked neck gene is twice as much in males than in females. A significantly ($P \leq 0.05$) low abdominal fat is an indication of a generally low fat content in the males. However when phenotype and sex were jointly analysed with respect to carcass yield the result showed no significant differences. [16] confirmed a lack of significance in genotype by sex interaction.

Table 3: Effect of the Naked Neck Gene on Carcass Characteristics of Broilers

	Response Parameters										
	Head Wt. (kg)	**Live Wt. (kg)**	**Bled Wt. (kg)**	**Defeathe red wt. (kg)**	**Dressed Wt. (kg)**	**Back Wt. (kg)**	**Breast Wt. (kg)**	**Neck Wt. (kg)**	**Drumstick Wt. (kg)**	**Shank Length (m)**	**Thigh Wt. (kg)**
Phenotype											
Normal feathered	0.065	2.23	2.115	1.968	1.633	0.248	0.396	0.102	0.224	0.083	0.238
Naked neck	0.072	2.399	2.287	2.158	1.809	0.283	0.445	0.101	0.248	0.149	0.236
SED	0.003	0.065	0.074	0.054	0.054	0.008	0.012	0.004	0.005	0.06	0.03
Sex											
Male	0.082	2.603	2.478	2.325	1.951	0.298	0.462	0.114	0.277	0.105	0.255
Female	0.055	2.026	1.924	1.8	1.49	0.232	0.379	0.088	0.195	0.127	0.219
SED	0	0.06	0.07	0.05	0.05	0.01	0.01	0	0.01	0.06	0.03
P values											
Phen	0.036	0.022	0.038	0.004	0.006	<0.001	0.014	0.862	<0.001	0.296	0.959
F.pr (Sex)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.721	0.264
F.Pr (inter)	0.068	0.394	0.75	0.215	0.181	0.182	0.215	0.238	0.244	0.381	0.56

Table 4: Effect of the Naked Neck Gene on Internal Organ Characteristics of Broilers.

	Response parameters									
	Abdominal fat wt. (kg)	**Full Intestine wt. (kg)**	**Empty intestine Wt. (kg)**	**Heart Wt. (kg)**	**Crop Wt. (kg)**	**Liver Wt. (kg)**	**Lung Wt. (kg)**	**Spleen Wt. (kg)**	**Empty gizzard wt. (kg)**	**Full gizzard Wt. (kg)**
Phenotype										
Normal feathered	0.01	0.135	0.08	0.012	0.011	0.043	0.015	0.004	0.047	0.076
Naked neck	0.008	0.144	0.084	0.011	0.018	0.047	0.014	0.004	0.047	0.079
SED	0.002	0.007	0.002	0.001	0.004	0.002	0.002	0	0.003	0.005
Sex										
Male	0.002	0.161	0.092	0.013	0.013	0.05	0.017	0.004	0.049	0.082
Female	0.016	0.118	0.072	0.01	0.016	0.04	0.012	0.004	0.045	0.073
SED	0	0.01	0	0	0	0	0	0	0	0.01
P-values										
F.pr (phen)	0.494	0.172	0.101	0.804	0.101	0.061	0.766	0.463	0.796	0.617
F.pr (sex)	<0.001	<0.001	<0.001	<0.001	0.457	<0.001	0.006	0.102	0.311	0.141
F.Pr	0.320	0.012	0.229	0.461	0.256	0.547	0.322	0.463	0.521	0.543

Effect of Temperature and Humidity on the Growth Performance of the Normal Feathered Birds

There was no significant (P≥0.05) difference between the individual or the combined effect of temperature and humidity on the feed conversion ratio of the normal feathered birds. However, humidity and temperature significantly (P≤0.05) affected feed intake individually and collectively. Also, though the combined effect of humidity and temperature significantly (P≤ 0.05) affected weight gain, only humidity and not temperature significantly affected it (Table 5). The two main factors that result in heat stress in birds are high ambient temperature and high humidity [26]. The relative humidity in the environment the bird finds itself has as relationship with the amount of heat the bird can dissipate through evaporative heat dissipation [8]. [27] concluded that hot and humid climates are negative factors in commercial poultry production. The result is in line with the work by a number of researchers [28]; [29] and [12], who indicated in their research that high ambient temperatures negatively affected all production parameters. [30] also confirms that high ambient temperature is a causative factor of low feed intake and thus low performance. Generally, heat stress increased mortality, reduced feed intake and lowered weight gain or egg production [25].

Table 5: Effect of temperature and humidity on the growth performance of normal feathered birds

	PARAMETERS			
VARIABLES	**Constant (Intercept)**	**Coefficient Of Humidity**	**Coefficient Of Temperature**	**F. Probability**
	18.6	0.016	-0.568	
Feed conversion ratio	0.226	0.852	0.110	0.073
probability – value				
Feed intake	1.20	0.0281	-0.094	
Probability value	0.515	0.010	0.029	<0.001
Weight Gain	-0.423	0.012	-0.010	
Probability value	0.581	0.008	0.563	<0.001

Effects of Temperature and Humidity on the growth Performance of naked neck birds

Temperature did not individually affect any of the growth performance parameters of naked neck significantly (P≥0.05), but humidity significantly (P≤ 0.05) affected both feed intake and weight gain. The combined effect of temperature and humidity also significantly (P≤ 0.05) affected feed intake and weight gain (Table 6).

[31] concluded that reduction in the feather mass of the naked neck birds improves heat dissipation through the bare area, leading to a relatively higher tolerance to heat and a higher productivity under high ambient temperatures. [32] also indicated that the naked neck gene has a positive effect of feather reduction which could lead to a better body temperature regulations and better performance of the birds. The result of this study in terms of the effect of temperature on the growth performance of the naked neck birds, is however contrary to the findings by the researchers cited above.

Table 6: Effect of Temperature and Humidity on the Growth Performance of Naked Neck Birds

	PARAMETERS			
VARIABLES	**Constant (Intercept)**	**Coefficient Of Humidity**	**Coefficient Of Temperature**	**F. Probability**
Feed conversion ratio	12.6	0.082	-0.531	
probability -value	0.542	0.494	0.268	0.095
Feed intake	0.12	0.037	-0.079	
Probability value	0.950	0.002	0.087	<0.001
Weight Gain	-1.58	0.017	-0.019	
Probability value	0.190	0.017	0.501	0.026

Hormonal analysis

The differences between the hormonal levels of the two phenotypes were not significantly different ($P \geq 0.05$). The means for the phenotypes however showed numerical differences where the naked neck birds had higher plasma concentrations of all the thyroid hormones (T3, T4 and TSH) than the normal feathered birds (Table 7). The presence of the thyroid hormones is essential because T_3 helps birds to tolerate heat stress and it also increases the bird' s growth rate, whilst T_4 and TSH facilitate the synthesis of T_3. In agreement with what [33] said, the level of T4 was far higher than that of T3. Though the levels of T3, T4 and TSH were all not significant ($P \geq 0.05$) in both the naked neck and the normal feathered birds, the mean values of all the three hormones were higher in the naked neck than in the normal feathered birds. This partly explains why the naked neck birds had superior ($P \leq 0.05$) live and dressed weight compared to the normal feathered ones. [26], described the relationship between T3 and feed intake as being linear, that is T3 directly affected feed intake. He further indicated that the level of T3 in the birds is one of the factors responsible for energy consumption and thus weight gain. According to Sylvia [33], presence of thyroid stimulates the intermediary metabolism of protein, lipids and carbohydrates to provide building units and energy to coordinate the synthesis of a wide range of proteins. These actions of the thyroid hormones though essential is bound to release some obligatory heat, causing levels and effect of T3 to decline at high ambient temperatures [20]. The abundance of thyroid hormones in the naked neck birds despite the high temperature and humid conditions is a positive sign for increased metabolism and consequently for growth and reproduction in tropical conditions. Though T3 happens to be the most effective thyroid hormone [34], the presence of T4 is also relevant because T4 is sent into the liver and other peripheral tissues in order to produce T3 [35]. In the same way, the presence of TSH is important to birds because according to [36], it facilitate the production of T4. He indicated that a suppression or reduction of TSH levels will reduce T4 levels which can subsequently reduce the availability of plasma T3 levels.

Table 7: Means of the Thyroid Hormones Present in the Two Phenotypes

Phenotype	T3 (pmol/l)	T4(pmol/l)	TSH (pmol/l)
Mcnabb and Darras (2015)	0.7-1.5 pmol/ml	6-19pmol/ml	
Normal feathered	5.22	21.5	0.0495
Naked neck	6.135	24.9	0.0735
F. probability	0.059	0.527	0.274

IV. CONCLUSIONS

Within humid tropical conditions with mean temperature and humidity values of 29^{o}C and 73.3% respectively, the naked neck gene has a positive influence on the productivity of meat type chickens. This is because birds carrying the naked neck gene (*Na*) showed better growth performance compared to the normal feathered birds, yielded higher carcass in economically important parts and also have a clear pattern of higher means of plasma concentrations of $T_{3,}$ T_4 and TSH all of which are essential for efficient growth and are usually low within high ambient temperatures.

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