THE EFFECT OF NAKED NECK, FRIZZLE AND NORMAL FEATHER GENOTYPES ON LAYING PERFORMANCE AND PTERYLOSIS OF BROWN AND WHITE LAYER PARENTS

BY

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DEDICATION

This work is dedicated to my caring mother Akua Forkuo, lovely wife, Harriet Affum and to my wards Faustina Duodu, Godwin Annor Duodu and Ellen Duodu for their love, financial, assistance and care throughout my education.

May God bless you all.

DECLARATION

I hereby declare that this submission is my own work towards the Master of Science (Animal Breeding and Genetics) and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, or elsewhere except where due acknowledgment has been made in the text.

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ABSTRACT

Three experiments were conducted in this study. In Experiment one, a study was conducted in the Afigya Sekyere and Ejura Districts, and Offinso Municipal of Ashanti Region with the aim of finding the laying performance of birds possessing various mutant genes in the population of indigenous chickens in the three areas. Questionnaires and interviews were used for the study. Twelve towns/villages (4 from each District) were sampled at random and 90 chicken keepers (30 from each area) who reared their birds under the extensive system of production were randomly selected from these towns/village. The average flock size of a keeper ranged between 22 and 25 in the ratio of 3 males: 9 females. The observed frequency of the normally feathered genotypes differed significantly ($P<0.05$) from that of the dominant genotypes. In terms of number of eggs laid per year per bird, the frizzled and the naked neck birds were significantly superior compared to the normally feathered birds. The number of eggs hatched in a year was significantly higher ($p<0.05$) for the frizzle birds than the normally feathered and naked neck birds. Disease resistance was also significantly higher ($p<0.05$) for the normally feathered birds than the naked neck birds but the naked neck birds did not differ significantly from the frizzle birds. Acceptability was significantly lower for the naked neck than the frizzle and normally feathered birds. Among the problems confronting the keepers were: small size of birds and eggs, theft, low acceptablilty of the *Nanaff*, annual Newcastle disease attack, lack of funds to maximize production, unavailability of improved breeds and predation. Multiplication, selection and usage of indigenous birds possessing naked neck and frizzle mutant genes in local chicken production coupled with improvement in housing, disease prevention and nutrition would improve productivity significantly.

Experiment two was conducted to assess the effects of the naked neck (*Nanaff*), frizzle (*nanaFf*) and normal feathered (*nanaff*) genotypes, and also gold (s-) and silver (S-) plumage colours on the performance of local-exotic crossbred pullets. The pterylosis of the dorsal, ventral and lateral tracts of 27 of these birds were also assessed. Three hundred and sixty (360) pullets of 24 weeks of age were studied in a 3X2 factorial design for 40 weeks. There were 120 pullets within each of the three genotypic groups (*Nanaff*, *nanaFf* and *nanaff*); there were two plumage colours (s- and S-) with three replications in each plumage colour. There were 18 pens with 20 pullets in each pen. *Nanaff* pullets had significantly higher values ($p<0.05$) in hen-day egg production, feed intake, age at 50% production, body weight and hen-house egg production than their *nanaFf* and *nanaff* counterparts, but the *nanaFf* pullets were significantly superior ($p<0.05$) to the *nanaff* in terms of age at 50% production. Egg mass was not significantly different ($p>0.05$) in *Nanaff* and *nanaFf* pullets and were also not significantly different ($p>0.05$) between *nanaFf* and *nanaff* genotypes but were significantly better ($p<0.05$) in *Nanaff* than *nanaff* groups. No significant differences ($P>0.05$) were recorded among the genotypes in terms of FCR and egg weight. The S- pullets performed significantly better ($p<0.05$) in hen-day egg production, egg mass, hen-housed egg production and age at 50% production than their s- counterparts whilst no significant differences ($p>0.05$) were recorded between the two plumage colour genotypes in terms of egg weight, feed intake and body weight. The naked neck birds had the highest number of feather follicles in the dorsopelvic tract and no feathers in the dorsal cervical tract and cloacal circlet. The naked neck genotype and silver plumage colour improve egg laying performance in layer parents.

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CHAPTER ONE

1.0 INTRODUCTION

The change in climate that the Earth is currently experiencing is dangerous to poultry farming. Global warming which refers to the rising average temperature of Earth's atmosphere and oceans and its projected continuation is a worldwide concern. In the last 100 years, the Earth's average surface temperature increased by about 0.8 ºC (1.4ºF) with about 2/3 of the increase occurring over just three decades (IPCC, 2007). The fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) indicated that during the 21st century the global surface temperature was likely to rise a further 1.1 to 2.9ºC (2 to 5.2ºF) for the lowest and 2.4 to 6.4ºC (4.3 to 11.5ºF) for the highest.

The harmful effects of high temperature on the performance of laying hens have been well studied. Under warm conditions, birds do not reach their full genetic potential for growth, body weight and egg production because dissipation of excessive heat produced internally is hindered by the feathers (Cahaner *et al.*, 2008). Feed intake, egg production, egg weight and shell quality are decreased in heat-stressed birds (Merat, 1986). Balnave (1996) reported that high environmental temperatures are the most important inhibiting factors to poultry production in hot regions. He further mentioned that the depression of chicken growth due to high temperature cannot be completely eliminated by management practices. Moreover, practices aimed at alleviating heat stress are for most part quite expensive and hence not economically feasible in most developing countries.

The rise in temperature of the earth's surface and its adverse effects on the environment are not the only issues of public concern but also the fast rate of population growth and its associated high demand for poultry products especially table eggs. According to the International Monetary Fund (IMF, 2011) the total population in Ghana was last reported to be 23.8 million people from 6.8 million in 1960, changing 251 percent during the last 50 years. Increased consumption of table eggs in human diets including pastries, stews and beverages in the country demands improvement of the level of production of local birds (Arthur and Osei-Somuah, 2001).There is therefore an urgent need for producing birds that can adapt to our hot environment and can lay at their highest potential. Galal and Fathi (2007) advocated the use of heat- tolerant genes like naked-neck (*Na*) and frizzle (*F*).

Gowe and Fairfull (1995) stated that the naked neck gene improves heat tolerance as indicated by higher egg production, better feed efficiency, earlier sexual maturity, larger eggs with possibly fewer cracks and fewer mortality when compared to the normally feathered with similar genetic background. Horst and Mathur (1992) observed that the feather restriction or naked-neck gene results in 40% less feather coverage overall, with the lower neck appearing almost naked. This considerably reduces the need for dietary nutrition to supply protein for feather production. The frizzle gene reduces the insulating properties of the feather cover (reduces feather weight) and makes it easier for the birds to radiate heat from the body more efficiently (Gowe and Fairfull, 1995). Marthur and Horst (1990) pointed out the superiority of birds with frizzle and naked neck genes both singly and in combination over birds with normal feathering for body weight and egg traits. The advantages of these genes in the heterozygous state are 50% of those in the homozygous state, but producing layers homozygous for these genes is not commercially feasible because of poor hatchability (Merat, 1986). Therefore to ensure further reduction in feather coverage and decrease the insulating efficiency of the feathers, birds with these genes are highly recommended for commercial production in the tropics (Horst and Mathur, 1992). Horst (1988) indicated that the use of birds with both exotic and indigenous background could be a solution to the problem.

The incorporation of the Naked Neck or the Frizzling gene into birds bred for commercial egg and meat production is a method which would not only help commercial birds to withstand the high temperatures in the tropics but also provide a reliable solution to the problem of higher population growth rate and its associated increase in demand for poultry products in the country. The main objective of this work was to assess the laying performance of two lines of local parent stocks which have three different sub-lines each namely Naked Neck, Frizzled and Normal Feathered.

Specific objectives

1. To estimate genotypic frequencies of mutant genes in two districts and one Municipality of the Ashanti Region.

2. To compare the laying performance of the two lines (white and brown) of layer parents

3. To determine the effects of three genotypes *Nanaff*, *nanaFf* and *nanaff* on two lines of local layer breeder parents.

4. To compare the pterylosis of dorsal, ventral and lateral tracts of the naked neck, frizzled and normally feathered birds.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Derivation of chickens

Recent development in genetic improvement in poultry makes knowledge of origins and history of chickens petinent. The domestic chicken is descended primarily from the Red Jungle fowl (*Gallus gallus*) and among the four species of the jungle fowl (*Gallus lafayettei*, *Gallus sonnerati*, *Gallus gallus* and *Gallus varius*), the red jungle fowl is found to be a major contributor or an ancestor to the domestic fowl (Crawford, 1990).

According to Encyclopaedia Britannica (2007) humans first domesticated chickens of Indian origin for the purpose of cockfighting in Asia, Africa, and Europe; very little formal attention was given to egg or meat production; cockfighting was outlawed in England in 1849 and in most other countries thereafter; exotic breeds and new standard breeds of chickens proliferated in the years to follow, and poultry shows became very popular; from 1890 to 1920 chicken raisers stressed egg and meat production, and commercial hatcheries became important after 1920.

2.2 Breeds of chickens

During the past two centuries many pure breeds and varieties of chickens have been developed. However, few have survived commercialism in the poultry industry to be used by poultry breeders today (Mack, 1972). He added that some of the early breeders have been lost forever; others are maintained by government breeding stations so that they may be available to commercial and other breeders if the need arises.

2.2.1 Varieties of chickens used for modern breeding

According to Mack (1972), in the early days of commercial poultry industry, most of the chicks sold represented pure breeds or varieties. Breeding practices at that time were confined to improving the economic potential of these pure lines. Generally, however, two or more breeds were crossed to improve their productivity. Eventually, particularly in the case of those birds bred for the production of meat, new synthetic lines were developed. Although many pure breeds were incorporated in their production, these new synthetics did not represent any former breed or variety. They were new and different; many more are being developed regularly.

Most of the breeds and varieties of chickens used in today's breeding programs, or used to develop synthetic lines, include: Single Comb White Leghorn, Single Comb Rhode Island Red, New Hampshire, White Plymouth Rock, Cornish, Barred Plymouth Rock and Light Sussex (Mack, 1972).

There are also local and fancy breeds throughout the world and they are characterized by medium or low performance and are often maintained in small populations (Horst, 1999). The fancy breeds such as the Cornish Red and the White Rock have been very important contributors to the strains that now produce our modern strains of broilers (Hagan, 2010). If these local breeds are genetically eroded it may lead to the loss of valuable genetic variability in specific characteristics that are at present unimportant in commercial breeding strategies (Ladokun *et al*., 2008). In light of this, it can be said that it is very important that these breeds are maintained in the future as gene banks because they may contain useful genes that could be exploited commercially (Smith, 1990).

2.3 General description of chickens

Chickens are omnivores and in the wild. They often scratch at the soil to search for seeds, insects and even larger animals such as lizards or young mice (Adler and Lawler, 2012); roosters can usually be differentiated from hens by their striking plumage (*saddle*) which is typically of brighter, bolder colours than those of females of the same breed. The identification can be made by looking at the comb.

2.3.1 Social behaviour

Chickens are gregarious birds and live together in flocks and have a communal approach to the incubation of eggs and raising of young (Adler and Lawler, 2012). Individual chickens in a flock will dominate others, establishing a "pecking order", with dominant individuals having priority for food access and nesting locations. Birkhead (2011) explained that removing hens or roosters from a flock causes a temporary disruption to this social order until a new pecking order is established; adding hens, especially younger birds, to an existing flock can lead to fighting and injury; when a rooster finds food, he may call other chickens to eat first; he does this by clucking in a high pitch as well as picking up and dropping the food; this behaviour may also be observed in mother hens to call their chicks and encourage them to eat. They further explained that a rooster crowing (a loud and sometimes shrill call) is a territorial signal to other roosters. However, crowing may also result from sudden disturbances within their surroundings. Hens cluck loudly after laying an egg, and also to call their chicks. Chickens also give a low "warning call" when they think they see a predator approaching.

2.3.2 Nesting and laying behaviour

For nesting and laying Birkhead (2011), Adler and Lawler,(2012) and McKeown (2010) explained that hens will often try to lay in nests that already contain eggs and have been known to move eggs from neighbouring nests into their own. They added that the result of this behaviour is that a flock will use only a few preferred locations, rather than having a different nest for every bird; hens will often express a preference to lay in the same location; it is not unknown for two (or more) hens to try to share the same nest at the same time. If the nest is small, or one of the hens is particularly determined, this may result in chickens trying to lay on top of each other; there is evidence that individual hens prefer to be either solitary or gregarious nesters; some farmers use fake eggs made from plastic or stone (or golf balls) to encourage hens to lay in a particular location.

2.3.3 Temperature control in chicken.

According to Sayed and Scott (2008), chickens have no sweat glands; thus, if they are exposed to high ambient temperatures, they have to rely on panting or heat loss from the surface of the skin to control their body temperature. He explained further that birds suffer from heat stress when they are having difficulty maintaining their correct body temperature. Heat stressed poultry, according to Sayed and Scott (2008), may display the following symptoms:

- trying to move away from other birds
- moving against cooler surfaces, such as the block walls or into moving air streams
- lifting their wings away from their bodies to reduce insulation and expose areas of skin with no feathers

- panting
- resting - to reduce heat generated by activity
- reduced feeding
- drinking more water
- darkened skin colour - caused by blood diverting from internal organs to the skin

In the long-term, heat stress will also cause a lower growth rate and reduced egg production. He concluded that normal body temperature of a bird is 41^{o}C and a bird is most comfortable and grows faster in temperature ranging from 10°C to 20°C measured inside the poultry house, at bird level.

Feathers provide insulation in cold weather but inhibit heat loss in hot weather. Normally feathered chickens have a well-covered body, which protects them from losing body heat (Cahaner *et al*., 2008).

2.4 Chicken breeding

Chicken breeding according to Maack (1972) is an outstanding example of the application of basic genetic principles of inbreeding, line breeding, and crossbreeding, as well as of intensive mass selection to effect faster and cheaper gains in broilers and maximum egg production for the egg-laying strains. It further explained that maximum use of heterosis, or hybrid vigour, through inbreeding and crossbreeding has been made. Crossbreeding for egg production has used the single-comb White Leghorn, the Rhode Island Red, the New Hampshire, the Barred Plymouth Rock, the White Plymouth Rock, the Black Australorp, and the White Minorca. Crossbreeding for broiler production has used the White Plymouth Rock or New Hampshire crossed with White or Silver Cornish or crosses utilizing widely diverse inbred strains within a single breed. Rapid and efficient weight gains and high quality, plump, meaty carcasses have been achieved thereby.

2.5 Plumage reducing genes and their functions in egg production

High temperature and its allied severe stress on birds in the tropics which cause low performance has been the concern of many writers and breeders including Gowe and Fairfull (1995). They stated that if progress is to be made in chicken production in hot climatic environment then the need to address the problem of adaptability to heat stress when the breeds located in temperate regions are introduced to the tropical regions and the need to develop strains that can tolerate the heat stress should not be overlooked. The problem of adaptability on the part of improved commercial stock and the low productivity of the indigenous stocks call for the necessity to complement the thermoregulatory genes of indigenous chickens with the high egg production genes of improved commercial breeds through crossbreeding (Nwosu, 1992).

There are a number of genes with major effects on the phenotype that seem to be of special interest for poultry keeping. According to FAO (1998), seven mutants that are common among local birds in the tropics and are found to be potentially useful are: *Na* - naked neck; *Dw* - dwarf; *K* -slow feathering; *Fa* - Fayoumi ; *F* - frizzle ; *H* - silky; and *Fm* - fibro-melanosis.

These major genes also called advantageous gene complexes or plumage reducing genes (Horst, 1998), have been described as genes that reduce feather coverage in the chicken. They can be split into three categories:□feather-reducing genes; genes that reduce body size; and □genes controlling plumage colour. Younis and Cahaner (1999) and Horst (1988) stated that these genes are relevant to hot tropical regions because they enable the local chicken to adapt favourably to the tropical environment.

Among these useful genes the emphasis has been on the Naked-neck (*Na*) and frizzle (*F*) genes with respect to high performance in egg production (Somes, 1990).

The advantages of these genes over their normal feathered counterparts in a hot humid environment are in terms of feed intake, growth rate, and weight gains which have been fully reviewed (Hanzle and Somes, 1983; Merat, 1990; Lou *et al*., 1992; Cahaner *et al*., 1993). The quality of eggs, apart from determining their food value, market desirability, or economic value is significant in poultry for their influence on the embryo development and successful hatching (Singh *et al*., 2004). It has been reported that external and internal qualities of eggs (Hurnik *et al*., 1978 and Nordstrom and Ousterhout, 1982) had significant effects on the hatchability of incubated and fertile eggs, weight and development of laying chickens.

Genetic and phenotypic heterogeneity have been observed to exist in domestic chickens. The diversity, which constitutes a valuable genetic resource, informs the reason for incorporating the local chicken into breeding programs aimed at producing an indigenous meat and egg type breed adapted to the tropical environment (Oke, 2011). There is a major global thrust on genetic preservation and biodiversity as reflected in the efforts on development of genome and data banks (Oke, 2011). Following this strategy, the local chicken, especially the naked neck and frizzle which are tropically relevant should be preserved from becoming extinct (Sonaiya, 2003). More importantly, the use of management practices to ameliorate the adverse effects of heat stress on poultry in many cases are not economical and alternative approach of breeding pullet lines with better heat tolerance has been suggested (Balnave, 1996).

Genetic improvement of heat tolerance may therefore provide a low-cost that is particularly attractive to developing countries with hot climates like Ghana.

A number of investigations on the production ability of birds with these genotypes under both temperate and hot conditions have been carried out. Mérat (1990) reviewed literature on the climatic effects on bodyweight at 8–10 weeks, and concluded that at temperatures above 25–26 °C chickens having the *Na* naked-neck gene grow at a faster rate than normal (*na/na*) chickens, and that above 30 °C feed efficiency is better in the naked neck birds than in the normal birds. Mathur and Horst (1990) compared the *Na* gene and the *F* gene (frizzling) in two controlled temperature settings – normal (22 °C) and high (32 °C) – as well as in an open-house system in Malaysia with temperature variation (22 °C to 32 °C), and concluded that both the *Na* gene and the *F* gene resulted in better growth and higher egg yield than the normal at high temperatures. Combining the *F* and the *Na* genes gave a higher yield, but the effect was less than purely additive.

Haque *et al*. (2001) compared the meat yield of native Bangladeshi naked-neck Deshi (*NaD*) chickens to that of their crosses with Rhode Island Red (RIR), White Leghorn and Fayoumi. For growth up to 17 weeks, the *NaD* × RIR had the highest daily gain among the crosses. However, no clear conclusions were drawn, except that the crosses involving Fayoumi had much lower mortality rates than the other crosses – 3.3 percent as opposed to 14–33 percent. Another study from Bangladesh (Zaman *et al*., 2004) compared the cross-bred offspring of *Na* cocks and *RIR* and Fayoumi hens to pure-bred Fayoumi birds in terms of egg production capacity to the age of 46 weeks. Hens were distributed to 54 farms, each of which was given five hens at 18 weeks of age. The results showed that the rate of lay of the Sonali (*RIR* × Fayoumi) hens was about twice that of the *Na* crosses. However, the *Na* crosses started to lay at an earlier age.

2.6 The naked neck (Na) gene

The naked neck is a breed of chicken that is naturally devoid of feathers on its neck and vent (Mérat, 1986). Naked neck chickens, are often referred to as Turkens, Transylvania Naked Necks, Bare Necks Hackleless, and rubber Necks (Graham, 2006). The naked neck trait which characterizes this breed is caused by an autosomal gene in chicken and controlled by an incompletely dominant allele (*Na*) located near the middle of Chromosome 3 (Warren, 1993).

Although it was first studied by Davenport in 1914, the gene symbol was assigned by Hertwig in 1933 (Somes, 1990). The gene is an incompletely dominant one with the heterozygotes ($Nana^{+}$) showing an isolated tuft of feathers on the ventral side of the neck above the crop, while in homozygote dominant situation (*NaNa*), the chickens either lack this tuft or it is reduced to just a few pinfeathers or small feathers (Crawford, 1976). The resulting bare skin becomes reddish, particularly in males as they approach sexual maturity (Somes, 1990). At hatching, the presence or absence of the tuft could be used to identify the two genotypes accurately (Scott and Crawford, 1977).

According to Rossier (2002), since this allele is dominant, individuals which are either_homozygous dominant (*Na/Na)* or heterozygous (*Na/na+*) will exhibit the naked neck characteristic though the heterozygous individual will exhibit less reduction in feathering. He stated further that individuals which are homozygous recessive (or wild type feathered) (*na+/na+*) would not exhibit any feather reduction characteristics of the naked necks and, barring mutation, would be unable to pass that trait down.

The naked neck birds do not only have their neck tracts almost naked but they also have other feather tracts either absent or reduced resulting in a reduced plumage cover (Somes, 1990). Being responsible for defeathering the neck region, the naked neck gene (*Na*) also restricts the feathered area around the body by as much as 20 to 30% in heterozygous (*Nana*) and up to 40% in homozygous (*NaNa*) genotypes because of the incomplete dominance of the gene (Islam and Nishibori, 2009).

Merat (1986) observed that the advantages of the naked neck gene (*Na*) in the heterozygous state are 50% that in the homozygous state but producing layers homozygous for this gene is not feasible because of poor hatchability. Having found the naked neck to do well under heat stress, Horst (1988) advocated introduction of naked neck gene into local birds in the tropics for higher productive adaptability. Galal and Fathi (2007) also advocated the use of heat tolerant genes like naked neck (Na) and frizzle (F) in the tropics in order to reach full potential of birds for growth, body weight and egg production which according to Cahanner *et al*. (2008) are hindered under warm conditions. Islam *et al*. (2009) stated that the introduction of the naked neck (*Na*) gene in chicken breeds improves the resistance of the birds to heat stress.

Mathur and Horst (1992) stated that the feather restriction or naked neck gene results in 40% less feather coverage, with the lower neck appearing almost naked and it considerably reduces the need for dietary nutrition to supply protein for feather production. In terms of heat stress susceptibility, because the naked neck birds have significantly greater dermal swelling capability compared to their '*nana*' counterparts in high ambient temperatures, they are less susceptible to heat stress than the normally feathered (*nana*) birds (El – Safty *et al.*, 2006). According to Eberhart and Washburn (1993) feather reduction in naked neck birds probably caused their greater ability in dissipating heat through exposed areas compared to birds not carrying the gene. The observation of Merat (1986) indicated that the naked neck birds have received greater attention for commercial poultry production due to their superiority in terms of heat tolerance and its associated higher performance.

2.6.1 Effect of the naked neck gene on egg production.

In a comparative study involving all the five genotypes (*NaNa, Nana, FF, Ff and nana/ff*) reared under intensive, semi-intensive and extensive management systems, Adomako (2009) observed that the *NaNa* and *Nana* birds performed better ($P<0.05$) than their *FF* and *Ff* counterparts in body weight, body weight gain, number of eggs per clutch, hen housed and hen-day rates of lay, egg size, Haugh unit, shell thickness, carcass yield and economics of production.

In an experiment to evaluate variation in the egg production performance of naked neck and normally feathered birds Merat (1986) and Horst and Rauen (1986) reported that there was a different response of the naked neck and normally feathered genotypes to high environmental temperature. From the result it was observed that egg numbers at moderate temperature were not significantly affected by the naked neck gene. The naked neck hens had a better laying rate at high temperature. Cahaner *et al.* (1993) indicated that the reduction of feather coverage provides relative heat tolerance and therefore, in high ambient temperature, heterozygous naked neck chickens are superior to their normally feathered counterparts. The naked neck gene has been associated with increased laying rate, egg size and egg mass in hot environments (Gracès *et al.*, 2001; Younis and Galal, 2006).

Under constant heat stress the heterozygous naked neck (*Nana*) layers have significantly higher egg number, egg weight, egg mass, body weight and productivity index than the normal feathered (Mathur, 2003; Haaren – Kiso, 1991). However, under natural conditions there were large differences between the heterozygous naked neck layers and the normal feathered in terms of egg number, egg mass, body weight, egg weight and productivity index at different locations (Mathur, 2003).

Njenga *et al*. (2005) researched into the productivity of *nana*, *Nana*, *Ff* and *dw* phenotypes from four agroecological zones in the tropics and reported that the *Nana* produced significantly ($p<0.05$) heavier eggs (45.8 ± 3.88g) compared to eggs produced by the *nana* (42.5 ± 3.88g) birds. They reported a favourable effect of the naked neck gene on body weight which resulted in heavier egg weight when the birds were reared under heat stress. Abdel – Rahman (2000) studied the effect of the naked neck gene on the egg production performance of sharkasi chickens under subtropical conditions and reported that the naked neck birds showed significant increases in egg production, 90 – day egg number and egg mass by 9.0, 17.80 and 13.30% for *Nana* and 3.70, 7.30 and 7.30% for *NaNa* compared with the *nana* genotype.

According to Yushimura *et al*. (1997) among the indigenous chickens, the naked neck is found superior in terms of egg production, egg size and body weight in a hot and humid environment. Rauen *et al*. (1986) reported that egg numbers were not significantly affected by the naked neck gene at moderate temperatures; however, naked neck hens had better laying rate at high temperature.

2.6.2 Effects of the gene on body temperature of birds.

A study by Aengwanich (2008) showed that when birds are exposed to a hot environment and/or performing vigorous physical activity, body temperature might rise by 1^{o}C or 2^{o}C as heat energy is stored. He added that heat storage cannot continue for extended periods before body temperature increases past the limit that is compatible with life.

On the contrary, once birds are uncovered in very cold environment, heat breaks out from the birds and if it is not replenished by energy from metabolism of food, body temperature will turn down until the bird is incapacitated and dies (Gowe and Fairfull, 1995).

Scientific studies have indicated that the naked neck gene (*Na*) improves breast size and reduces heat stress in chickens of non-broiler breeds which are homozygous for the trait (Graham, 2006). Additionally, in tropical climates if the naked neck trait (*Na*) is bred into broiler strains it has been found to facilitate lower body temperature, increased body weight gain, better feed_conversion ratios and carcass traits compared to normally feathered broilers.

It was observed in the study conducted by Singh *et al*. (1996) that heterozygous naked neck broilers gained about 3% more weight than their normally feathered counterparts under commercial conditions during the spring and summer months, and that this advantage was almost tripled at high ambient temperature of about 32^{o}C. In a study to appraise some immunological traits and laying performance of two genotypes (*Nana* and *nana*) it was reported that the heterozygous naked neck had a slightly higher average body temperature compared to the *nana* ones but the difference was not significant (P > 0.05). In the evaluation of the performance of homozygous naked neck (*NaNa*), heterozygous naked neck (*Nana*) and normally feathered (*nana*) at moderate (23°C) and high (34°C) temperature environments, Bordas and Merat (1984) recorded average rectal temperatures of 39.97°C, 40.11°C and 40.15°C for *NaNa*, *Nana* and *nana*, respectively where significant difference occurred between *NaNa* and *nana* but not the *Na* ones. Their conclusion was that the lower rectal temperature in the *NaNa* genotype compared with other genotypes suggests that the *NaNa* birds could increase feed intake, without suffering from heat stress, as a means of generating more heat to maintain the body temperature within the normal physiological range.

2.6.3 Effects of the gene on growth traits

To overcome heat stress in birds, and thereby improve productivity of layers, Galal and Fathi (2007) advocated the use of heat tolerance genes like naked neck (*Na*) and frizzle (*F*); the relevance of the naked neck gene in the tropics is attributed to its association with thermoregulation; the reduction in feather coverage of about 30 – 40% in these birds facilitates better heat dissipation resulting in a better relative heat tolerance under hot climates.

In a study conducted by Yalcin *et al*. (1997) and Patra *et al*. (2002) on birds reared under high temperatures, it was observed that under high temperatures, birds carrying the naked neck gene had higher breast weight, superior growth rate, and better feed conversion ratio and carcass traits. Pech – Waffenschmidt (1992) studied naked neck and frizzle genes and observed that when the genes interact they confer on the bird better efficiency especially in warm humid environments. This might be due to the fact that naked neck and frizzle have reduced feathers and therefore protein which could have been used to grow feathers was channeled productively into egg production (Adomako, 2009).

In an experiment involving the study of naked neck and normally feathered broilers kept under three different temperatures (20^oC, 25^oC and 30^oC), Merat (1986) stated that at 20^oC or lower, the differences between the normally feathered and the naked neck birds in terms of body weights and weight gain were almost the same. He further stated that growth and feed efficiency between the naked neck and the normally feathered genotypes were slight and at 30^oC or higher, the naked neck birds were heavier and had better feed efficiency than the normally feathered birds.

Galal and Fathi (2001) reported that at high ambient temperature, the naked neck gene was associated with higher feed consumption compared to the normally feathered counterparts.

The report also indicated that the *Na* allele had a better effect on feed conversion ratio, where the *Nana* genotypes had significantly lower feed conversion ratio as compared to the *nana* ones. In the work of Alvarez *et al*. (2002), it was found that the feed conversion ratio was 1.02 in *NaNa*, 1.84 in *Nana* and 2.42 for *nana* hens under moderate ambient temperature.

2.6.4 Effects of the gene on mortality.

Mahrous *et al*. (2008) assessed the growth performance of *Nanaff* and *nanaff* and stated that the *nanaff* hens recorded a significantly ($p<0.05$) higher mortality and culling rate than the *Nanaff* birds. Hagan *et al*. (2010) observed that the double heterozygotes experienced significantly ($p < 0.05$) less mortalities as compared to their counterparts which were either single heterozygotes or normally feathered. *NanaFf* (double heterozygous frizzled naked neck), *nanaFf* and *Nanaff* (heterozygous frizzle and heterozygous naked neck) and *nanaff* (normally feathered) and reported mortality rate of 17.56, 18.22 and 18.89%, respectively although the difference was not significant ($p > 0.05$).

The naked neck recorded a significantly ($p < 0.05$) lower mortality rate than the frizzle and normal feathered birds in a survey conducted by Adomako *et al*. (2009) to appraise the potential of indigenous naked neck (Nana) and frizzle (Ff) birds in Ghana.

In an experiment under tropical conditions, to evaluate the laying performance of hens, Njenga *et al*. (2005) reported a higher mortality rate (74.4%) for *nanaff* birds compared to all other genotypes. The *Nanaff*, *nanaFf* and *dw* birds recorded mortalities of 45.1, 56.1 and 49.2% respectively. The conclusion of the study confirms the observations of Kitalyi (1998) that birds in the tropics carrying the *Na*, *F* and *dw* genes have higher disease resistance compared to those not carrying the genes.

Mazzi (1998) also stated that the *Na* gene showed lower mortality and weight loss during severe gradual heat stress (28 to 42^{o}C) compared to normally feathered birds.

El – Safty *et al*. (2006) found that the naked neck had better ability to secrete Acute Phase Protein (APP) which offers protection to birds against infection or any pathogenic invasion. Yakubu *et al*. (2008) reported a significantly ($p < 0.05$) lower rate of mortality in *NaNa* birds (28.66%) as against 36.85% in *nana* ones.

According to Abdel – Rahman (2000) the average mortality rate during the laying season was less in Sharkasi naked neck birds than in their normally feathered (*nana*) counterparts, though the differences were not significant.

2.6.5 Effects of the naked neck (*Na*) gene on sexual maturity.

Njenga (2005) and Nasrollah (2008) stated that the realization of sexual maturity was significantly different in the midst of breeds of birds. The naked neck birds reached sexual maturity significantly ($p < 0.05$) earlier than the normally feathered birds by about 5 days in a study conducted by Abdel – Rahman (2000) to evaluate the effect of the naked neck gene on the egg production performance.

2.7 The frizzle (*F*) gene

Frizzle is a mutant in the chicken in which the feathers grow so that they curve outward, instead of lying smoothly along the bird's body (Hutt, 1949). Frizzling is caused by a single incompletely dominant autosomal gene, known as *F*, restricted by an autosomal recessive modifier, *mf* (Landauer and Dunn, 1930). According to Somes (1990), the frizzle was first suggested to be a dominant gene by Davenport after it had been first described by Aldrovandi in 1600. Landauer (1933) described an autosomal recessive modifier gene which greatly restricted the effect of *F*. He stated that the shafts of all feathers in the homozygotes are extremely recurved and the barbs are curled. He added that in the heterozygote, only the contour feathers are recurved and that these birds are not able to fly, and the feathers look bare. The modifying genes make the extent of curling less extreme and in unmodified homozygous frizzled chickens, the rachises of all feathers are extremely recurved (Landauer, 1933; Landauer and Dunn, 1930).

The frizzle (*F*) gene which is positioned on chromosome 6 causes the outline feathers to curve outward away from the body (Somes, 1990). He further explained that the modifying gene lessens the extreme aspects of the homozygote so that they appear less wooly.

High ambient temperature has a negative effect on growth rate and egg production of commercial chickens due to the difficulty of dissipating metabolic heat, which leads to an increase in body temperature that can be lethal in extreme cases (Cahaner *et al*., 2008). The reduction of feather coverage has proved to increase heat dissipation, allowing a greater rate of radiation of body heat and a better thermoregulation (Eberhart and Washburn, 1993). Some major genes have been described as affecting feather mass. The naked neck gene (*Na*) reduces the number of feathers by limiting the feathered body surface in chickens, and the frizzle gene (*F*) has a feather curling effect and causes feather mass reduction. Although the adaptive effect of the naked neck gene at high environmental temperatures has been extensively studied (Bordas and Mérat, 1984; Deeb and Cahaner, 1999; Chen *et al*., 2004), the effect of the frizzle gene has been investigated mostly in its heterozygous form (Bordas and Mérat, 1990) and often in association with the naked neck (*Na*) gene (Younis and Cahaner, 1999), the dwarf gene (*dw*) (Missohou *et al*.,2003) or both (Garcês *et al*., 2001), and the results are rather contrasted.

2.7.1 Effect of the frizzle (*F*) gene on egg production

Studies have shown that birds with the frizzle gene perform well under hot humid conditions (Gowe and Fairfull, 1995). Horst and Mathur (1992) observed that when reared under high tamperatures, the frizzling feathered layers performed better in terms of egg production as compared to their normally feathered groups. Adedeji *et al*. (2006) ascribed the better performance of the frizzle birds to their feather structure which enhances heat dissipation. The frizzle gene reduces the insulating properties of the feather cover (reduce feather weight) and makes it easier for the bird to radiate heat from the body more efficiently (Horst, 1989). Horst (1989) and Adedeji *et al*. (2006) found that air passes over the exposed body surface to reduce internal heat of the birds. This grants the birds the ability to feed more compared to those stressed by heat and hence improve laying performance. A research conducted by Merat (1990) proved that the frizzle gene resulted in an increase in egg number under hot and humid conditions.

2.7.2 Effect of the frizzle (*F*) gene on body temperature

The influence of genotype × temperature interactions on the reproductive traits (sexual maturity, egg production, fertility, hatchability, and chick production) of hens of a broiler breeder dam line carrying major genes for dwarfism (*dw*-) and frizzle (*F*) was investigated by Sharifi (2006). In experiment 1, the frizzle genotype (*Ff*) had no significant effect on sexual maturity, egg production, fertility, hatchability, and chick number. In experiment 2, there was a significant interaction between feathering genotype (*FF*) and environmental temperature for all traits except sexual maturity. They indicated that under heat stress, there was a distinct reduction in all reproductive traits except sexual maturity for normally feathered hens compared with frizzle-feathered hens, whereas under temperate conditions, egg production and number of chicks of the *FF* genotype were reduced and sexual maturity was delayed. In experiment 1, the interaction between dwarf genotype and environmental temperature for egg production was significant. Under temperate conditions, the egg production of dwarf hens was inferior to that of normally sized birds, whereas under hot temperatures, the egg production of the 2 body sizes did not differ. The genotype combining the 2 major genes (*FFdw-*) proved to be inferior to the normally feathered dwarf type (*ffdw-*) for laying performance but superior in fertility.

Younis and Cahaner (1999) reported that at high ambient temperatures, the frizzle heterozygous hens had a deterioration of egg productivity and quality comparable to that of normally feathered animals, suggesting that the frizzle gene in the heterozygous form has no adaptive effect on heat stress. According to them, one reason could be that the overall feather mass of heterozygous frizzle is not significantly reduced when compared to their normally feathered sibs. Similar results were obtained earlier by Bordas and Merat (1990). However, Haaren-Kiso *et al*. (1994) reported a 40% decrease in feather intensity in frizzle heterozygous hens.

2.7.3 Effect of the frizzle (*F*) gene on sexual maturity, growth traits and mortality.

In a study with a total of 210 day-old local chickens generated from a main cross and reciprocal crossing of local chickens possessing some major genes (naked-neck (Na), frizzle (F) and normal feathered gene (na) that were used to evaluate the growth characteristics of the pullets in a randomized complete block design. The genetic groups produced were homozygous naked neck, Na/na and frizzle (F/Na), reciprocal naked neck (Na/F) and frizzle (F./Na) and normal feathered (na/na) chickens. There was a significant difference ($p<0.05$) in mean daily feed intake at week 8, with the

Na/F genotypes consuming more than other groups. Mean body weight gain and feed conversion ratio did not differ among all the genetic groups. Results indicate that the F/F genotype had significantly ($p<0.05$) highest mean day-old body weight (30.90±2.73g), highest mean body weigh at sixteen (442.50±6.61g) and twenty four weeks (114.00±32.99g) of age. The growth rate of frizzle genotypes in all combinations (F/F, F/Na, F/na) were significantly ($p<0.05$) higher than both naked neck homozygous and heterozygous (Na/Na, Na/na) and normal (na/na crosses when compared. The coefficient of determination (R2) of F genes (97.4, 84.40, 92.90) were high and compared favorably with other genetic groups indicating that F genes highly contributed to significant rates of growth of frizzle crosses. The na/na individuals survived most and had significantly least mortality compared to other genetic groups. This result depicts the frizzle genotype as a fast growing indigenous chicken which may be involved in breeding for developing native foundation stock for production of meat type chicken in the humid tropics (Oke, 2011).

In a study to evaluate the effect of plumage modifier genes on some internal and external egg quality indices in the Nigerian local chicken in the guinea savanna, Egahi *et al.* (2010) reported that the frizzle *(FF*) and naked neck (*Na*) local birds had a significantly ($p<0.05$) higher egg weight than the normal feathered birds (*na*). Mean egg weights were 33.29±0.27, 36.16±0.20 and 43.15±0.21 in the *na*, *ff* and *Na* genetic groups respectively. The frizzle and naked neck genes positively increased egg weights by 8.62 and 29.62 per cent over the normal feather gene. However, egg shape index significantly ($p<0.05$) favoured the local chicken studied. Similarly, shell thickness was significantly ($p<0.05$) higher in the *FF* and *Na* birds than in the *na*. Consequently, the modifier genes of frizzling and naked neck are relevant in the development of a layer breed for the local environment. Peters *et al*. (2007) noted that the major genes of frizzling and naked neck are important as they enhance the thermoregulatory activities of the birds. Several other researchers (Ikeobi *et al*., 1996; Mathur, 2003) have reported on the effects of the frizzle and naked genes on growth rate, egg number, fertility and hatchability in the Nigerian local chicken.

Mathur and Horst (1990) compared the *Na* gene and the *F* gene for frizzling in two controlled settings – at normal (22 °C) and high (32 °C) temperatures – as well as in an open-house system in Malaysia with temperature variation (22 °C to 32 °C), and concluded that both the *Na* gene and the *F* gene resulted in better growth and higher egg yield at high temperatures. They stated that combining the *F* and the *Na* genes gave a higher yield, but the effect was less than purely additive.

Adomako *et al.* (2009) compared the performance of naked neck (*Nana)*, frizzle (*Ff*), normal feathered (*nanaff*) and *NanaFf* (Double heterozygous frizzled- naked neck) birds in the tropics. They concluded that the superior performance of the naked neck was due to the effect of thermo- regulatory genes which improved conversion of feed into into body tissues than their normal feathers counterparts.

2.8 Acceptability of birds with mutant genes

Though breed utilization depends to a great extent on farmers' preferences, the choices may be based on the income that the farmer can obtain by selling chickens or chicken products, and the colour of the plumage or the temper and behaviour of the birds (Barua *et al.*, 1998). They reported that among smallholders in Bangladesh, coloured indigenous fowls are more acceptable than international hybrids because of their motherly instincts (i.e. broodiness) and because they can be used to incubate and rear chicks under rural conditions- their camouflaged plumage, alertness and fighting character enable them to protect themselves and their chicks from predatory animals. The study conducted by Njenga (2005) in coastal Kenya showed that normal birds were preferred to naked neck, frizzle or dwarf birds; although the naked neck was known to grow faster, only the normal birds could be presented to visitors as a gift. The frizzle birds could be used only for rituals and for home consumption. The dwarf was ranked fourth because of its small size. Azharul *et al.* (2005) reported that dwarf hens have a good reputation for mothering ability. Singh *et al*. (2004) reported that in India the naked neck and frizzle birds are not the preference of most people because of their unfamiliar look but demand is increasing year after year after realizing the advantage of these genotypes in tropical adaptation and productivity.

2.9 Frequency of frizzle and naked neck genotypes in the population.

In Ghana, Hagan (2010) reported very low gene frequencies for frizzle (0.03) and naked-neck (0.05) compared to the normally feathered counterparts (0.95). He explained that the lower than expected gene frequencies for the dominant genes might be attributed to the naked neck and frizzled birds being used for rituals which normally feathered birds would not be used for.

A survey conducted by Adomako (2009) to assess the percentage of naked neck (*Nana*), frizzle (*Ff*) and normal feathered (*nana/ff*) birds within the population of indigenous birds in the Asante Akim South, Ejisu Juabeng and Bosomtwe Atwima Kwanwoma Districts in Ghana showed that a high percentage of indigenous chickens were normal feathered (78.33%) compared to naked neck (13.33%) and frizzle (8.33%) phenotypes. This means that the naked neck and frizzle genes are present within the random-mated indigenous chicken population but their combined frequency within the population is low. These thermoregulatory genes are at the brink of extinction (Adesina, 2002; Ojo, 2002; Fayeye and Oketoyin, 2006) and this may have been caused partly by random drift.

2.10 Pterylosis

Crawford (1990) explained that in normal chickens, the main feathers are located in tracts or pterylae, of which there are ten; the spaces between the tracts are called the apteria and they usually contain scattered down feathers and semiplumes; chicken shanks and feet are usually not feathered; normally the apteria carry scattered down and semiplume feathers, but the apteria of naked neck birds contain no feathers. The feather tracts themselves are also either absent or reduced in area so that naked neck birds have greatly reduced feather cover (Classen and Smyth, 1977). The reduction of feathers, according Bordas *et al*. (1978) was less in heterozygotes than in homozygotes, 27 and 22 percent for Na/na^{+} females and males, respectively and 41 and 33 percent for *Na/Na* females and males respectively. They further stated that the capital tract of the head, except for around the comb, and the dorsal and ventral cervical tracts of the naked neck birds are absent. The dorsopelvic, dorsal caudal and pectoral tracts are all markedly reduced in area in the naked neck (Classen and Smyth, 1977). The resulting bare skin becomes reddish, particularly in males as they approach sexual maturity (Somes, 1990).

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1 Preamble

Two studies were conducted. The first study was a survey on the determination of the various feather mutations and their egg production performance in three District of the Ashanti Region. The second phase of the work was a performance evaluation experiment on three feather genotypes of two lines of layer parents.

3.2 EXPERIMENT 1: Survey of farms in two districts and one Municipality of the Ashanti Region.

3.2.1 Location and duration of experiment.

The survey was conducted from 9th February, 2012 to 30th November, 2012 in three Districts of the Ashanti Region namely Sekyere South District, Offinso Municipal and Ejura District.

The towns selected for the study included Agona, Jamasi, Asamang, Kona, Kokote, Nkwakwa, Akrofua, Nkenkansu, Ayinasu, Sekyedumase, Boayaase and Ejura. These districts and towns were selected because of their proximity to the researcher and availability of reliable chicken keepers. Thirty poultry farmers were selected using simple random sampling from each District to give a total population of 90 respondents.

3.2.2 Administration of questionnaires

Questionnaires and interview schedules were used to gather information for the project. The farmers who could read were issued the questionnaires, which they answered and returned. On the other hand farmers who could not read and write were asked the questions on the questionnaires and the answers provided. Most of the farmers were contacted in their various homes and the questionnaires or interview schedules administered. Information ascertained included flock size, number of birds showing mutant genes, years in chicken keeping, management system, feed supplementation, weights of birds and eggs, number of eggs per clutch, clutches per year, average number of eggs per year, hatchability of eggs, survivability of chicks, total mortality, sales of eggs and birds per year, cost of production, health of birds.

The responses were collated and sorted out according to the answers provided. These were tallied and counted according to the number of response to each item. The data were analyzed using the MIXED procedure of SAS (SAS Institute, 2002-2003) at $p < 0.05$. Where significant differences were observed, the least squares means were separated by the pdiff procedure of SAS (SAS Institute, 2002-2003).

3.3 EXPERIMENT 2: Evaluation of Three Feather Genotypes

The experiment was conducted from 9th February, 2012 to November, 2012 at Akate Farms and Trading Company Limited in the Ashanti Region of Ghana. The objective of this study was to determine the effect of three feather genotypes on the laying performance of two lines of layer parents.

3.3.1 Genetic Stock and Management.

Three hundred and sixty (360), twenty-four (24) week old local x exotic crossbred layers made up of one hundred and twenty (120) heterozygous naked neck (*Nanaff*), one hundred and twenty (120) heterozygous frizzles (*nanaFf*) and one hundred and twenty (120) normally feathered (*nanaff*) birds were housed in a deep-litter pen partitioned into 18 compartments with twenty (20) females in each compartment.

These birds were developed through a reciprocal crossing between Lohmann Brown parents and indigenous naked neck and frizzle birds.

Figure 3.0 A diagrammatic illustration of generations

Figure 3.1 A diagrammatic illustration of F_1 generation

♂ ♀ ♀
♂
` *Nanaff* x *nanaff* *nanaff* *x* *nanaFf*

F_1 generation

		Male gamete	
		Naf	*naf*
Female gamete	*naf*	*Nanaff*	*nanaff*
	naf	*Nanaff*	*nanaff*

F_1 generation

		Male gamete	
		naF	*naf*
Female gamete	*naf*	*nanaFf*	*nanaff*
	naf	*nanaFf*	*nsanaff*

The F_1 heterozygous naked neck males were then mated to F_1 heterozygous frizzle females in a reciprocal cross to produce NanaFf, nanaFf, Nanaff and nanaff in the F_2 generation in both matings.

Figure 3.2 A diagrammatic illustration of F_2 generation

♀ ♂ ♂
♀
` *nanaFf* x *Nanaff* *nanaFf* *x*
Nanaff

F_2 generation

Female gamete	Male gamete: *Naf*	*naf*
naF	*NanaFf*	*nanaFf*
naf	*Nanaff*	*nanaff*

F_2 generation

Female gamete	Male gamete: *naF*	*naf*
Naf	*NanaFf*	*Nanaff*
naf	*nanaFf*	*nanaff*

The naked neck (Nanaff), frizzle (nanaFf), normally feathered (nanaff) and doudle heterozygous frizzled-naked necks (NanaFf) of the second filial gereration (F_2) were selected and mated inter se, producing homozygous naked neck (NaNaff), heterozygous neck (Nanaff), homozygous frizzles (nanaFF), hetetrozygous frizzle (nanaFf), normally feathered (nanaff) and frizzled naked neck birds (NaNaFf, NanaFF, NanaFf and NaNaFF) as the third filial (F_3) generation.

Figure 3.3 A diagrammatic illustration of F_3 generation

Heterozygous naked neck parents

Heterozygous frizzle oarents

♂ ♀ ♀

♂

` *Nanaff* x *Nanaff* *nanaFf* *x*

nanaFf

F_3 generation

	Male gamete	
Female gamete	*Naf*	*naf*
Naf	*NaNaff*	*Nanaff*
naf	*Nanaff*	*nanaff*

F_3 generation

	Male gamete	
Female gamete	*naF*	*naf*
naF	*nanaFF*	*nanaFf*
naf	*nanaFf*	*nanaff*

Heterozygous frizzed-naked neck parents

♂ ♀

NanaFf x *NanaFf*

F_3 generation

	Male gamete			
Female gamete	*Naf*	*Naf*	naF	naf
NaF	*NaNaFF*	*NaNaFf*	*NaNaFF*	NanaFf
Naf	*NaNaFf*	*NaNaff*	NanaFf	Nanaff
naF	NaNaFF	NanaFf	nanaFF	nanaFf
Naf	NanaFf	Nanaff	nanaFf	nanaff

Normal feathered parents

♂ ♀

nanaff x *nananf*

F_3 generation

	Male gamete: *naf*	Male gamete: *naf*
Female gamete: *naf*	*nanaff*	*nanaff*
Female gamete: *naf*	*nanaff*	*nanaff*

Heterozygous naked neck (Nanaff), heterozygous frizzle (nanaFf) and normally feathered (nanaff) birds of F_4 generation were selected for the research.

3.3.2. FEEDING

The birds were fed layer mash containing 17.43% crude protein and 2700kcal/kg of metabolizable energy from the 24th week of age to the end of the experiment (64th week). Feed and water were supplied *ad libitum*.

3.3.3. Ambient Temperature

A minimum and maximum thermometer was used to measure the daily temperature of the experimental pen. The temperature values were read at 3:00pm daily.

3.3.4. Diseases and Parasite Control

Newcastle vaccination (NEW CAVAC) was carried out every eight (8) weeks. A coccidiostat, amprolium was added to their drinking water occasionally to control coccidiosis. Treatment for worms and lice were occasionally done using Levasol and Ectomin respectively.

Procedures for vaccination were as recommended by the Ministry of Food and Agriculture and dosages were given according to the manufacturer's specification (Veterinary service Division, 2008).

3.3.5. Mortality

Mortality was estimated from the number of dead birds recorded as a percentage of the number of live birds.

3.3.6 Data Collection and Parameter Estimation

3.3.6(a). Egg Production

Data on daily egg production were kept throughout the laying period on replicate basis. This was summed up every week and expressed as weekly hen-day egg production.

Hen-day egg production was therefore calculated as the percentage of the number of eggs laid to the number of hen days.The formula used was as shown below:

$$\text{Hen-day egg production} = \frac{\text{Number of eggs laid}}{\text{Number of hen days}} \times 100$$

Number of hen-days = Number of laying days x Number of birds alive.

3.3.6(b). Age at sexual maturity

The age at which birds within each genotypic group produced eggs at a rate of 50% was considered the age at sexual maturity.

3.3.6(c). **Egg Mass**

This was calculated by weighing samples of the eggs laid. The total weight of the entire sample was then determined, and was divided by the number of eggs in the sample to obtain the average egg weight. After the mean egg weight has been determined in grams, the following formula was used to compute egg mass.

$$P \times W = M$$

When: P = % hen-day egg production

W = Average egg weight in grams

M = Average egg mass per replicate in grams.

3.3.6(d). Egg Weight, Feed Intake and Feed Conversion Ratio (FCR)

Mean egg weight was obtained by weighing samples of eggs from each of the genotypic groups. The eggs were weighed from 24 weeks - of - age and every week thereafter.

Feed intake was computed by the use of the following formula:

$$\text{Feed intake / bird /day} = \frac{\text{Weekly feed consumption by a replicate}}{\text{No. of birds in a replicate during that week}} \times \frac{1}{7}$$

The feed conversion ratio was calculated as the amount of feed consumed (kg) in order to produce a kg of eggs. The following formula was used to compute the feed conversion:

$$\text{FCR} = \frac{\text{Feed consumption / replicate}}{\text{Number of eggs produced} \times \text{average egg weight}}$$

3.3.6(e). Hen-housed, Egg Production

This was measured by calculating the number of eggs produced divided by the number of birds housed. It was calculated weekly.

The following formula was used:

$$\text{Hen-housed egg production} = \frac{\text{Number of eggs laid}}{\text{number of birds housed}} \times 100$$

3.3.6(f). Rectal Temperature

This was measured monthly with the use a multi-purpose thermometer.

3.4. Experimental Design

The experimental design used was 3 X 2 factorial (3 genotypes – Nanaff, nanaFf, and nanaff and 2 lines – white and brown birds).

3.5. Statistical Analysis: Data were analyzed using the MIXED procedure of SAS (SAS Institute, 2002-2003) at $p < 0.05$. Where significant differences were observed, the least squares means were separated by the pdiff procedure of SAS (SAS Institute, 2002-2003). All data were analyzed for the main effect of genotype and plumage colour. Microsoft Office Excel 2007 was used to analyse the correlation between ambient temperature and egg production.

3.6. Pterylosis of Dorsal, Ventral and Lateral Tracts

Nine birds, three from each genotype were slaughtered for three consecutive weeks for the determination of the pterylosis in their dorsal, ventral and lateral feather tracts. In all, twenty seven birds, nine from each group were used. The feather follicles of the following tracts: dorsal cervical tract, interscapular tract, dorsopelvic tract, dorsal (for dorsal part of the body) : ventral cervical tract, ventral cervical apterium, pectoral tract, sternal tract, medial abdominal tract, cloacal circler (for ventral part of the body) and lateral body tract, femoral tract (for the lateral part of the body) were counted according to the number of follicles of feathers found in each tract (region). Adobe photoshop cs was used to deepen the follicles to make them clearer and more visible. The results were analyzed using the MIXED procedure of SAS (SAS Institute, 2002-2003) at $p < 0.05$. Where significant differences were observed, the least squares means were separated by the pdiff procedure of SAS (SAS Institute, 2002-2003).

CHAPTER FOUR

4.0 RESULTS

This chapter has been divided into four (4) parts, namely: (i) survey results, (ii) egg laying performance results (iii) correlation between ambient temperature and egg laying performance results and (iv) pterylosis of dorsal, ventral and lateral tracts results.

4.1 Survey Results

4.1.1 Frequency of genotypes, number of eggs laid, hatchability, disease resistance and acceptability of chickens

Table 4.1 Genotypic frequencies, number of eggs laid, hatchability, disease resistance and acceptability of chickens in the areas surveyed.

	Parameters				
Genotype	Genotypic frequencies	No. of eggs laid /year/bird	No. of eggs hatched/year/bird	Disease resistance	Acceptability*
Frizzle	15.7^b	60.5^a	46.3^a	10^b	5^b
featherless	2.3^b	-	-	-	-
Naked neck	5.0^b	58.8^a	38.0^b	8.6^b	17.3^a
Normal feather	556^a	47.5^b	35.7^b	11.3^a	2.7^b
Ptilopody	2.3^b	-	-	-	-
SEM	7.77	3.12	2.53	0.66	0.97
P. Value	0.01	0.01	0.01	0.01	0.01

$^{a-b}$ Indicates significant difference between mean within the same column at 5% significant level. SEM: Standard error of means. *Higher figures indicates low acceptability

The observed frequency of the normally feathered genotype differed significantly ($P<0.05$) from the frequencies of the other genotypic groups (Table 4.1). The frizzled and the naked neck birds were significantly superior in terms of number of eggs laid within a year as compared to the normally feathered birds. According to the information given by the respondents the number of eggs hatched in a year was significantly higher ($p<0.05$) for the frizzle birds than the normally feathered and naked neck birds. The analysis of the results of the information given by the respondents in this study indicates that disease resistance was significantly higher ($p<0.05$) for the normally feathered birds than the naked neck birds but the naked neck birds did not differ significantly from the frizzle birds. It could be observed from the table that acceptability was significantly lower for the naked neck than the frizzle and normally feathered birds

4.2 Egg laying Performance Results

Effects of feather type

In terms of age at 50% production the *Nanaff* birds were significantly better ($p<0.05$) than the *nanaFf* and *nanaff* layers but between the *nanaFf* and *nanaff* birds age at 50% production was significantly superior ($P<0.05$) for *nanaFf*. Again, the *Nanaff* birds had significantly higher ($p<0.05$) hen-day egg production values than their *nanaFf* and *nanaff* counterparts (Table 4.2a).

The *Nanaff* pullets maintained their superiority ($P<0.05$) in terms of average hen-housed egg production compared to the frizzle and normally feathered birds (Table 4.2a). No significant difference was recorded among the feather types in terms of egg weight. With regards to egg mass the *Nanaff* layers were significantly better ($p<0.05$)

than the *nanaff* pullets but the difference between *Nanaff* and *nanaFf* was not statistically different (P>0.05).

Table 4.2a shows the effects of feather type and feather colour on pooled egg production

Table 4.2a Effects of feather type and feather colour on pooled egg production performance.

	Parameter				
Feather type	Age at 50% production	Hen day egg production (%)	Hen housed egg production (%)	Egg weight (kg)	(g) Egg mass
Naked neck (Na)	166^{c}	86.0^{a}	74.8^{a}	51	439^{a}
Frizzle (Ff)	179^{b}	77.5^{b}	62.1^{b}	52	399^{ab}
Normal feathered (na)	189^{a}	74.7^{b}	62.3^{b}	51	383^{b}
SEM[1]	2.39	2.61	1.72	1	14
Feather colour (FC)					
White birds	182^{a}	85.4^{a}	74.0^{a}	51	439^{a}
Brown birds	175^{b}	73.4^{b}	58.8^{b}	51	376^{b}
SEM	1.95	2.14	1.41	1	116
Feather type x FC					
Na x White	200^{a}	79.6	73.3	51	467
Na x Brown	179^{bc}	78.4	69.6	51	438
Ff x White	185^{b}	77.7	71.6	52	441
Ff x Brown	174^{c}	69.2	69.5	51	427
na x White	161^{d}	76.9	68.3	51	406
na x Brown	171^{cd}	72.4	71.3	51	414
SEM	3.38	3.7	2.44	1	111
P.Values					
Feather type	0.01	0.03	0.01	0.79	0.04

Feather colour	0.02	0.02	0.01	0.83	0.03
Feather type x FC	0.02	0.24	0.09	0.65	0.12

[a-d] Indicates significant difference between mean within the same column at 5% significant level.; [1]Standard error of mean.

Effects of feather colour

The birds with brown plumage (*s*-) reached the age at 50% production significantly earlier ($P<0.05$) than their white(*S*-) groups. Hen-day egg production and egg mass were significantly better ($P<0.05$) in S- birds than their s- counterparts while no significant difference was recorded with respect to egg weight (Table 4.2a).

Feather type and feather colour interaction

Pooled age at 50% production showed a significant feather type x feather colour effect. Pooled hen-day egg production, hen-housed egg production, egg weight and egg mass did not show any significant feather type x feather colour interaction. Age at 50% production was significantly lengthened in the naked neck and frizzled birds that have white feathers whereas in the normal feathered background the performance (age at 50%) was not affected by feather colour.

Table 4.2b shows the effects of feather type and feather colour on the other pooled parameters.

Table 4.2b Effects of feather type and feather colour on pooled feed intake, feed conversion ratio (FCR), rectal temperature body weight and mortality.

	Parameter				
Feather type	Feed intake (g)	FCR	Rectal temperature (^{O}C)	Body weight (kg)	Mortality (%)
Naked neck (Na)	138^{a}	2.96	40.7^{b}	1.71^{a}	15.0^{b}
Frizzle (Ff)	119^{b}	2.98	40.8^{b}	1.59^{b}	18.8^{a}
Normal feathered (na)	111^{b}	2.95	41.0^{a}	1.60^{b}	18.2^{a}
SEM[1]	0.04	0.15	0.08	0.03	0.39
Feather colour (FC)					
White birds	125	2.88	40.8	1.66	15.7^{b}
Brown birds	119	3.04	40.8	1.60	19.0^{a}
SEM	0.03	0.12	0.06	0.02	0.31
Feather type x FC					
Na x White	141	2.93	40.8	1.76^{a}	11.3^{c}
Na x Brown	135	2.98	40.6	1.67^{ab}	18.7^{ab}
Ff x White	126	2.81	40.7	1.67^{ab}	18.7ab
Ff x Brown	112	3.15	40.8	1.51^{c}	19.0^{a}
na x White	109	2.9	40.9	1.57^{bc}	17.0^{b}
na x Brown	112	3.01	41.1	1.63^{b}	19.3^{a}
SEM	0.01	0.21	0.11	0.04	0.54
P.Values					
Genotype	0.02	0.99	0.01	0.04	0.01
Fcolour	0.24	0.35	0.89	0.06	0.01

G x FC	0.38	0.76	0.57	0.02	0.02

[a-d] Indicates significant difference between mean within the same column at 5% significant level. [1]Standard error of mean.

Effects of feather type

The *Nanaff* pullets had significantly superior ($P<0.05$) values in terms of feed intake, body weight and mortality compared to the *nanaFf* and *nanaff* pullets (Table 4.2b). FCR was not significantly different among the feather types. With regards to rectal temperature, the *nanaff* birds had significantly higher ($P<0.05$) values than the birds with mutant genes.

Effects of feather colour

The white plumage (S-) layers had significantly better ($P<0.05$) values in terms of mortality compared to their brown plumage (s-) counterparts while no significant difference was recorded with respect to feed intake, FCR, rectal temperature and body weight (Table 4.2b).

Feather type and feather colour interaction

Body weight and mortality showed a significant feather type x feather colour effect. Pooled feed intake, FCR and rectal temperature did not show any significant feather type x feather colour interaction. Body weight significantly increased in the naked neck birds (white and brown) and in the frizzled birds that have white feathers whereas in the frizzled brown and normally feathered background the performance (body weight) is not affected by feather colour.

Mortality significantly decreased in the naked neck and normally feathered birds that have white feathers and increased in the naked neck birds that have brown feathers whereas in the frizzled birds and normally feathered with brown colour the performance (mortality) was not affected by feather colour.

4 .3 Correlation between Ambient Temperature and Egg Laying Performance Results

4.3a Correlation between Ambient Temperature and Hen day egg production in different feather types.

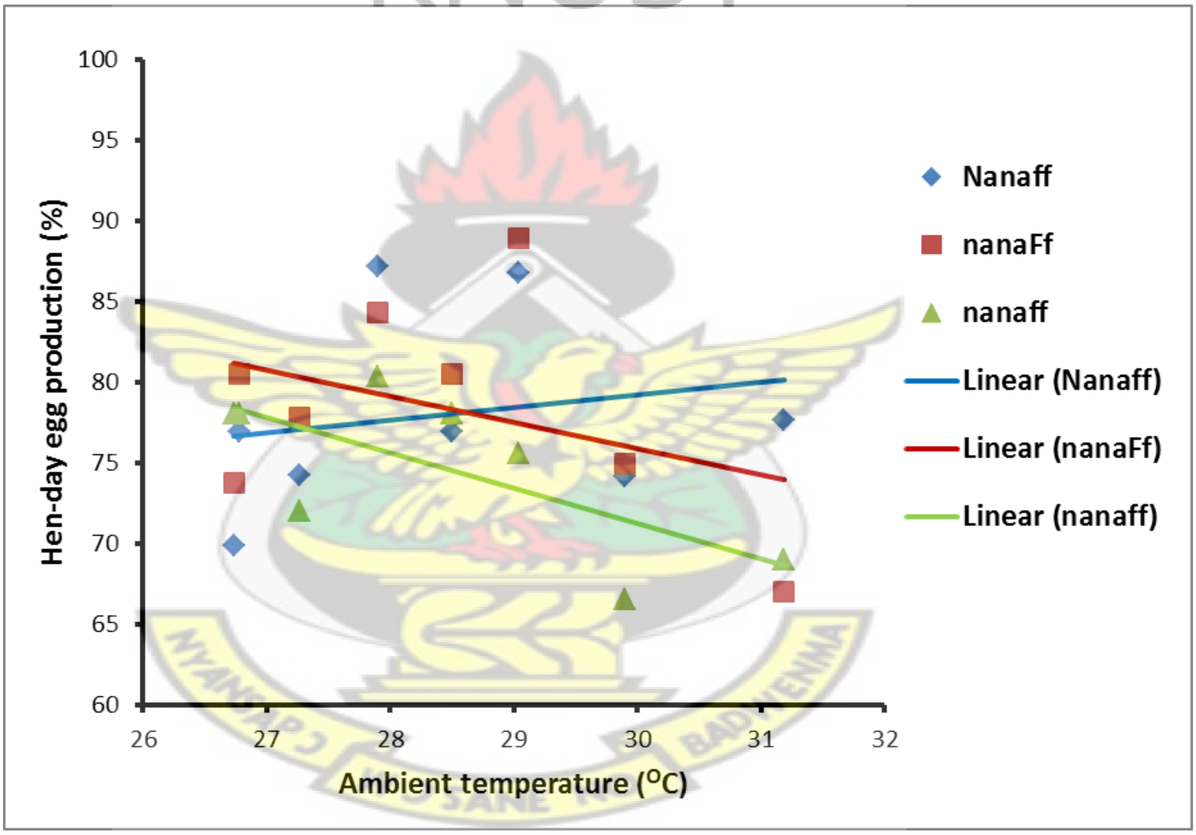

Figure 4.3a: The relationship between ambient temperature and hen day egg production in different feather types.

Figure 4.3a shows the relationship between ambient temperature and hen day egg production in different feather types. The figure indicates that at 27^{O}C the frizzle (*nanaFf*) birds had the highest percentage (80%) in terms of hen day egg production, followed by the normally feathered (*nanaff*) groups (78%) and the naked neck (*Nanaff*) birds producing the lowest (76%). However, the performance of the birds changed when the temperature increased to 31.5^{O}C with the values of the naked neck (*Nanaff*) increasing to 81% while the values of the frizzle (*nanaFf*) and the normally feathered (*nanaff*) birds decreased to 75% and 68% respectively.

4.3b Correlation between Ambient Temperature and hen day egg production in different plumage colours.

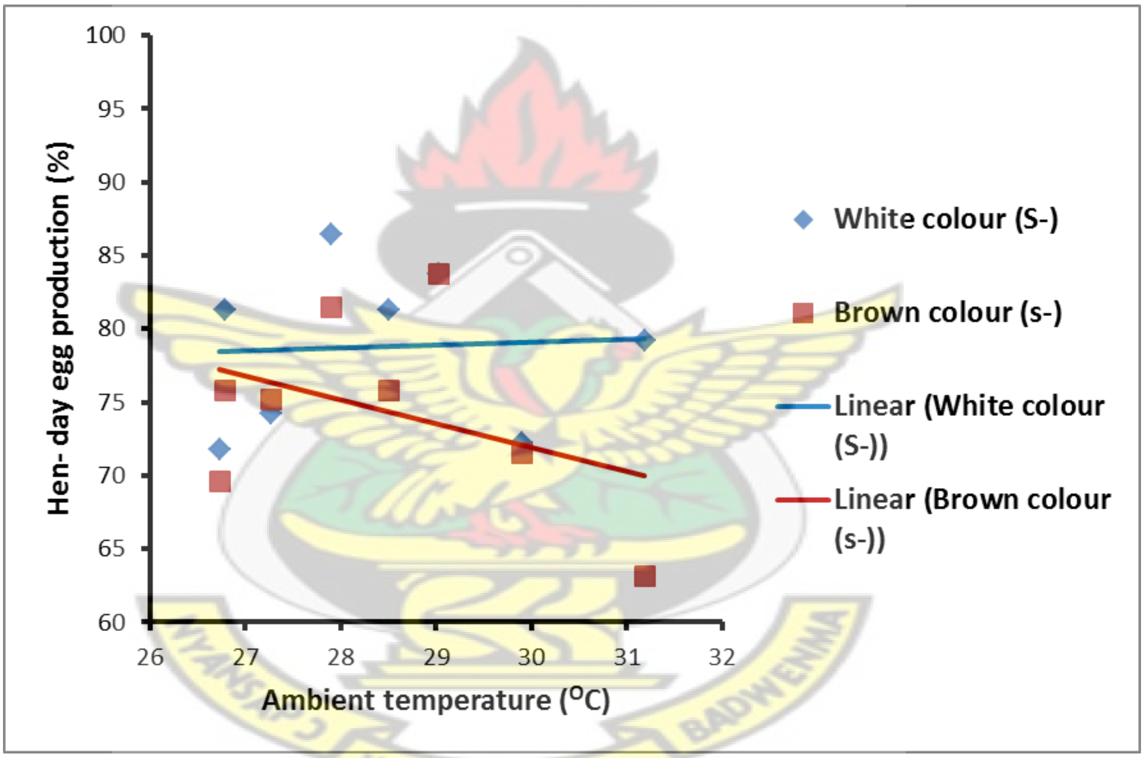

Figure 4.3b: The relationship between ambient temperature and hen day egg production in different plumage colours.

Figure 4.3b shows that the white plumage layers (S-) were better (79%) than the brown plumage birds (s-) with respect to hen-day egg production at 27^{O}C. Conversely, when temperature increased to 31.5^{O}C production in birds with s-plumage colour decreased to 70% while no change occurred in the performance of white plumage layers (S-).

4.3c Correlation between ambient temperature and egg weight in different feather types.

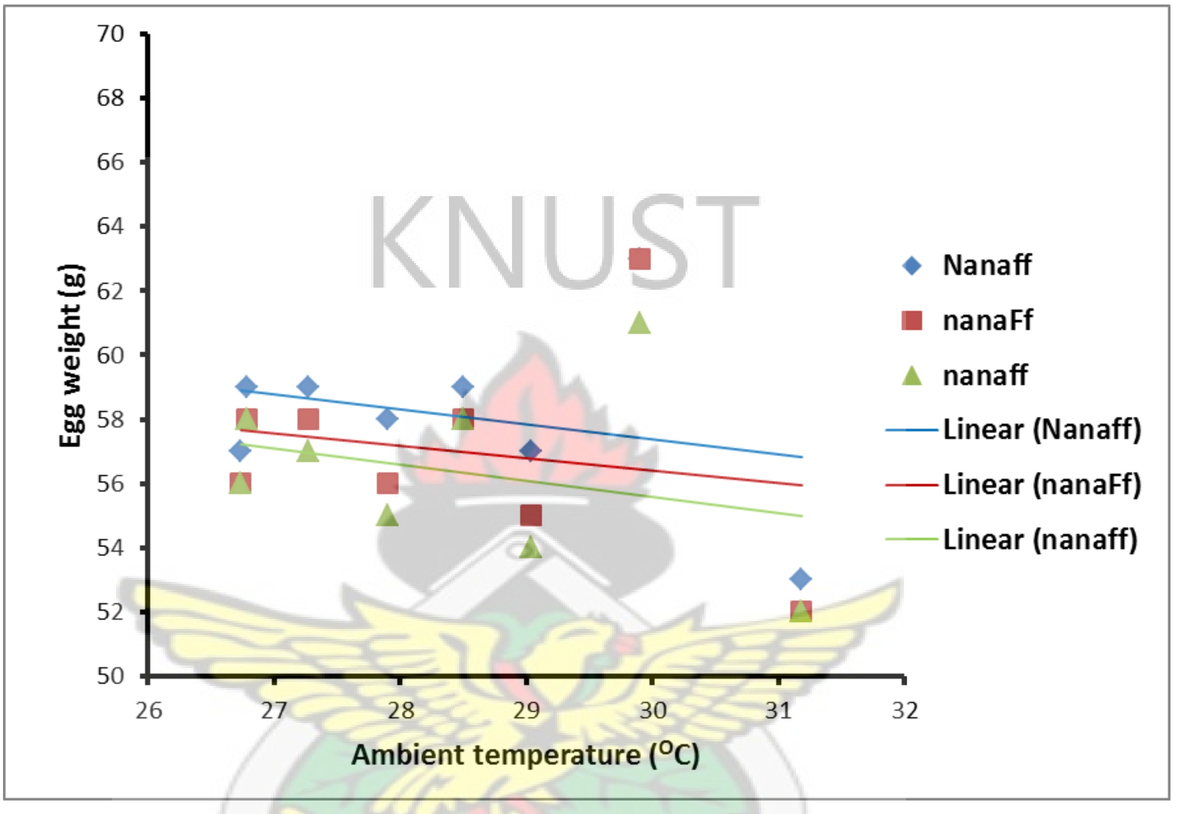

Figure 4.3c: The relationship between ambient temperature and egg weight in different feather types.

Figure 4.3c shows the relationship between ambient temperature and egg weight in different feather types. At 27^{O}C the naked neck (*Nanaff*) layers had higher egg weight values (59g) compared with the frizzle (*nanaFf)* birds (58g) and normally feathered (*nanaff*) birds (57.5g). There was a decrease in egg weight when temperature increased from about 27.2^{O}C to 31.5^{O}C for all the birds with the decrease occurring higher in the normally feathered birds (3g) followed by the frizzle layers (2g) and the naked neck layers (1g).

4.3d Correlation between ambient temperature and egg weight in different plumage colours

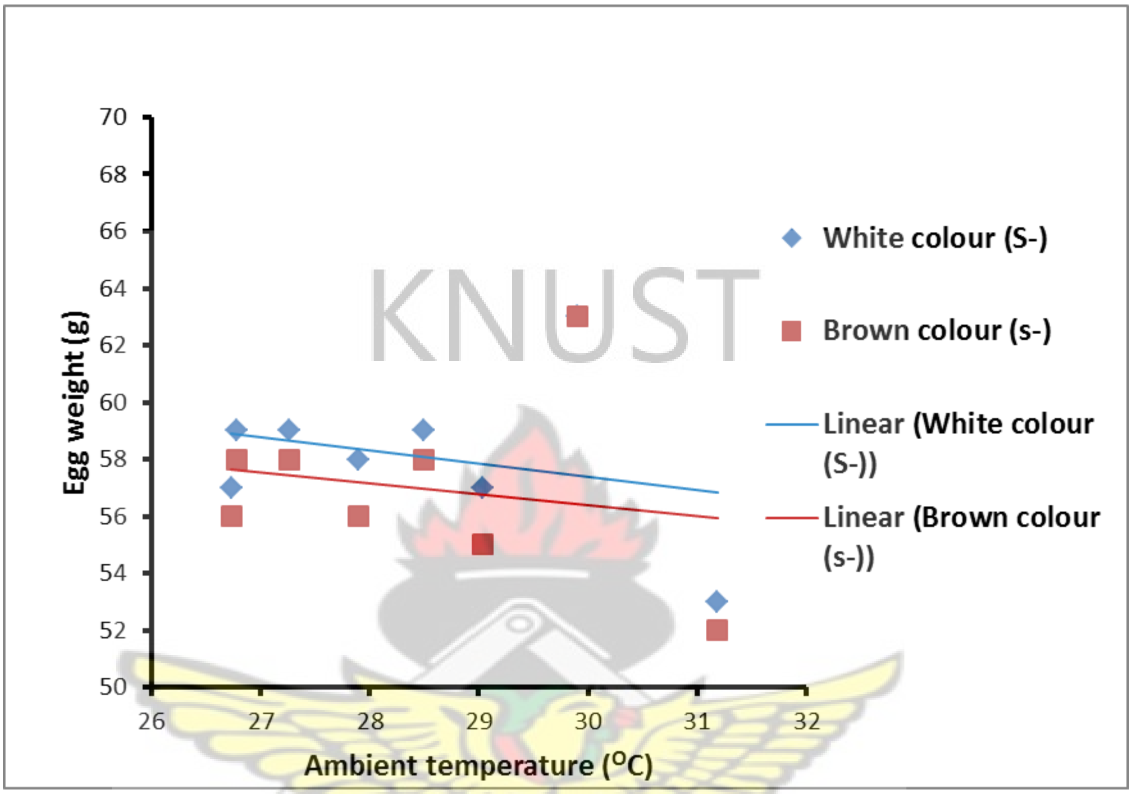

Figure 4.3d The relationship between ambient temperature and egg weight in different plumage colours.

Figure 4.3d shows the relationship between ambient temperature and egg weight for different plumage colours. With respect to egg weight, white plumage birds had higher values at 27^{O}C compared to the brown plumage birds. Egg weight decreased slightly in both plumage colours when the temperature increased to 31^{O}C.

4.3e Correlation between ambient temperature and egg mass in different feather types.

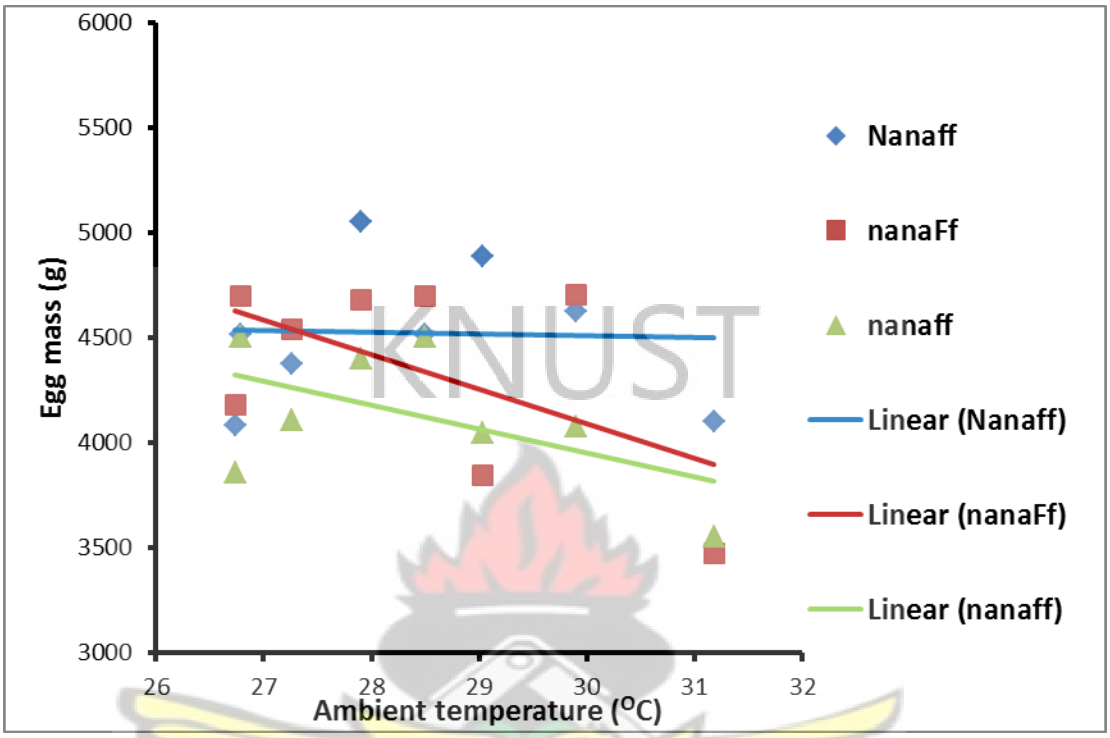

Figure 4.3e: The relationship between ambient temperature and egg mass in different feather types.

Figure 4.3e shows the relationship between ambient temperature and egg mass in different feather types. At 27^{O}C the frizzle layers obtained greater egg mass values (4700g) followed by the naked neck birds (4500g) and normally feathered birds (4350g). There was a sharp decrease in egg mass when temperature increased from about 27.2^{O}C to 31.5^{O}C for the frizzle and the normally feathered birds while the naked neck layers maintained their value with the temperature increase.

4.3f Correlation between ambient temperature and egg mass in different plumage colours.

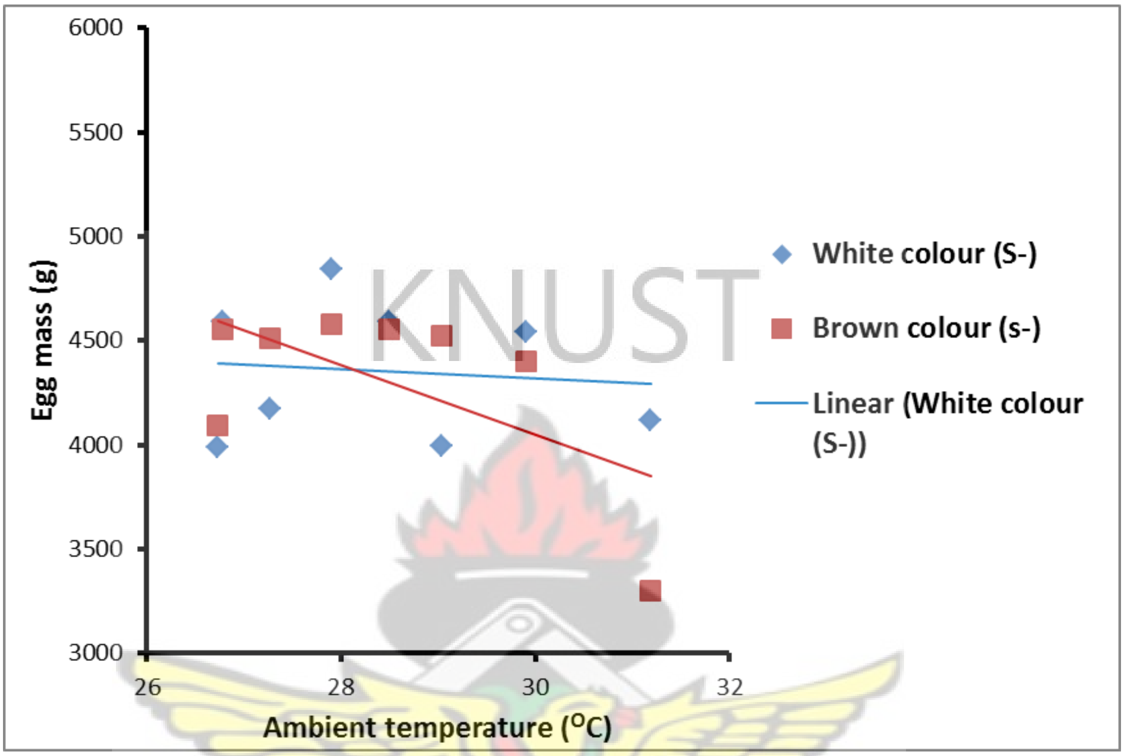

Figure 4.3f: The relationship between ambient temperature and egg mass in different plumage colours.

Figure 4.3f shows the relationship between ambient temperature and egg mass for different plumage colours. Egg mass was higher in the brown plumage birds (4600g) than in the white plumage birds (4400g) at the temperature of 27^{O}C. There was a drop in egg mass for both feather colours when the temperature increased from about 27.2^{O}C to 31.5^{O}C with the brown plumage birds showing a sharp decrease while the decrease was slight in the white plumage birds.

4.3g Correlation between ambient temperature and feed intake in different feather types.

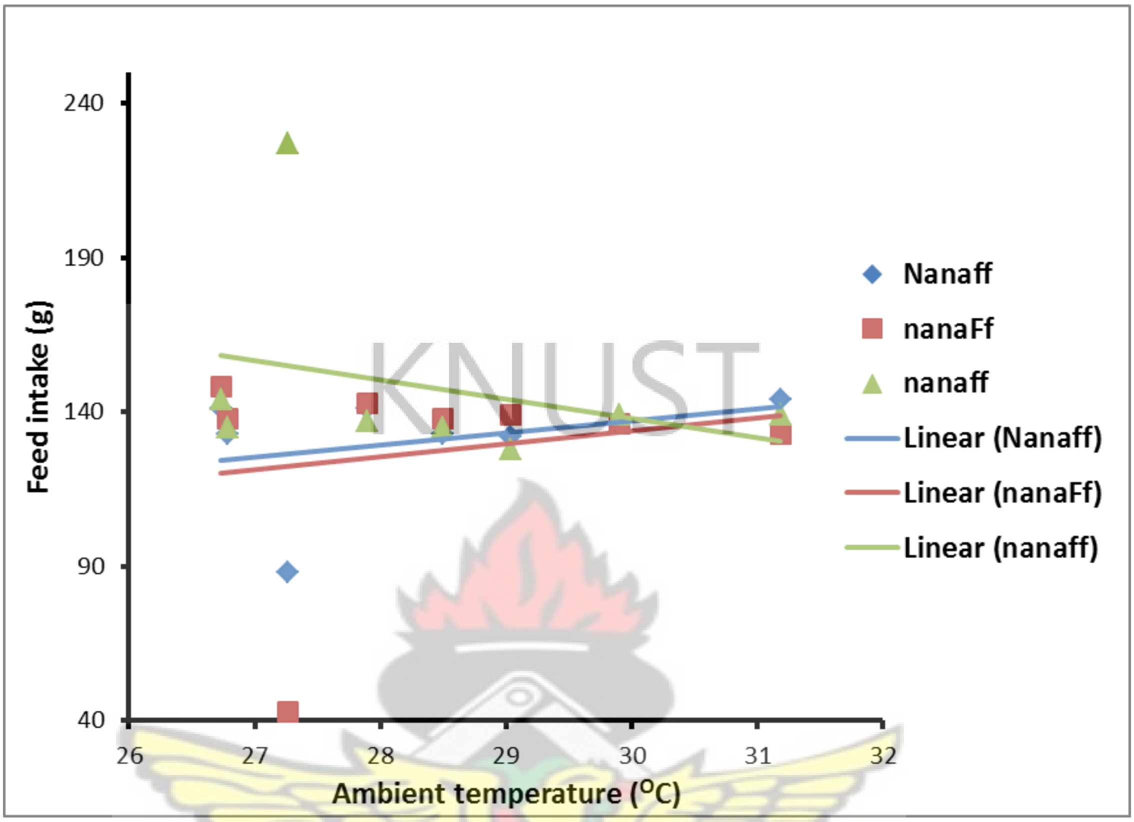

Figure 4.3g: The correlation between ambient temperature and feed intake in different feather types.

Figure 4.3g shows the relationship between ambient temperature and feed intake in different feather types. At the lower temperature (27^{O}C) the normally feathered birds had higher feed intake values (160g) followed by the naked neck layers (125g) and the frizzle birds (120g). There was a sharp decrease in feed intake for the normally feathered birds when the temperature increased to 31.5^{O}C but this increase in temperature resulted in increased in feed intake for the naked neck and frizzle layers (140g and 135g respectively).

4.3h Correlation between ambient temperature and feed intake for different plumage colours.

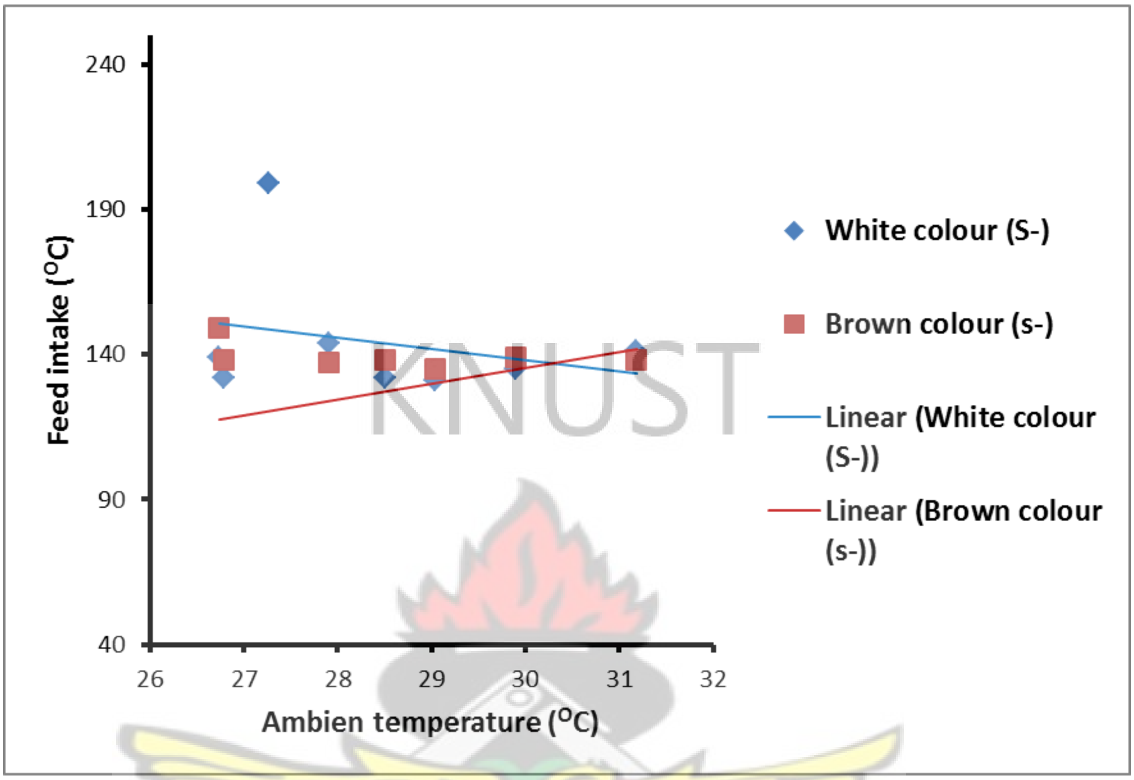

Figure 4.3h The relationship between ambient temperature and feed intake for different plumage colours.

Figure 4.3h shows the relationship between ambient temperature and feed intake for different plumage colours. Feed intake was better in the white plumage birds (158g) than in the brown plumage birds (120g) at the temperature of 27^{O}C. Feed intake went down for white plumage birds when the temperature increased from about 27.2^{O}C to 31.5^{O}C while in the brown plumage birds feed intake increased with temperature increase.

4.3i Correlation between ambient temperature and feed conversion ratio (FCR) in different feather types.

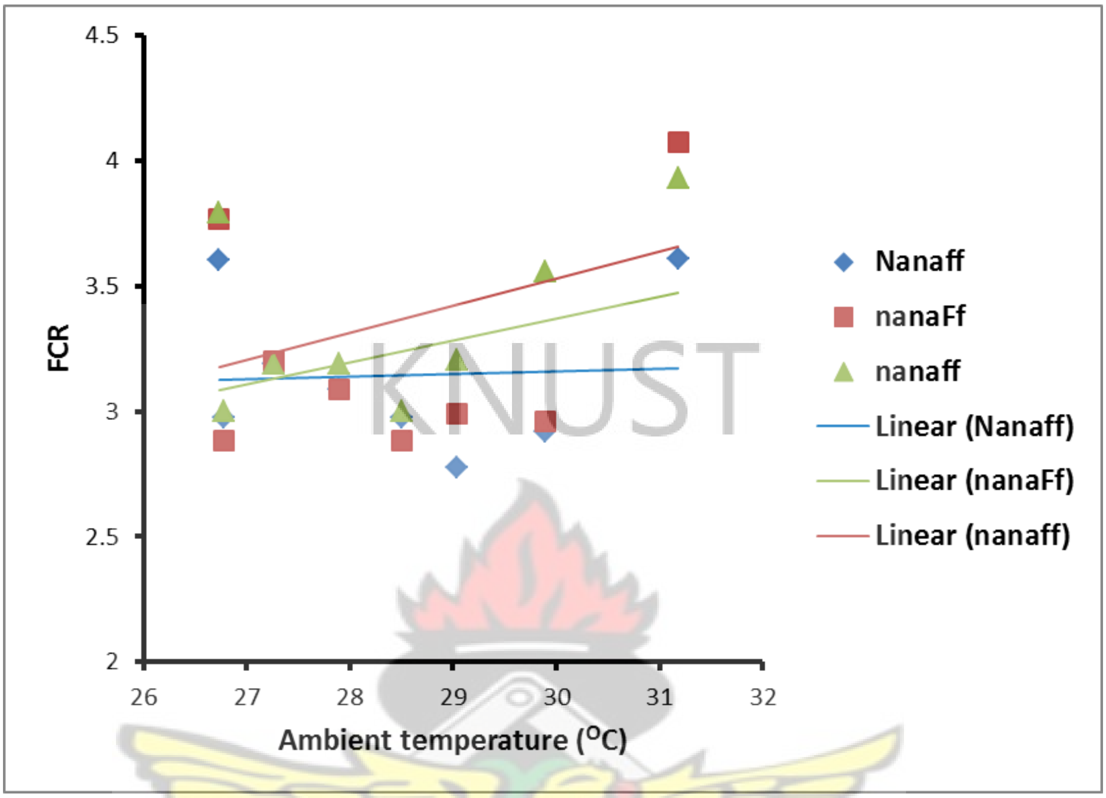

Figure 4.3i: The correlation between ambient temperature and feed conversion ratio (FCR) in different feather types.

Figure 4.3i shows the relationship between ambient temperature and feed conversion ratio in different feather types. In terms of FCR, the frizzle birds had better values (3.1) followed by the naked neck layers (3.2) and the normally feathered (3.4) at 27^{O}C. The naked neck layers maintained their values in respect of FCR when the temperature increased to 31.5^{O}C but the temperature increase resulted in increases in FCR figures in the frizzle and normally feathered layers, 3.4 and 3.6 respectively.

4.3j Correlation between ambient temperature and feed conversion ratio (FCR) for different plumage colours.

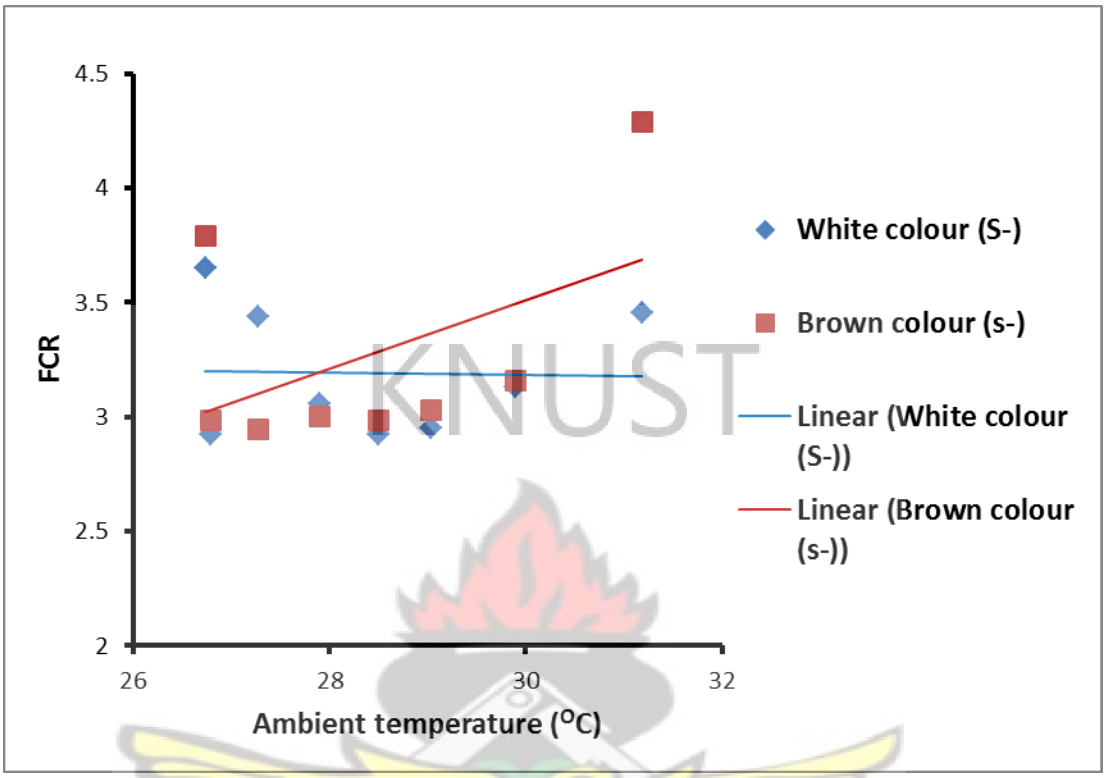

Figure 4.3j: The relationship between ambient temperature and FCR for different plumage colours.

Figure 4.3j shows the relationship between ambient temperature and FCR for different plumage colours. FCR figures were higher in the white plumage birds than in the brown plumage birds at the temperature of 27^{O}C. The figures of FCR for brown plumage birds increased when temperature increased from about 27.2^{O}C to 31.5^{O}C while the white plumage birds maintained their figures throughout this period.

4.3k Correlation between ambient temperature and rectal temperature in different feather types.

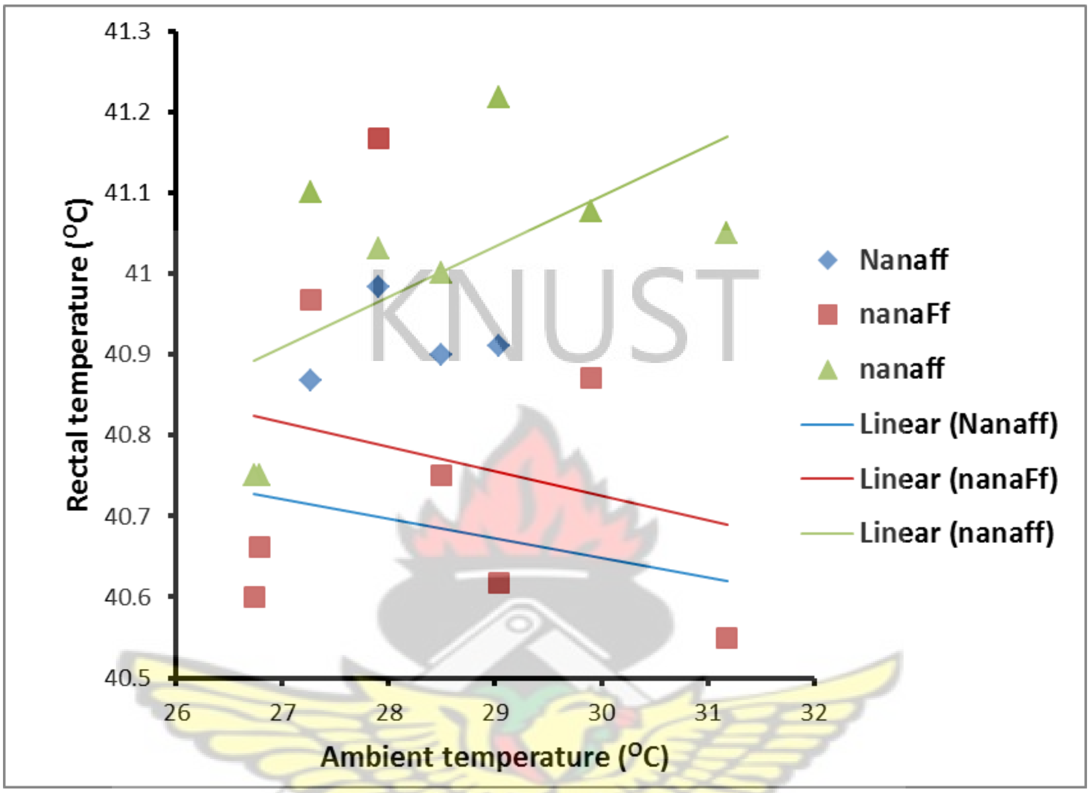

Figure 4.3k: The correlation between ambient temperature and rectal temperature in different feather types.

Figure 4.3k shows the relationship between ambient temperature and rectal temperature in different feather types. The rectal temperature was higher (40.89^{O}C) for the normally feathered birds followed by the frizzle (40.85^{0}C) and naked neck (40.75^{O}C) birds at ambient temperature of 27^{O}C. Increased in ambient temperature to 31.5^{O}C resulted in a drastic increased in rectal temperature in the normally feathered layers but in the naked neck and frizzle birds rectal temperature decreased when the ambient temperature increased with the naked neck layers showing higher decrease than the frizzle birds.

4.3l Correlation between ambient temperature and rectal temperature for different plumage colours.

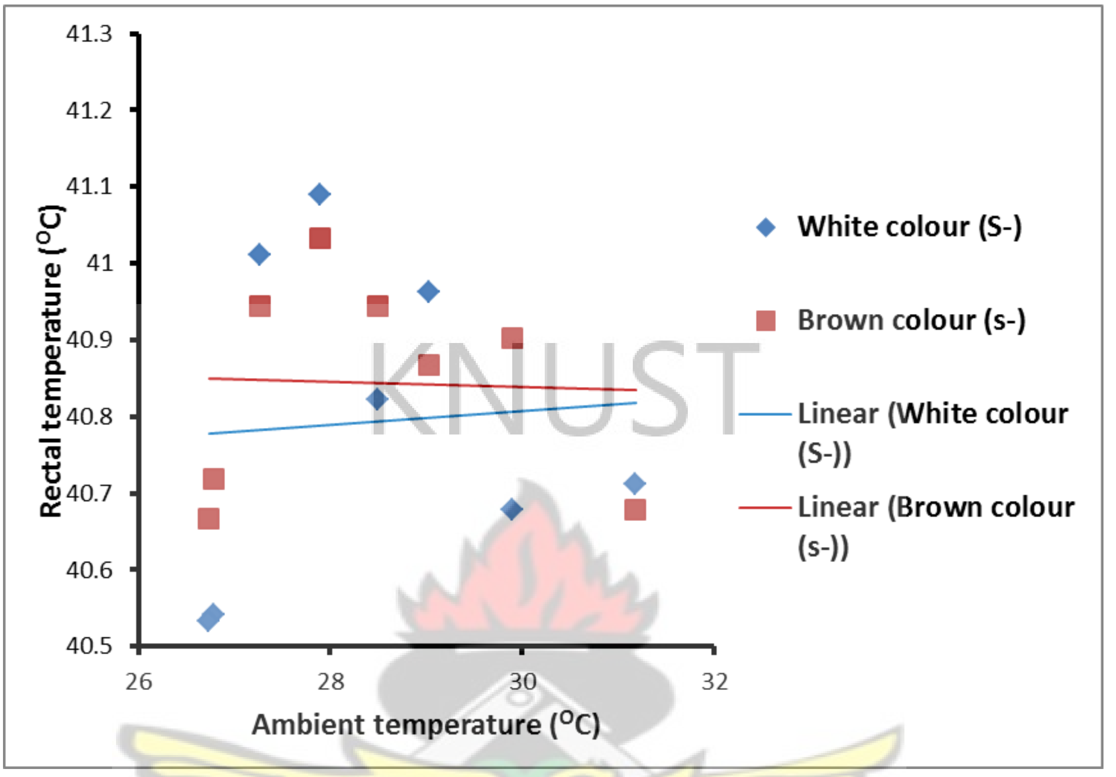

Figure 4.3l: The relationship between ambient temperature and rectal temperature for different plumage colours.

Figure 4.3l shows the relationship between ambient temperature and rectal temperature for different plumage colours. Rectal temperature was higher in the brown plumage birds than in the white plumage birds at ambient temperature of 27^{O}C. This trend changed when the temperature increased to 31.5^{O}C with the brown plumage birds showing a slight decrease in rectal temperature with the white plumage birds showing a minor increase.

4.4 Pterylosis of Dorsal, Ventral and Lateral Tracts Results

Table 4.3a shows feather (follicle) distribution of some dorsal tracts in naked neck (Nanaff), frizzle (nanaFf) and normally feathered (nanaff) layers.

Table 4.4a: Feather Distribution in the Dorsal cervical, Interscapular and Dorsopelvic tracts of the Naked neck (Nanaff), Frizzle (nanaff) and Normally feathered (nanaff) Layers

Genotype	Dorsal tract		
	Dorsal cervical	Interscapular	Dorsopelvic
Nanaff	0[b]	65.7[c]	384
nanaFf	188[a]	70.0[b]	381
nanaff	191[a]	80.0[a]	382
SEM	0.86	0.9	0.92
P. Value	0.01	0.01	0.11

[a-b] Indicates significant difference between mean within the same column at 5% significant level. SEM: Standard error of means.

Plate 4.1 indicates clear distinction between the naked neck and the other layers in terms of dorsal cervical tract with the normally feathered and the frizzle layers having almost the same number of follicles while the naked neck groups had no follicle in this tract (Table 4.4a). Again, there were dissimilarities of feather distribution in respect of interscapular tract (Plate 4.2) where the number of follicles were significantly ($p<0.05$) more for the normally feathered layers followed by the frizzle layers and then the naked neck groups (Table 4.4a). From plate 4.3 the follicle distribution in the dorsopelvic tracts of the genotypes was similar (Table 4.3a).

Table 4.4b shows feather (follicle) distribution of some ventral tracts in naked neck (Nanaff), frizzle (nanaFf) and normally feathered (nanaff) layers.

Table 4.4b: Feather (follicle) Distribution in the Ventral cervical tract, Ventral cervical apterium, pectoral tract and Sternal tract of the Naked neck (Nanaff), Frizzle (nanaff) and Normally feathered (nanaff) Layers

	Ventral tract			
Genotype	Ventral cervical tract	Ventral cervical apterium	Pectoral tract	Sternal tract
Nanaff	10.3[b]	0[c]	109[c]	32.2[b]
nanaFf	77.7[a]	140[a]	134[b]	70.9[a]
nanaff	77.3[a]	135[a]	164[a]	69.2[a]
SEM	2.51	1.45	0.64	3.10
P.Value	0.01	0.01	0.01	0.01

[a-c] Indicates significant difference between mean within the same column at 5% significant level. SEM: Standard error of means.

The follicle distribution of ventral cervical tracts (Plate 4.4b) and ventral cervical apterium (Plate 4.5) was not significantly ($p<0.05$) different between normally feathered (*nanaff*) and frizzle (*nanaFf*) layers but in these tracts the naked neck (*Nanaff*) birds had lower figures compared to the others (Table 4.3b). However, in the pectoral tract (Plate 4.6) the difference was obvious with the normally feathered birds again, having significantly ($p<0.05$) higher values than the frizzle (*nanaFf*) and the naked neck (*Nanaff*) layers (Table 4.4b). The trend changed with regards to sternal tract (Plate 4.7) with the frizzle (*nanaFf*) and normally feathered birds recording the highest number of follicles compared to the naked neck (*Nanaff*) layers.

Table 4.4c shows feather (follicle) distribution of some ventral and lateral tracts in naked neck (*Nanaff*), frizzle (*nanaFf)* and normally feathered (*nanaff*) layers.

Table 4.4c: Feather distribution of medial abdominal tract, lateral body tract, femoral tract and cloacal circlet in naked neck (*Nanaff*), frizzle (*nanaFf*) and normally feathered (*nanaff*) layers.

	Ventral and Lateral tracts			
Genotype	Medial abdominal tract	Lateral body tract;	Femoral tract	Cloacal circlet
Nanaff	90[c]	2.9[b]	197	0[c]
nanaFf	112[b]	7.3[a]	223	10.3[a]
nanaff	139[a]	7.9[a]	244	11.3[a]
SEM	2.74	0.73	49.5	0.27
P. Value	0.01	0.01	0.27	0.01

[a-c] Indicates significant difference between mean within the same column at 5% significant level. SEM: Standard error of means.

The number of follicles in the medial abdominal tract (Plate 4.8) was significantly ($p<0.05$) higher for the normally feathered layers followed by the frizzle birds and then the naked neck groups (Table 4.4c). No significant ($p>0.05$) difference was recorded in respect of follicles distribution in femoral tracts of the genotypes (Plate 4.9 and Table 4.4c). With regards to lateral body tracts and cloacal circlet, obvious distinctions between the naked neck groups and the other birds (Plate 4.10 and 4.11) were observed with the naked neck layers having only 3 follicles in the lateral body tract and no follicles in the cloacal circlet while between the normally feathered and the frizzle layers the follicle distribution in respect of these tracts were almost the same with no clear distinctions (Table 4.4c).

Plate 4.1: Dorsal cervical tracts of Nanaff (Na), nanaFf (Ff) and nanaff (cc) genotypes.

Plate 4.2: Interscapular tracts of Nanaff (NN), nanaFf (Ff) and nanaff (cc) layers

Plate 4.3: Dorsopelvic tracts of Nanaff (NN -1), nanaFf (Ff -1) and nanaff (cc -1) layers

Plate 4.4: Dorsal cervical tracts of Nanaff (Na), nanaFf (Ff) and nanaff (cc) layers

Plate 4.5: Ventral cervical apetrium of Nanaff (NN2), nanaFf (Ff-2) and nanaff (cc-3) layers

Plate 4.6: Pectoral tract of Nanaff (NN2), nanaFf (Ff-1) and nanaff (cc-1) layers

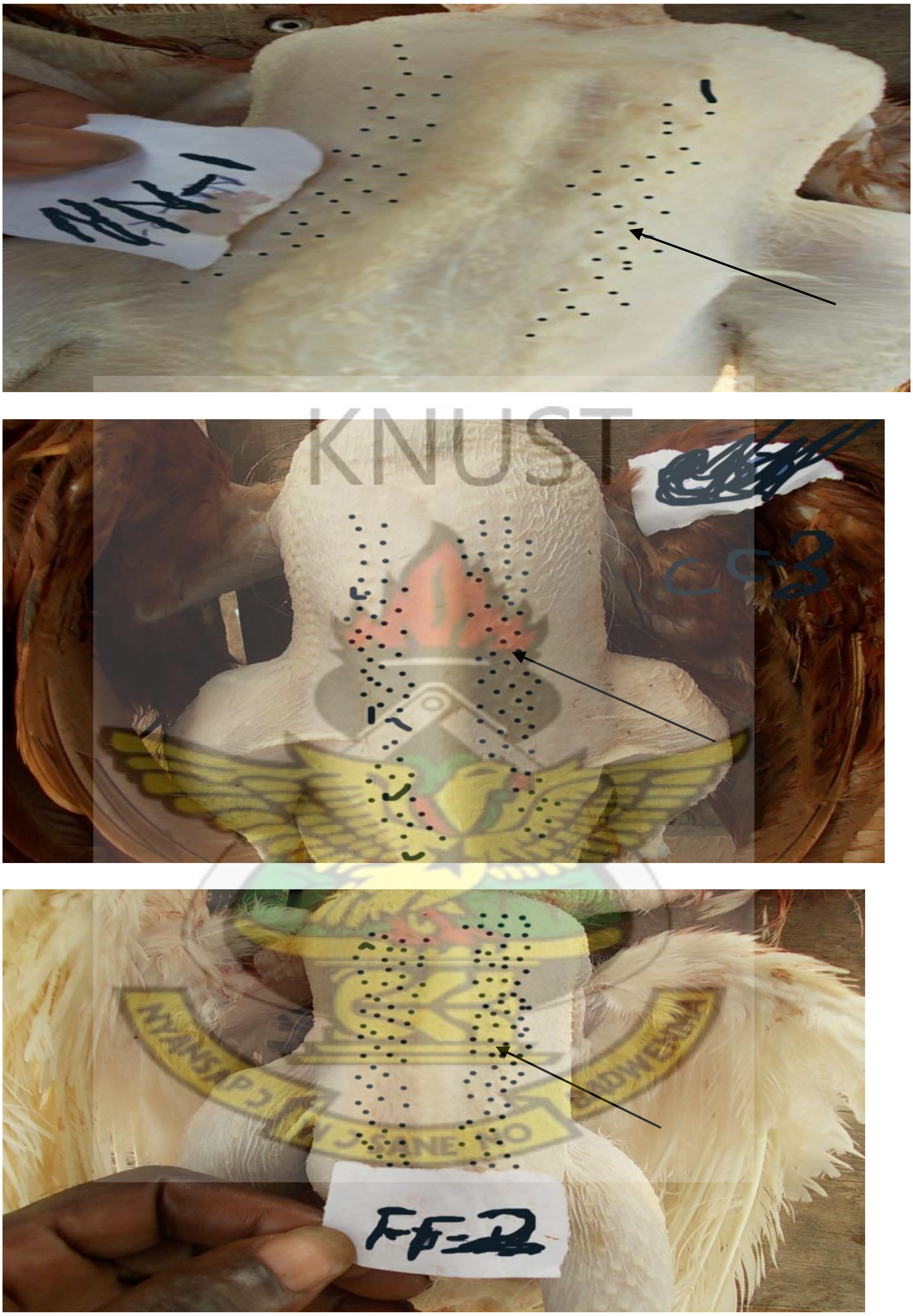

Plate 4.7: Sternal tract of Nanaff (NN-1), nanaFf (Ff-2) and nanaff (cc-3) layers

Plate 4.8: Medial abdominal tract of Nanaff (N), nanaFf (F) and nanaff (c) layers

Plate 4.9: Lateral body tract of Nanaff (NN-3), nanaFf (Ff-2) and nanaff (cc-1) layers

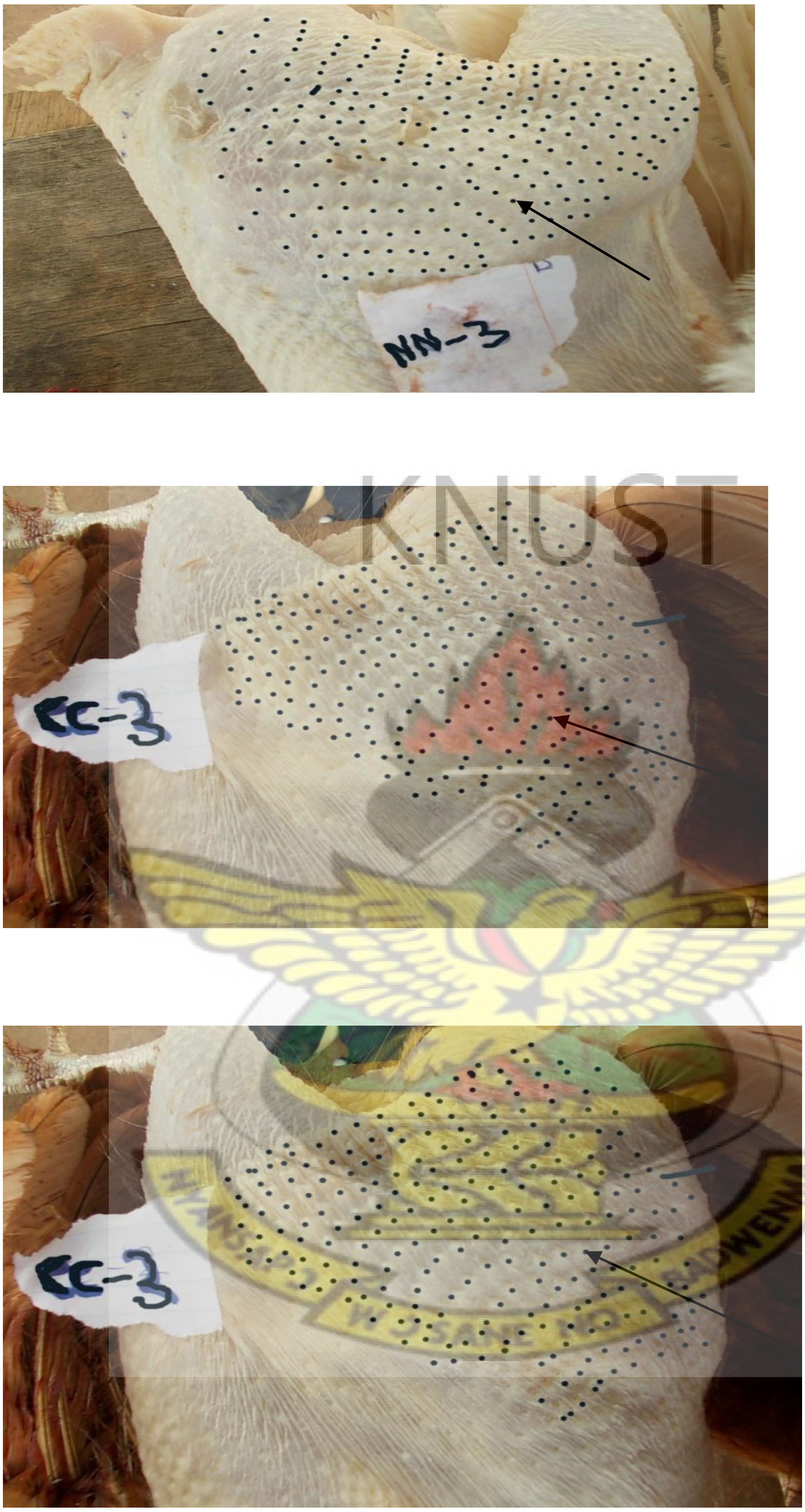

Plate 4.10: Femoral tract of Nanaff (NN-3), nanaFf (Ff-3) and nanaff (cc-3) layers

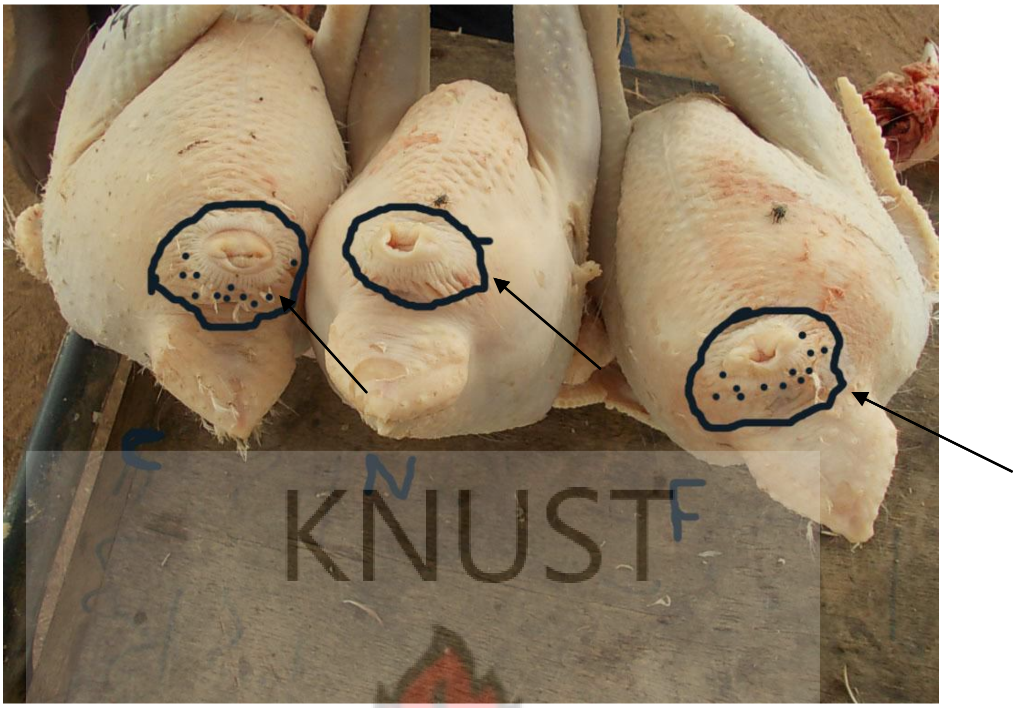

Plate 4.11: Cloacal circlet of Nanaff (N), nanaFf (F) and nanaff (c) layers

CHAPTER FIVE

5.0 DISCUSSION

5.1 Survey Results

5.1.1 Frequencies of genotypes

From the responses, it was found that most of the farmers in Sekyere South District, Ejura District and Offinso Municipal kept mainly normal feathered birds(Table). This confirms the results of a survey conducted by Adomako *et al.* (2009) to assess frequency of naked neck (*Nana*), frizzled (*Ff*) and normal feathered (*nana/ff*) birds within the population of indigenous birds in the Asante Akim South, Ejisu Juabeng and Bosomtwe Atwima Kwanwoma Districts in Ghana which showed that a higher frequency of indigenous chickens were normal feathered (78.33%) compared to naked neck (13.33%) and frizzles (8.33%). The keepers actually preferred rearing normal feathered birds to the other birds because they found easy market for the normal birds.

The lower frequencies of the naked neck and frizzled chickens might be due to the fact that the majority of the people did not use these birds for meat and rituals, especially the naked neck. Sonaiya (2003) also observed that the naked neck and frizzle might become extinct if efforts were not made to preserve and conserve them. Moreki and Masupu (1997) reported that the frizzle and naked neck genes appeared to be in serious danger of extinction and were endangered in Botsowana.

5.1.2 Number of eggs laid by genotypic groups.

Nevertheless, respondents who kept naked neck and frizzled birds reported that they laid more eggs than the normal ones. This confirms the observations of Adomako *et* *al*. (2009), Merat (1986) and Haaren- Kiso *et al*. (1991) that the naked neck and frizzle genotypes were superior in egg production in hot humid environments (temperature above 30^0C). Horst and Mathur (1992) observed that the naked-neck gene resulted in 40% less feather coverage overall, with the lower neck appearing almost naked. The frizzle gene reduces the insulating properties of the feather cover (reduces feather weight) and makes it easier for the birds to radiate heat from the body more efficiently (Gowe and Fairfull, 1995). Marthur and Horst (1990) reported that the individuals with the frizzle and naked neck genes both singly and in combination were superior to birds with normal feathering for body weight and egg laying traits.

5.1.3 Disease resistance of genotypes

According to the observation of the farmers the normal feathered birds were more resistant to diseases than the naked neck and the frizzled birds (Table 3). This assessment of the farmers may not be scientific, because using only visual observation to determine resistance of the birds to diseases cannot provide the correct answer. Most researchers, including Mahrous *et al.* (2008) have associated the dominant genes (Na and F) with high resistance to diseases.

5.1.4 Acceptability of genotypic groups.

Despite their higher number of eggs, there were complaints from the consumers concerning the use of naked neck and the frizzled birds, especially the naked neck, as meat. The naked neck was considered as an ugly and cursed bird, and the feathers of frizzle compared to the hair of a traditional priest. This belief and attitudes of the people might be a contributing factor of the low frequency of naked neck and frizzle birds in all the study areas since those with this belief refused to keep such birds.

Conversely, some farmers continue to keep these birds because of their first-class mothering and egg laying abilities.

5.2 Egg Laying Performance

5.2.1 Effects of feather type

The significantly better (P<0.05) performance in hen-day egg production of the *Nanaff* in the pooled hen-day egg production rate over the *nanaFf* and *nanaff* birds confirms the observation that under constant heat stress the heterozygous naked – neck (*Nana*) layers have significantly higher egg numbers, egg weight, egg mass, body weight and productivity index than the normal feathered birds (Mathur, 2003)

Similarly, Bordas and Merat (1990) and Younis and Cahaner (1999) reported that at high ambient temperature, the heterozygous frizzle hens had a deterioration in egg productivity and quality comparable to that of normally feathered birds, suggesting that the frizzle gene in the heterozygous form may not be as well adapted to heat stress as the naked neck. One reason could be that unlike the naked neck, the overall feather mass of heterozygous frizzle birds is not significantly reduced when compared to the normally feathered ones. Cahaner *et al*. (1993) indicated that the reduction of feather coverage provides relative heat tolerance and therefore, at high ambient temperature, heterozygous naked – neck chickens are superior to their normally feathered counterparts. The better performance of the frizzle pullets with regards to hen-day egg production compared with the normally feathered birds confirms the findings of Host and Mathur (1992) that when reared under high temperatures, the frizzling feathered layers performed better in terms of egg production when compared to their normally feathered groups. Adedeji *et al*. (2006) ascribed the better performance of the frizzle birds to their feather structure which enhances heat dissipation. The frizzle gene reduces the insulating properties of the feather cover (reduce feather weight) and makes it easier for the bird to radiate heat from the body more efficiently (Horst, 1989). He found that air passes over the exposed body surface to reduce internal heat of the birds. This grants the birds the ability to consume more feed and hence lay more eggs. Merat (1990) proved that the frizzle gene resulted in an increase in egg number under hot and humid conditions

The naked neck pullets maintained their superiority in terms of egg mass, confirming the observations of Graces *et al*. (2001) and Younis and Galal (2006) who found that the naked neck gene is associated with increased laying rate, egg size and egg mass in hot environment. This might be due to the ability of the naked neck genotypes to perform creditably in terms of higher egg numbers and bigger egg weight as observed by Mathur (2003) and Haaren- Kiso *et al*. (1991).Though the birds with the heat-tolerant genes were expected to have laid significantly bigger eggs than their normally feathered counterparts since these genes are associated with laying bigger eggs in hot environment (Younis and Galal, 2006), it was the naked neck birds which laid significantly bigger eggs only in the first two months. The results showed no significant differences in the rest of the months as well as in the pooled egg weight results. This might be due to the fact that the ambient temperature recorded (25^0C - 32^0C) was not stressful enough to elicit a significant difference in egg weight. The significantly higher ($P<0.05$) feed consumption of the naked neck genotypes than their counterparts supports the observation made by Galal and Fathi (2001) that the birds with naked neck gene had higher feed intake compared to the normally feathered.

Contrary to the results of the studies of Abdel- Rahman (2000) that the naked neck birds had a significantly better (P<0.05) feed conversion efficiency than the normally feathered genotypes and the conclusion that the feed conversion was better in *nana* birds (Alvarez *et al*., 2002), the results of this study indicated no significant difference among the genotypes in terms of FCR. The significantly higher (P<0.05) performance of the *Nanaff* layers than their *nanaFf* and *nanaff* counterparts in terms of hen-housed egg production agrees with the findings of Hagan *et al*.(2010), Merat (1986) and Haaren- Kiso *et al*. (1991) that the birds with the naked neck genotypes were superior in egg production under hot humid environment (temperature above 30^0C).

The significantly higher (P<0.05) rectal temperature values of the *nanaff* layers than the *Nanaff* and *nanaFf* genotypes can be explained from the findings of Bordas *et al*. (1978) that in terms of dominance, the homozygous (*nana*) birds tend to have full plumage cover as compared to their heterozygote (*Nana*) counterparts (41 and 27%) and (33 and 22%) for males and females respectively. This full plumage cover as well as internally generated heat might have caused the higher rectal temperature of the normally feathered (*nana*) birds because the birds have poor dissipation of heat (Cahaner *et al*., 2008).

The significantly bigger (P<0.05) body weight recorded by the *Nanaff* birds compared to the other two genotypes agrees with the findings of Yoshimura *et al*. (1997) that among the indigenous chickens, the naked – neck was found to be superior in terms of egg production, egg size and body weight in a hot and humid environment. This can be ascribed to their ability to save protein for body development which otherwise could have been used for feather growth (Adedeji *et al*., 2006).

The significantly earlier ($P < 0.05$) age at 50% production of the *Nanaff* groups and the *nanaFf* genotypes compared to the *nanaff* counterparts supports the findings of Njenga (2005) that the naked neck birds reached sexual maturity significantly ($p < 0.05$) earlier than the normally feathered birds by about 5 days.

The significantly ($p < 0.05$) lower mortality rate recorded by the naked neck compared with the frizzle and normal feathered ones agrees with an experiment involving nana (normally feathered), *Na* (naked – neck), *F* (frizzle) and *dw* (dwarf) genes under tropical conditions to evaluate the laying performance of hens by Njenga *et al*. (2005) who reported higher *nanaff* mortality rate (74.4%) compared to all other genotypes. The conclusion of his study confirms the observations of Kitalyi (1998) that birds in the tropics carrying the *Na*, *F* and *dw* genes have higher disease resistance compared to those not carrying the genes.

Mazzi (1998) also stated that the *Na* gene recorded lower mortality and weight loss during severe gradual heat stress (28 to 42^{o}C) compared to normally feathered birds.

5.2.2 Effects of feather colour

The statistically better ($P<0.05$) hen-day egg production, egg mass, hen-housed egg production and mortality rate in *S*- birds than their *s*- groups may be as a result of their white colour which absorb less heat than the brown birds confirming the findings of Bright (2007) that white feathers reflect at a higher intensity than black or grey feathers. According to him, white hens had less feather damage from feather pecking than birds with other plumage colours. These might have assisted the *S*- birds to perform significantly better than their s- counterparts since ability to reflect at a higher intensity aids in avoidance of heat stress and less feather damage would permit the use of protein for other development instead of feather growth (Adedeji *et al*., 2006).

5.2.3 Genotype and feather colour interaction

The superior performance of the naked neck and frizzled birds that have white feathers throughout this experiment might be due to the union of these genes (Na, F and S-) which confer on the birds combined additive effect albeit improved egg production. This confirms what most researchers have reported about these genes in chickens. Horst (1988) advocated for introduction of naked neck gene into local birds in the tropics for higher productive adaptability. Galal and Fathi (2007) also advocated for the use of heat tolerant genes like naked neck (Na) and frizzle (F) in the tropics in order to reach the full potential of the birds for growth, body weight and egg production which according to Cahanner *et al*, (2008) are hindered under warm conditions. Islam *et al*. (2009) stated that the introduction of the naked – neck (*Na*) gene in chicken breeds improves the resistance of the birds to heat stress.

The *Na* gene and its effects on heat dissipation positively affects appetite and this happens for two opposing reasons in cool climates, because of higher energy demands, and in hot climates because of an increase in body temperatures (Islam and Nishibori, 2009).

Merat (1986) indicated that the naked neck birds have received greater attention for commercial poultry production due to their superiority in terms of heat tolerance and its associated higher performance.

Again, studies have shown that birds with the frizzle gene perform well under hot humid conditions (Gowe and Fairfull, 1995). Host and Mathur (1992) observed that when reared under high tamperatures, the frizzled layers performed better in terms of egg production as compared to their normally feathered groups. Adedeji *et al*. (2006) ascribed the better performance of the frizzle birds to their feather structure which enhances heat dissipation.

Bright (2007) indicated that white colour reflects high intensity of light which aids the birds to reduce heat stress and the aptitude to avoid feather damage by feather pecking which also helps the birds to channel protein to egg production instead of for feather development.

5.3 Correlation of ambient temperature and egg production.

5.3.1 Correlation of ambient temperature and egg laying performance of the genotypes

The superior performance of the naked neck and frizzled birds compared to their normally feathered counterparts with regards to hen-day egg production, egg mass, FCR and feed intake supports the conclusion made by Mathur and Horst (1990) that both the *Na* gene and the *F* gene resulted in better growth and higher egg yield at high temperatures. It also agrees with the findings of Gowe and Fairfull (1995) who stated that the naked neck gene improves heat tolerance as indicated by higher egg production, better feed efficiency, earlier sexual maturity, larger eggs with possibly fewer cracks and fewer mortality when compared to the normally feathered with similar genetic background. The frizzle gene also reduces the insulating properties of the feather cover (reduces feather weight) and makes it easier for the birds to radiate heat from the body more efficiently (Gowe and Fairfull, 1995). Marthur and Horst (1990) reported that the birds with frizzle and naked neck genes both singly and in combination were superior to individuals with normal feathering for body weight and egg traits. The lower feather coverage of the naked neck and the reduced feather weight of the frizzle birds give these birds better heat tolerance and the ability to escape heat stress at high temperatures through efficient heat radiation as indicated by Horst and Mathur (1992) and Gowe and Fairfull (1995). The lower feather coverage and reduced weight of feathers also help these birds to use their energy productively instead of for heat radiation. This considerably reduces the need for dietary nutrition to supply protein for feather production.

5.3.2 Correlation of ambient temperature and plumage colour in terms of egg laying performance

The observation that as the ambient temperature increased the performance of white birds was better than that of brown birds in terms of hen-day egg production, egg mass, egg weight, and FCR may be attributed to the ability of the white feathers to reflect sun beams confirming the findings of Bright (2007) that white feathers reflect at a higher intensity than black or grey feathers. According to him, white hens had less feather damage from feather pecking than birds with other plumage colours. These might have assisted the *S-* birds to perform significantly better than their *s*-counterparts since less feather damage would permit the use of protein for egg production instead of feather growth (Adedeji *et al*., 2006) and ability to reflect sun beams aids heat radiation.

5.4 Pterylosis of dorsal, ventral and lateral tracts.

Though according to Classen and Smyth (1977), the dorsopelvic, dorsal caudal, pectoral and some other tracts of chickens are all markedly reduced in area in the naked neck, the results of this studies showed significantly higher (P<0.05) percentage follicles in interscapular, dorsopelvic, medial abdominal, and femoral tracts in the naked neck birds compared to the other genotypes. This might be due to the larger areas of these tracts in the naked neck birds than that of the frizzle and the normally feathered groups since the naked neck birds always had higher body mass than the other genotypes.

The observation that the frizzle and normally feathered birds possessed significantly higher (P<0.05) percentage follicles in dorsal cervical tract, ventral cervical tract, ventral cervical apterium, pectoral tract, lateral body tract and cloaclet tract than the naked neck pullets confirms the findings of Bordas *et al*. (1978) that in terms of dominance, the homozygous (*NaNa*) birds tend to have less plumage cover as compared to their heterozygote (*Nana*) counterparts (41 and 27%) and (33 and 22%) for males and females respectively. Similarly, Bordas and Merat (1990) and Younis and Cahaner (1999) reported that at high ambient temperature, the heterozygous frizzle hens had a deterioration in egg productivity and quality comparable to that of normally feathered birds, suggesting that the frizzle gene in the heterozygous form may not be as well adapted to heat stress as the naked neck. Adding that unlike the naked neck, the overall feather mass of heterozygous frizzle birds is not significantly reduced when compared to the normally feathered ones.

CHAPTER SIX

6.0 Conclusions and recommendations

6.1 Conclusions

The following were the conclusions made from this study:

1. Though the naked neck and frizzled birds had very low percentage in the population studied in the villages surveyed, they have high potential for commercial egg production.
2. The white colour line was also better than the brown line.
3. There were more feathers in the dorsal, ventral and lateral tracts of the frizzled and normal feathered birds compared to the naked neck birds.

Recommendations

1. There is the need to conserve and preserve the naked neck, frizzle, silver and gold genes so that they can be used in future breeding programmes.
2. Further studies should be conducted to evaluate the pterylosis of the other feather tracts of the birds which were not covered in this study.

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