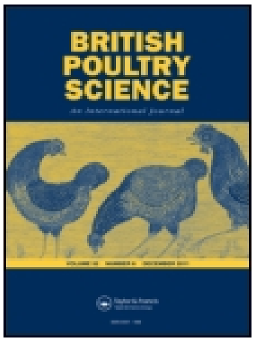

British Poultry Science

ISSN: 0007-1668 (Print) 1466-1799 (Online) Journal homepage: https://www.tandfonline.com/loi/cbps20

Growth performance of crossbred naked neck and normal feathered laying hens kept in tropical villages

K. Adomako, O. S. Olympio, J. K. Hagan & J. A. Hamidu

To cite this article: K. Adomako, O. S. Olympio, J. K. Hagan & J. A. Hamidu (2014) Growth performance of crossbred naked neck and normal feathered laying hens kept in tropical villages, British Poultry Science, 55:6, 701-708, DOI: 10.1080/00071668.2014.960805

To link to this article: https://doi.org/10.1080/00071668.2014.960805

Published online: 05 Sep 2014.

British Poultry Science, 2014
Vol. 55, No. 6, 701–708, http://dx.doi.org/10.1080/00071668.2014.960805

Taylor & Francis
Taylor & Francis Group

Growth performance of crossbred naked neck and normal feathered laying hens kept in tropical villages

K. ADOMAKO, O. S. OLYMPIO, J. K. HAGAN[1] AND J. A. HAMIDU

Department of Animal Science, KNUST, Kumasi, Ghana and [1]Department of Animal Science, University of Cape Coast, Cape Coast, Ghana

Abstract 1. Two experiments were conducted to develop naked neck (*Na/na*) and normal feathered (*na/na*) crossbreds and compare their growth performance, linear body measurements and carcass characteristics in the first and second filial generations.

2. In the first experiment, 4 indigenous naked neck males (*Na/na*) were mated to 36 Lohmann commercial females (*na/na*) in a ratio of 1:9. The two genotypes (*Na/na, na/na*) were allocated randomly according to batches of hatch, sire lines and sex to three different villages.

3. In the second experiment, 10 males and 100 females of F_1 *Na/na* birds were selected and mated *inter se* in a ratio of 1:10. The three genotypes (*Na/Na, Na/na* and *na/na*) were compared in a randomised complete block design experiment, with the three villages, hatch and sex as blocks and the three genotypes as treatments. F_1 *Na/na* birds had significantly higher ($P < 0.05$) feed conversion ratio, body weight, body weight gain, linear body measurements, survivability and carcass yield than their *na/na* counterparts.

4. In the F_2 generation, *Na/Na* and *Na/na* birds had significantly higher ($P < 0.05$) feed conversion ratio, body weight, body weight gain, linear body measurements, survivability and carcass yield compared to their *na/na* counterparts.

5. The birds showing the naked neck phenotype appeared to show superior performance compared to normal feathered birds and could be exploited for potential utilisation in local poultry production.

INTRODUCTION

The contribution of rural poultry to the national economy of developing countries cannot be underestimated. In Bangladesh, rural chicken contributes about 1.37% of gross domestic products (GDP). While boosting nutritional status of many villages, local chicken production has significantly improved income levels of many smallholder farmers and landless communities (Creevey, 1991). However, the potential of rural poultry production has been little explored in Ghana. The problem in Ghana is lack of a reliable local breed chicken that can be adopted commercially for higher production in the stressful tropical environmental temperature (Adomako *et al.*, 2009). There is a need to develop a "bridge" breed in Ghana through selection which could have the potential for adoption by commercial poultry farmers. In addition, if production could be improved, village poultry production would create an opportunity for the development of the poorer segments of society (Quisumbing *et al.*, 1995; Todd, 1998; Permin *et al.*, 2000). The necessary type of bird should be able to meet the meat production and growth rate required by local farmers when compared to breeds commonly used in Ghana.

The two breeds considered suitable for crossbred production were a normal feathered bird, the Lohmann strain, and the naked neck bird genotype. The Lohmann strain is a dual-purpose commercial breed widely used in Ghana that is adaptable to high ambient temperatures, is bigger in size and has a higher hen-d rate of lay (70–90%) than local chickens. The naked neck gene (*Na*), which is located on chromosome 3, has been linked to growth and differentiation factor

Correspondence to: K. Adomako, Department of Animal Science, KNUST, Kumasi, Ghana. E-mail: kwadom75@yahoo.co.uk
Accepted for publication 5 June 2014.

7 (*GDF7*). It is partly responsible for the control of feather inhibition in the naked neck mutation (Headon, 2013) and is characterised by either a fully featherless neck or featherless neck with a tuft of feather at the base of the neck and a reduction in the entire feather coverage by 20–40%. The gene, *Na*, has been found to possess thermoregulatory properties and therefore birds carrying it are able to dissipate heat under very high ambient temperature conditions so that productivity in terms of meat and eggs would not be depressed through the reduced feed intake resulting from the difficulty in dissipating excess body heat as in normally feathered birds (Cahaner *et al*., 1993; Njenga, 2005; Adomako *et al*., 2009, 2010). Incorporation of the naked neck gene into chickens for higher productivity under tropical conditions has long been advocated (Merat, 1986). According to Adomako et *al.* (2009), birds carrying the *Na* gene are sparsely found within the population of local birds in Ghana. The objective of this study therefore was to determine the effect of the *Na* gene on growth performance, survivability and carcass yield of local-exotic crossbred chickens (50% local and 50% exotic).

MATERIALS AND METHODS

Location and duration of experiment

The experiment was carried out at the Animal Science Department, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi (altitude 261.4MSL, latitude 06°41′N and longitude 01°33′W) (Meteorological Services Department, Kumasi); and three selected villages/towns within the Asante-Akim South District of Ashanti Region, namely, Yawkwei, Juaso and Nkwanta. These villages were selected based on convenience and availability of reliable chicken keepers. The average ambient temperature at the experimental sites was 26.9°C. The study was approved by the departmental board after they had ensured that the welfare of the birds would be protected. The experiment lasted for two years.

Experimental birds

A total of 36 Lohmann brown layers at the age of 52 weeks were obtained from a commercial poultry farm (Akate Farms and Trading Company Limited, Kumasi, Ghana) and crossed with 4 indigenous heterozygous naked neck (*Na/na*) males of the same age. The local naked neck males were bought from Nkwanta, Juaso and Yawkwei villages within the Asante-Akim South District of Ashanti Region, Ghana. The 4 sires varied in colour, which helped in their identification.

Upon arrival, the feet of the males was washed with disinfectant and they were dewormed and vaccinated against Newcastle disease (Nobilis Newcavac, MSD Animal Health) to avoid the spread of infections before they were brought to the Animal Science Department, KNUST. All birds were weighed individually and then housed in 4 separate pens measuring 1.5 m × 3.1 m, with the layers, in a ratio of 1:9 for natural mating.

Flock management

The birds were kept in a deep litter system for 3 months. They were fed on layer mash *ad libitum* (175 g CP/kg and 11.3 MJ ME/kg) and were also provided with fresh water *ad libitum.* Each of the 4 pens had two laying boxes measuring 15 cm × 15 cm. Eggs were collected twice daily, labelled and stored for not more than 7 d at room temperature (25°C) before incubation. The birds were dusted with Malathion poultry dust (Kepro, the Netherlands) against lice, soft ticks and mites. They were also dewormed and given Pen Strip (Kepro, the Netherlands), which is a source of antibiotics and vitamins.

Incubation

The eggs of the F_1 generation were selected for artificial incubation by discarding eggs which did not fall within the range of 55–65 g (very small eggs or very large eggs), broken shells, blood stained or dirty eggs. The eggs were incubated and hatched at the hatchery of Akropong Farms, a commercial hatchery in Kumasi, Ghana. The incubation was done weekly for 5 consecutive weeks for both the F_1 and F_2 generation birds.

Chick rearing

After hatching, the chicks were wing-tagged and weighed individually. Chicks were then brooded at the Department of Animal Science, KNUST experimental houses for 6 weeks. In the brooding house, electric bulbs (100 W) were used to provide light and heat for the chicks. Glucose was administered via drinking water. Chicks were fed on a commercial chick mash containing 195 g CP/kg and 11.72 MJ ME /kg (AGRICARE Ghana Ltd, Ghana). Drinking water was supplied *ad libitum.* The chicks were vaccinated against Newcastle and Gumboro diseases. Coccidiostat, antibiotics and vitamins were also given through their drinking water during the first month. The growth rates of chicks were recorded weekly up to 6 weeks after which the chicks were randomly distributed to three selected villages (Yawkwei, Juaso and Nkwanta) for performance trials of F_1 birds.

Parents for the second-generation birds

At the end of the 6th week, 20 heterozygous naked neck males and 120 heterozygous naked neck females were selected to be mated *inter se* to produce the second generation. The males were kept separated from the females. The birds were fed on a commercial grower mash from AGRICARE Ltd, Ghana (150 g CP/kg and 11.10 MJ ME/Kg) at 6 weeks of age and layer mash (AGRICARE Ltd, Ghana) at 17 weeks of age (175 g CP/kg and 11.30 MJ ME/kg). Feed and freshwater were given *ad libitum*. They were vaccinated against fowl pox and Newcastle diseases. Deworming and vitamin supplementation were done after every 3 months via their drinking water. Four weeks after the first egg was laid, the males were introduced to the females in a ratio of 1:10; and collection of eggs for incubation took place 2 weeks thereafter. Chicks were reared up to 6 weeks. After the 6th week, these F_2 birds were transferred to the three villages mentioned earlier (Yawkwei, Juaso and Nkwanta).

One chicken keeper was selected in each of the three villages/towns, namely Yawkwei, Juaso and Nkwanta. At the end of the 6th week, the chicks were distributed to the keepers in each of the three selected villages. Each famer was given 288 F_1 birds, 144 each of heterozygous naked neck (72 males and 72 females) and normal feathered (72 males and 72 females) birds. For the second-generation birds (F_2), each farmer was given the same number of birds (288), 96 from each of the three genotypes (*Na/Na, Na/na* and *na/na*). Each farmer was given guidance on the preparation of the mash to supplement scavenging feeds (Table 1). The mash was given to the birds three times daily (75 g/bird/d). Fresh water was provided *ad libitum*.

Growth performance

Records on the F_1 birds were taken up to the end of the 6th week at the Department of Animal Science (on-station) and continued in the villages (on-farm) when the birds were transferred, except those used as parents (P2) in the second mating which remained at the Department of Animal Science. The records taken included weight at 1-d-old, weekly feed intake, weekly body weight and weight gain to sexual maturity, shank length, body length, body width, mortality and carcass parameters for both F_1 and F_2 birds.

Table 1. *Composition of the feed supplement*

Ingredients	Quantity used (g/kg)
Maize	630
Wheat bran	135
Palm kernel cake	130
Dried fish waste	10
Sodium chloride	5

Calculated: CP = 137 g/kg, ME = 11.42 MJ/kg and CF = 47.5 g/kg.

Feed intake, body weight, body weight gain and feed conversion ratio (FCR) were recorded. The weight gain from day-old to sexual maturity (week 20) was used to study the growth pattern of each genotype in both the F_1 and F_2 generations. Feed intake was calculated using the formula: average feed intake (g) = feed supplied per replicate (g) – feed leftover per replication (g)/number of birds per replication. The FCR was calculated as FCR = average feed intake from day-old to the end of week 20 (g)/average weight gain between day-old and week 20(g).

Body length, body width and shank length

The body length of birds was measured when the birds were 20 weeks of age using a measuring tape. The shank length (SL) was taken as the length of the *tarso metatarsus* from the *hock* joint to the *metatarsal* pad, and the body length (BL) between the tip of the *rostrum maxillare* (beak) and that of the *cauda* (tail, without feathers). Body width (BW) was measured as the distance between the two shoulders. The same measurements were performed in F_2 birds.

In both F_1 and F_2 generations, the mortality was recorded as and when it occurred and was expressed as a percentage of the total number of birds.

Carcass analysis

The carcass traits were taken at the end of the 20th week. In each village, three males and three females from each genotype (*Na/na* and *na/na*) were selected for the carcass analysis for both the F_1 and F_2 generations.

Statistical analysis

Analysis of variance (ANOVA) was performed on the data using Genstat, Discovery Edition 3 (2007). Separation of significantly different means at $P < 0.05$ was done by the least-significant difference test. The fixed effect of genotype (*Na/Na, Na/na* and *na/na*) was analysed with the linear model in a randomised complete block design (RCBD) with the village where the birds were tested as the block effect and sire lines, hatch and sex were blocks and genotype was the treatment effect.

RESULTS

Mating and rearing

The first cross of normal feathered Lohmann layers (*na/na*) and indigenous heterozygous (*Na/na*) naked neck males produced offspring that were 48.7% heterozygous naked neck (*Na/na*) and 51.3% normal feathered birds (*na/na*) in the F_1. The second cross of an *inter se* mating of the crossbred heterozygous naked necks (*Na/na*) from the F_1 generation produced 16.8% homozygous naked neck (*Na/Na*), 54.5% heterozygous naked neck (*Na/na*) and 28.7% normal feathered (*na/na*) birds. Both F_1 and F_2 birds were made up of full-sib and half-sib sire families, but due to the difficulty of separating these, they were reared together as sire families.

Growth performance of F_1 naked neck (*Na/na*) and normal feathered (*na/na*) birds

Average weekly feed intake was not significantly different ($P > 0.05$) among the two genotypes. The *Na/na* birds had a significantly lower ($P < 0.05$) FCR values compared to their normal feathered (*na/na*) counterparts (Table 2). Body weight and body weight gain of F_1 birds at 1-d-old, 6 weeks and 20 weeks were significantly higher ($P < 0.05$) in the naked necks (*Na/na*) as compared to their normal feathered counterparts (Figure 1) while percentage mortality was higher in normal feathered birds compared to the naked necks (Table 2).

Table 2. *Growth performance of F_1 naked neck (Na/na) and normal feathered (na/na) birds*

Trait	*Na/na*	*na/na*	SEM
Live weight, 1-d old, g	43.2[a]	41.6[b]	0.144
Average weekly feed intake, g	305	302	1.685
Feed conversion ratio, FCR[1], feed/gain	3.18[a]	3.70[b]	0.025
Live weight, week 6, g	449.0[a]	409.7[b]	0.004
Weight gain, week 6, g/week	103.5[a]	96.7[b]	0.007
Live weight, week 20, g	1895.8[a]	1565.4[b]	16.07
Weight gain, week 20, g/week	117.9[a]	94.6[b]	1.617
Mortality, %	7.89[a]	9.10[b]	0.199

[1]The calculation of FCR did not include scavenging feed intake.

[a,b]Mean values within the same row sharing a common superscript letter are not statistically different at $P < 0.05$.

Linear body measurements in F_1

Body length and body width values were significantly higher ($P < 0.05$) in the naked neck birds compared to the normal feathered birds (Table 3). However, shank length did not show a significant difference ($P > 0.05$).

Carcass parameters of F_1

The heterozygous naked neck birds had a significantly higher ($P < 0.05$) de-feathered weight, dressed weight, thigh and drumstick weight, breast muscle weight, weight of wings and gizzards than the normal feathered birds (Table 4). However, weights of intestines, heart and liver were not significantly affected by the phenotypes of the birds (Table 4).

Table 3. *Average linear body measurements of F_1 Na/na and na/na birds*

Parameters/genotype	*Na/na*	*na/na*	SEM
Body length (cm)	36.04[a]	34.83[b]	0.115
Body width (cm)	13.93[a]	13.42[b]	0.078
Shank length (cm)	8.38	8.34	0.056

[a,b]Mean values within the same row sharing a common superscript letter are not statistically different at $P < 0.05$.

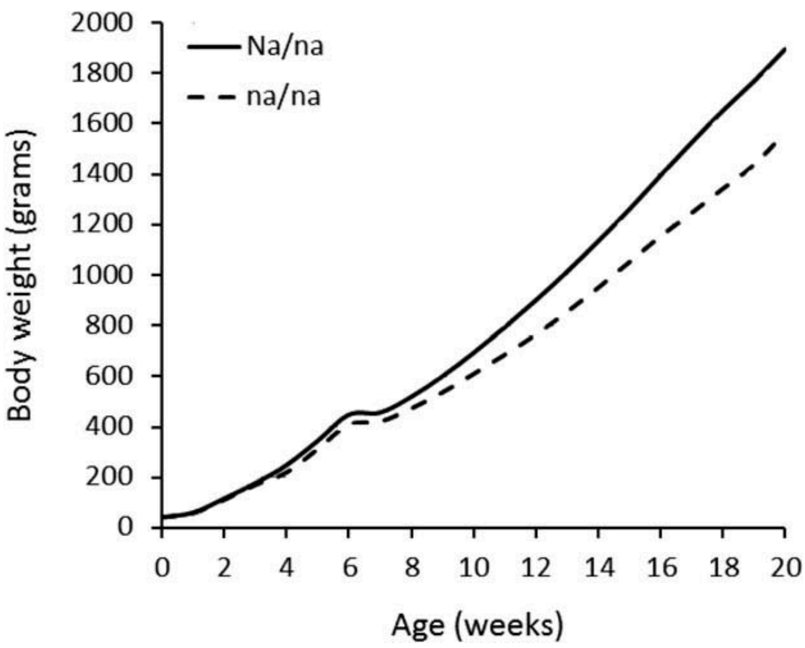

Figure 1. *Growth pattern of Na/na and na/na birds from hatch to week 20.*

Table 4. *Mean carcass parts and organ weights of F_1 Na/na and na/na birds*

Parameters/genotype	*Na/na*	*na/na*	SEM
De-feathered carcass (%)	91.40[a]	86.01[b]	0.036
Dressed weight (%)	74.70[a]	66.88[b]	0.046
Thigh and drumstick (%)	23.24[a]	23.11[b]	0.060
Breast muscle (%)	19.01[a]	16.08[b]	0.319
Weight of wings (%)	10.36[a]	10.22[b]	0.056
Gizzard (%)	3.77[a]	3.66[b]	0.037
Weight of intestines (%)	3.71	3.69	0.019
Heart weight (%)	1.47	1.48	0.013
Liver weight (%)	1.84	1.83	0.018

[a,b]Mean values within the same row sharing a common superscript letter are not statistically different at $P < 0.05$.

Growth performance of F_2 *Na/Na, Na/na* and *na/na* birds

Body weight at 1-d-old was significantly higher ($P < 0.05$) in the F_2 normal feathered chicks compared to their naked neck counterparts (Table 5). Average weekly feed intake was not significantly different ($P > 0.05$) among the three genotypes. The naked neck birds (*Na/Na, Na/na*) had a significantly better ($P < 0.05$) FCR compared to their normal feathered (*na/na*) counterparts. Body weight and body weight gains of F_2 *Na/Na* and *Na/na* birds were significantly greater ($P < 0.05$) than the normal feathered birds at the end of weeks 6 and 20 (Table 4). Significantly fewer ($P < 0.05$) F_2 naked necks *(Na/Na, Na/na)* died compared with their normal feathered counterparts (Table 5).

Linear body measurements of F_2

Average body length of the *Na/na* F_2 birds was significantly higher ($P < 0.05$) than that of the *Na/Na* F_2 birds whose average body length was also significantly higher than that of the *na/na* F_2 birds. Body widths of *Na/Na* and *Na/na* F_2 birds were significantly higher ($P < 0.05$) than that of the *na/na* F_2 birds. However, shank length did not show a significant difference ($P > 0.05$) between the F_2 birds (Table 6).

Table 5. *Growth performance of F_2 Na/Na, Na/na and na/na birds*

Trait	*Na/Na*	*Na/na*	*na/na*	SEM
Live weight, d old	39.7[b]	38.7[b]	42.3[a]	0.99
Average weekly feed intake, g/bird	303	301	300	1.8
Feed conversion ratio, feed/gain[1]	2.76[a]	2.70[a]	2.85[b]	0.03
Live weight week 6, g	384[a]	385[a]	373[b]	2.4
Weight gain week 6, g/week	83.8[a]	83.9[a]	78.1[b]	1.18
Live weight week 20, g	2086	2124[a]	2009[b]	22.3
Weight gain week 20, g/week	175	184[a]	163[c]	3.6
Mortality, %	7.9[b]	8.2[b]	13.822[a]	0.34

[1]The calculation of FCR did not include scavenging feed intake.
[a,b,c]Mean values within the same row sharing a common superscript letter are not statistically different at $P < 0.05$.

Table 6. *Average linear body measurements of F_2 Na/Na, Na/na and na/na birds*

Measurement	*Na/Na*	*Na/na*	*na/na*	SEM
Body length (cm)	38.17[a]	38.50[b]	36.50[c]	0.1445
Body width (cm)	14.00[b]	14.00[b]	13.50[a]	0.1320
Shank length (cm)	8.50	8.42	8.33	0.0803

[a,b,c]Mean values within the same row sharing a common superscript letter are not statistically different at $P < 0.05$.

Carcass parameters of F_2 birds

Percent de-feathered weight, dressed weight, thigh and drumstick weight, breast muscle weight, gizzard weight and liver weight were significantly higher ($P < 0.05$) in the carcasses of *Na/Na* and *Na/na* F_2 birds compared to those of *na/na* F_2 birds. However, relative weight of intestines was significantly higher ($P < 0.05$) in *na/na* F_2 birds compared to that of *Na/Na* and *Na/na* F_2 birds. Percent de-feathered weight, dressed weight and breast muscle weight were significantly higher ($P < 0.05$) in *Na/Na* F_2 birds than *Na/na* and *na/na* ones, whereas relative weight of intestines was significantly higher ($P < 0.05$) in *Na/Na* than *Na/na* which again had relative heavier intestines than *na/na* F_2 birds (Table 7).

DISCUSSION

Egg storage for 7 d at room temperature (25°C) before incubation is not the standard practice but was necessary because the focus of this study was to develop a crossbred for small-scale poultry production in Ghana under conditions that would be available to small-scale farmers in order to make adoption of the research outcome easier.

Table 7. *Mean weights of carcass, carcass parts and organs of F_2 Na/Na, Na/na and na/na birds*

Trait	*Na/Na*	*Na/na*	*na/na*	SEM
De-feathered weight (%)	95.97[a]	93.76[b]	88.54[c]	0.210
Dressed weight (%)	74.48[a]	73.09[b]	69.29[c]	0.494
Thigh and drumstick weight (%)	23.62[a]	23.42[a]	22.71[b]	0.173
Chest muscle weight (%)	17.79[a]	17.36[b]	13.37[c]	0.073
Wing weight (%)	10.00	10.26	10.09	0.150
Gizzard weight (%)	4.13[a]	4.19[a]	3.59[b]	0.041
Intestine weight (%)	4.26[c]	4.41[b]	4.96[a]	0.081
Heart weight (%)	1.58	1.60	1.64	0.026
Liver weight (%)	2.00[b]	2.10[b]	2.31[a]	0.051

[a,b,c]Mean values within the same row sharing a common superscript letter are not statistically different at $P < 0.05$.

The F_1 and F_2 naked neck birds had significantly lower FCR values and also had significantly higher body weights and weight gains than normal feathered birds. It is assumed that 20–40% less feather coverage in naked neck birds reduced the need for dietary nutrition to supply protein input for feather production and saved protein, which may result in faster growth (Horst, 1987; Merat, 1990; Ajang *et al.*, 1993; Cahaner *et al.*, 1993). Secondly, the naked neck gene (*Na*) may have a linkage with some of the genes which control body weight and body weight gain in chicken (Crawford, 1976). Furthermore, reduction in feather coverage increases the rate of irradiation of internally produced heat, thus improving thermoregulation under high (30°C) or even moderate (22°C) ambient temperatures. Thus, naked neck chickens have a better capacity to maintain their body temperature at high ambient temperatures (Yahav *et al.*, 1998) due to the absence of feathers on their neck, and also the absence of scattered down and semi plume feathers on the *apteria*, which radiate heat that are normally held-in by the feathers of chickens. According to Bordas *et al.* (1978), the reduction in feather coverage of naked neck birds by 20–30% and 30–40%, respectively, for the heterozygous (*Na/na*) and homozygous (*Na/Na*), facilitates better heat dissipation and improves thermoregulation resulting in better relative heat tolerance under hot climates. This, according to Ward *et al.* (2001), results in relief from heat stress, which enhances the productive and reproductive performance of naked neck birds, since chickens minimise endogenous heat production, to avoid a dangerous increase in body temperature, by reducing feed intake, resulting in decreased growth and meat yield (Yahav *et al.*, 1998).

The present results are similar to those of Njenga (2005), who compared the growth of naked neck, frizzle, dwarf and normal feathered birds from 1-d-old to week 5, and concluded that the naked neck birds were significantly heavier than all the other chicken genotypes. In studies involving slow-growing birds under fluctuating temperatures, N'Dri *et al.* (2005) and Sharifi *et al.* (2010) observed that heterozygous naked neck birds reached 2 kg 3.3 d earlier than normal feathered birds. Merat (1986) and Rauen *et al.* (1986) reported that heterozygous naked neck birds had significantly higher growth performance than their normal feathered counterparts at temperatures of 30°C and higher. Somes (1988), Hareen-Kiso (1991) and Mathur (2003) found that under constant heat stress, heterozygous naked neck birds perform significantly better than their normal feathered counterparts in terms of growth performance.

Mortality was significantly lower ($P < 0.05$) in naked neck birds than in normal birds (*na/na*), suggesting that the presence of the *Na* gene in the birds might have increased their resistance against diseases. Additionally, the naked neck birds were very docile and did not peck at each other when housed in the same room, despite their bare necks, unlike their normal feathered counterparts within which a few deaths occurred as a result of cannibalism, and this might have increased the relative survivability of naked neck birds.

The F_2 *Na/na* birds having higher values for body length than *Na/Na* ones could be due to overdominance (a situation where the heterozygous form of a gene (*Na/na*) performs better in a trait than the two homozygotes (*Na/Na and na/na*)). Additionally, the *Na/Na* birds have only been found to perform better than *Na/na* ones under constant artificial higher ambient temperatures (>25°C) (Deeb and Cahaner, 1999). Therefore, it is possible that the fluctuating natural temperatures in the tropics give more advantage to heterozygous naked neck birds in terms of body length than homozygous naked neck ones.

The F_1 and F_2 naked necks (*Na/Na, Na/na*) had higher values for de-feathered weight, dressed weight, thigh and drumstick weight, breast muscle weight than their naked neck and normal feathered (*na/na*) counterparts (Tables 4 and 7) because of the reduction of plumage (20–40%) in naked neck birds, protein that might have been used for feather development, is used to develop meat tissues. Also, the fewer feathers resulted in higher carcass yields than their normal feathered counterparts. According to Headon (2013), the growth of a full plumage imposes a significant nutritional demand and necessitates removal after slaughter, producing large quantities of feather waste per year. Additionally, naked neck birds have a higher proportion of muscle in the pectoral region and this gives them more meat. The effect of the reduction in feather mass caused by the *Na* gene on breast muscle yield mimics the effect of reducing ambient temperature (AT). Several studies with normally feathered birds have shown that breast muscle yield is higher at low-to-moderate AT than at high AT (Howlider and Rose, 1989; Leenstra and Cahaner, 1992). Therefore, the higher meat yield of the naked neck birds, especially because it is even higher in the *Na/Na* genotype than in the *Na/na*, also indicates that their ability to endure heat stress under high ambient temperatures has an effect equivalent to that of a lower environmental temperature. The result is also similar to that of Fathi *et al.* (2008), who found the two naked neck genotypes to be superior in relative drumstick weight compared to their normal feathered counterparts. They also found dressing percentage and relative breast muscle weight to be higher in the naked neck genotypes (*Na/Na* and *Na/na*) compared to their normal feathered counterpart (*na/na*) which is similar to what was found in this study.

The homozygous naked necks had higher values for de-feathered weight, dressed weight and breast muscle weight than the heterozygous naked necks because the phenotypic influence of the naked neck gene in a homozygous form is more pronounced than that of the heterozygous. This, coupled with the fact that the birds had similar genetic backgrounds, indicates that the *Na* gene has a substantial influence on carcass traits. This result is similar to that of Deeb and Cahaner (1999), who studied three genotypes (*Na/Na, Na/na* and *na/na*) in broilers under alternating ambient temperature (24:32°C) and reported that the heterozygous and homozygous naked neck broilers gained 4.5 and 8.1% more body weight, respectively, than their normally feathered sibs from 35 to 49 d of age. Deeb and Cahaner (1999) also stated that the naked neck birds, especially the homozygotes, exhibit higher breast weight and percentage compared with their fully feathered sibs. The average advantage of *Na/na* and *Na/Na* broilers compared with their fully feathered sibs (*Na/na*) was 5.5 and 7.0% at a constant temperature of 24°C (Cahaner *et al.*, 1993); 3.0 and 9.0% at a constant temperature of 28°C (Deeb and Cahaner, 1994); 8.4 and 11.5% at a constant temperature of 32°C (Cahaner *et al.*, 1993); and 3.8 and 7.6% at an alternating temperature of 24:32°C.

It is concluded that growth performance, survivability and carcass parameters in chickens could be improved markedly by the presence of the naked neck gene in the heterozygous (*Na/na*) or homozygous (*Na/Na*) state. The mating procedures and field trial reported in this study could be used to significantly increase the productivity of rural poultry production and confirm that the advantages of the *Na* gene in experimental studies can also be obtained in a village setting.

REFERENCES

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. *Proceedings of the 16th Biennial Conference of Ghana Society of Animal Production*, KNUST, Kumasi, pp 181–185.

Adomako, K., Hagan, J. K. & Olympio, O. S. (2010) Egg production performance of first and second filial generation naked neck (NaNa, Nana) and normal feathered (nana) birds of a cross between indigenous naked neck (NaNa, Nana) males and exotic commercial females (nana). *Livestock Research for Rural Development*, **22**. Available: http://www.lrrd.org/lrrd22/12/adom22223.htm.

Ajang, O.A., Prijono, S. & Smith, W.K. (1993) Effect of dietary protein content on growth and body composition of fast and slow feathering broiler chickens. *British Poultry Science*, **34**: 73–91. doi:10.1080/00071669308417564.

Bordas, A., Merat, P., Sergent, D. & Ricard, F.H. (1978) Influence of the naked neck gene on the performance of chickens. *Journal of Animal Genetics*, **10**: 209–231.

Cahaner, A., Deeb, N. & Gutman, M. (1993) Effects of the plumage-reducing naked neck (Na) gene on the performance of fast growing broilers at normal and high ambient temperatures. *Poultry Science*, **72**: 767–775. doi:10.3382/ps.0720767.

Crawford, R.D. (1976) Incomplete dominance of the gene for naked neck in domestic fowl. *Journal of Poultry Science*, **55**: 820–822. doi:10.3382/ps.0550820.

Creevey, L.E. (1991) Supporting small-scale enterprises for women farmers in the Sahel. *Journal of International Development*, **3**: 55–386. doi:10.1002/jid.4010030311.

Deeb, N. & Cahaner, A. (1994) Genotype-environment interaction and heat tolerance of naked-neck broilers, in: Gall, G.A.E. & Chen, H. (Eds) *Proceedings of the 5th World Congress on Genetics Applied to Livestock Production*. **20**: 65–68, Guelph, Canada.

Deeb, N. & Cahaner, A. (1999) The effects of naked neck genotypes, ambient temperature, and feeding status and their interactions on body temperature and performance of broilers. *Poultry Science*, **78**: 1341–1346. doi:10.1093/ps/78.10.1341.

Fathi, M.M., El-Attar, A.H., Ali, U.M. & Nazmi, A. (2008) Effect of the naked neck gene on carcase composition and immunocompetence in chicken. *British Poultry Science*, **49**: 103–110. doi:10.1080/00071660802005137.

Genstat, Discovery Edition 3 (2007) *VSN International Software for Biosciences* (Oxford, UK, VSN International).

Haaren-Kiso, A. (1991) The effects of naked neck and frizzle genes on performance and immunocompetence of chickens. *Ph.D Thesis*, Institute for Animal Production, Technical (Umboldt) University of Berlin.

Headon, D. (2013) Systems biology and livestock production. *Animal*, **7**: 1959–1963. doi:10.1017/S1751731113000980.

Horst, P. (1987) Some remarks on poultry improvement in Bangladesh as related to socio-economic factors. *Paper Presented to the FAO Expert Consultation on Rural Poultry Development in Asia*, Dhaka, Bangladesh.

Howlider, M.A.R. & Rose, S.P. (1989) Temperature and the growth of broiler. *Worlds Poultry Science Journal*, **45**: 228–236.

Leenstra, F. & Cahaner, A. (1992) Effects of low, normal, and high temperatures on slaughter yield of broilers from lines selected for high weight gain, favorable feed conversion, and high or low fat content. *Poultry Science*, **71**: 1994–2006. doi:10.3382/ps.0711994.

Mathur, P.K. (2003) Genotype-environment interactions: problems associated with selection for increased production, in: Muir, M.W. & Aggrey, S.E. (Eds) *Poultry Genetics, Breeding and Biotechnology*, 546 (UK, CABI Publishing).

Merat, P. (1986) Potential usefulness of the Na (naked neck) gene in poultry production. *World's Poultry Science Journal*, **42**: 124–142. doi:10.1079/WPS19860010.

Merat, P. (1990) Pleiotropic and associated effects of major genes, in: Crawford, R.D. (Ed) *Poultry Breeding and Genetics*, 442–448 (Amsterdam, Elsevier).

N'Dri, A.L., Mignon-Grasteau, S., Sellier, N. & Tixier-Boichard, M. (2005) Influence of the naked neck gene on heat tolerance of slow growing broilers on growth, body composition and meat quality. *Fourth European Poultry Genetics Symposium*, Croatia. Abstract of poster.

Njenga, S.K. (2005) Productivity and socio-cultural aspects of local poultry phenotypes in Coastal Kenya. *Masters of Science Degree Thesis*. Network for Smallholder Poultry Development, the Royal Veterinary and Agricultural University, Dyrlaegevej 2, 1870 Frederiksberg C, Copenhagen, Denmark

Permin, A., Pedersen, G. & Riise, J.C. (2000) *Poultry as a tool for poverty alleviation: opportunities and problems related to poultry production at village level* (Denmark, The Royal Veterinary and Agricultural University).

Quisumbing, A.R., Brown, L.R., Feldstein, H.S., Haddad, L. & Pena, C. (1995) Women, the key to food security. Food Policy Statement. Available: http://www. cgiar.org/ifpri/fps/Fps 21.htm. Accessed 21 Number.

Rauen, H.W., Horst, P. & Valle-Zarate, A. (1986) Influence of the naked neck and frizzle genes on productive performance of birds under high ambient temperatures. *Archive of Genetics*, **50**: 235–245.

SHARIFI, A.R., HORST, P. & SIMIANER, H. (2010) The effect of naked neck gene and ambient temperature and their interaction on reproductive traits of heavy broiler dams. *Poultry Science*, **89**: 1360–1371. doi:10.3382/ps.2009-00593.

SOMES JR., R.G. (1988) *International Registry of Poultry Genetic Stocks*. (University of Connecticut, Storrs, Storrs Agricultural Experimental Station Bulletin) p. 476.

TODD, H. (1998) Women climbing out of poverty through credit: or what do cows have to do with it?. *Livestock Research for Rural Development*, **10**: 1–3.

WARD, J.M., HOUSTON, D.C., RUXTON, G.D., MCCAFFERTY, D.J. & COOK, P. (2001) Thermal resistance of chicken (*Gallus domesticus*) plumage: a comparison between broiler and free-range birds. *British Poultry Science*, **42**: 558–563. doi:10.1080/00071660120088335.

YAHAV, S., LUGER, D., CAHANER, A., DOTAN, M., RUSAL, M. & HURWITZ, S. (1998) Thermoregulation in naked neck chickens subjected to different ambient temperatures. *British Poultry Science*, **39**: 133–138. doi:10.1080/00071669889510.