KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA

# The Influence of the Naked Neck (*Na*) and Frizzle (*F*) Genes on Performance and Blood Parameters of $F_2$ and $F_3$ Generations of Crosses of Local and Commercial Chickens



by

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## DEDICATION

I dedicate this work to my wife, Abigail Yeboah and children, Angela Twenewaah-Asumah and Mordecai Kwadwo Asumah for their love and care. God bless you all.

## CERTIFICATION

I hereby declare that this submission is my own work towards the MSc 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, except where due acknowledgement has been made in the text.

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## ABSTRACT

Two experiments were conducted in this study. In Experiment 1, a total of 1,565 eggs distributed in a randomized complete block design (RCBD) comprising 4 genotypes (treatments) and 15 hatches (blocks) were used. The eggs were produced from 33 $F_2$ crossbred *nanaff* (normal feathered), *Na* (Naked neck), frizzle (*F*) and frizzle-naked neck chickens to determine their fertility and hatchability levels. The eggs were stored from one to seven days in a room at an average temperature of $26.06^0$C. The *Na*, *F* and *Na_F_* birds produced eggs of significantly ($p<0.05$) higher fertility levels compared to the *nanaff* genotypes. Hatchability (eggs set and fertile eggs) were significantly higher for the *F_* birds than birds carrying the *Na* gene.

One hundred and ninety-nine (199) $F_3$ crossbred chickens obtained from six hatches generated by the $F_2$ generation were used in Experiment 2 for the evaluation of growth, egg production, haematological and biochemical parameters. The genotypic groups were *nanaff* (normal feathered), *NaNaff* (homozygous naked neck), *Nanaff* (heterozygous naked neck), *nanaFF* (homozygous frizzle), *nanaFf* (heterozygous frizzle), *NaNaFF* (double homozygous frizzled-naked neck) and *NanaFf* (double heterozygous frizzled-naked neck). Feed and water were provided ad libitum. The *Nanaff* recorded a significantly ($p<0.05$) heavier day-old body weight compared to all other genotypes except the *NaNaff* ones.

Generally, ($p<0.05$), body weight was lower in *nanaFF*, *nanaFf* and *NaNaFF* birds compared to other genotypes. The nanaff birds reached sexual maturity significantly earlier than all other genotypes. Hen day production and egg weight were also significantly ($p<0.05$) higher in *nanaff* birds compared to *Na_*, *F_*, and *Na_F_* birds. All birds carrying the naked neck and frizzle gens had significantly ($p<0.05$) higher packed cell volume concentration than the *nanaff* birds. The *Nanaff* birds had a significantly higher Hb concentration compared to the *nanaff*, nanaFf and *NaNaFF* ones.

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# CHAPTER ONE

## 1.0 INTRODUCTION

The tropical environment is characterized by stress factors. Among them is high ambient temperature, which can lead to heat stress and thus affect the performance of birds. High ambient temperature and feather coverage of chickens decrease the rate of heat dissipation. This decreases feed intake and adversely affect productivity (Nwachukwu *et al*., 2006).

Farmers are therefore advised to use management practices (use of cooling pads, foggers) to reduce heat stress in their facilities. However, the depression of chicken growth due to high temperature cannot be completely eliminated by such management practices. Moreover, most of these practices aimed at alleviating heat stress are for most part quite expensive and hence not economical feasible in rural areas of developing countries (Saxena and Ketelaars, 1993).

A number of genes or gene complexes have been identified in the genome of the native fowl of the tropics. Genes that reduce plumage cover or lower its insulation power increase heat losses from the body to the ambient air. Prominent among them are the native neck (*Na*) and frizzle (*F*) genes.

The aim of the study was to;

1. Compare the growth and laying performance of the different genotypes.
2. Compare the blood parameters of the different genotypes and
3. Determine the effect of different length of storage on the fertility and hatchability of eggs produced from the different genotypes.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Local Poultry as sources of pertinent genetic materials

Current breeding strategies for commercial poultry concentrate on specialized production lines derived by intense selection from a few breeds and very large populations with a great genetic uniformity of traits under selection (Acamovic *et al*., 2005). There are local and fancy breeds throughout the world that are characterized by medium or low performance and are often maintained in small populations (Horst, 1999). Genetic extinction of these local breeds may lead to the loss of valuable genetic variability in specific characteristics that are momentarily unimportant in commercial breeding strategies (Ladokun *et al*., 2008).

Local breeds contain the genes and alleles pertinent to their adaptation to particular environments and local breeding goals. Local breeds are needed to maintain genetic resources permitting adaptation to unforeseen breeding requirements in the future and a source of research material (Notter, 1999).

### 2.2 Relevance of heat tolerant genes in chickens

One of the main obstacles to efficient poultry production in tropical countries is the high environmental temperature, which decreases feed intake and increases energy required for heat output via the respiratory tract, thereby leading to a drop in performance (Deeb and Cahaner, 2001). However, various genotypes tolerant to heat stress due to reduced feather coverage or modification of the feather structure are available for use in breeding a stock suited to such climates. Some major genes have been described that improve the mechanism of insensible heat loss in poultry among rural chickens in the tropics, including the sex-linked dwarf (*dw*), autosomal incompletely dominant naked neck (*Na*) and autosomal incompletely dominant frizzle (*F*) genes (Gowe and Fairfull, 1995).

Major genes are economically interesting in modern breeding systems as they act as sex markers and disease resistant factors (Crawford, 1976). Recent research findings have proved that several major genes can affect productive adaptability to tropical climates and management conditions. Some are associated with improved feed intake, productivity and survivability under heat stress conditions (Islam and Nishibori, 2009).

The naked neck (*Na*) gene affects heat loss directly by reducing feather cover; the sex-linked recessive gene for dwarfism (*dw*) reduces body size thereby reducing metabolic heat output (Gowe and Fairfull, 1995). The frizzling (*F*) gene however, results in the contouring of the feathers reduces the insulating power of the feather cover (reduce feather weight) and makes it easier for birds to reduce heat from the body.

## 2.3 The naked neck (*Na*) gene

### 2.3.1 Phenotypic description of the naked neck (*Na*) chicken

Naked neck chickens often referred to as turkens, Transylvania Naked necks, Bare necks, Hackleless and Rubber necks are characterized by the naked neck trait, caused by a single autosomal dominant gene (Davenport, 1914). The naked neck gene (*Na*) is incompletely dominant and the heterozygote (*Nana*) can be identified by a tuft of feathers on the ventral side of the neck above the crop (Cahaner, 1993). The dominant chickens (*NaNa*) however, either lack this tuft or it is reduced to just a few pinfeathers or small feathers (Crawford, 1976). Scott and Crawford (1977) demonstrated that the presence or absence of the tuft could be used to identify the two genotypes accurately at hatching. The resulting bare skin becomes reddish, particularly in males as they approach sexual maturity (Somes, 1990). The origin of the strange looking naked neck chicken is disputed (Nthimo, 2004).

The naked neck chicken is thought to have originated from Malaysia and spread all over the world by Dutch East India Company in the course of trading around the 17th century (Ramsey *et al*., 2000). The *Na* gene is associated with significantly less plumage cover than chickens not carrying the gene (Nthimo, 2004). They are very colourful - white, red and black feather combinations are found. The autosomal incompletely dominant naked neck (*Na*) gene is not only responsible for defeathering the neck region, but it also restricts the feathered area around the body by 20 to 30% in heterozygous (*Nana*) and up to 40% in homozygous (*NaNa*) genotypes because of the incomplete dominance of the *Na* gene (Islam and Nishibori, 2009).

In terms of sex differences, *Nana* females have 4.8% greater naked area compared to *Nana* males (Howlider *et al*., 1995). Bordas *et al*. (1978) reported that the *Nana* birds tend to have more feather cover as compared to their *NaNa* counterparts (41 and 27%) and (33 and 22%) for males and females respectively. 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 birds have greatly reduced feather cover (Greenwood, 1927). Feather follicles are absent from the head and neck except around the comb, the anterior spinal tract and two small patches on each side above the comb. Islam *et al*. (2004) suggested that the *Na* gene and its effects on heat dissipation positively affect 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 the upper limits of the critical body temperature. Under such conditions, feed intake increases, resulting in improved body weight, egg sizes and liveability. The introduction of the naked neck (*Na*) gene in chicken breeds seems to improve the resistance of the birds to heat stress (Islam *et al*., 2009).

The incorporation of this gene in commercial breeds might contribute to the production of birds with a high genetic potential and better performance at high temperatures.

The relationship between the presence of the *Na* gene and the resistance of the naked neck bird to heat stress is due to the fact that the gene reduces feathering by about 30% in the heterozygous birds (*Nana*) and 40% in homozygous birds (*NaNa*). The homozygous naked neck (*NaNa*) is slightly superior in most tests to the heterozygote (*Nana*) for body-weight and feed efficiency (Gowe and Fairfull, 1995). Eberhart and Washburn (1993) stated that feather reduction in naked neck birds probably caused their greater ability in dissipating heat through exposed areas compared to birds not carrying the gene. Singh *et al*. (2004) reported that in India, the naked neck and frizzle birds were not liked by 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.

### 2.3.2 Effect of the naked neck (*Na*) gene on growth traits of birds

Growth in animals is influenced by genotype of the individual animal, nutrition, hormones, tissue specific regulatory factors and other aspects of the animal's environment (Carlson, 1969). In a stress-free environment, given adequate intake of essential nutrients, growth will increase until a genetically determined upper limit is reached (Campbell and Taverner, 1988).

In a study to evaluate the growth performance of *nanaff* (normal feathered), *Nanaff* (heterozygous naked neck) and *Na_F_* (frizzled-naked neck) chickens, Mahrous *et al*. (2008) reported that the *Nanaff* (30.26 g) and frizzled-naked neck (29.63 g) chicks recorded a significantly ($p<0.05$) heavier day old body weight compared to the *nanaff* (28.25 g) ones under moderate temperature.

Nthimo (2004) recorded the lowest body weight at 3 days of age for naked neck (25.0 g) chicks when a study was conducted to examine the growth of pure indigenous chickens under intensive system of management in the tropics. The conclusion from the study was that the naked neck birds used to produce the eggs for hatching had relatively lower body weights accounting for the lower day old body weights of their progeny.

Njenga (2005) examined the growth performance of *nana*, *Nana*, *Ff* and *dw* birds with different agro-ecological characteristics under tropical conditions. The results showed that at 21 days of age, the *nana* (90.3±13.8 g) birds weighed significantly ($p<0.05$) heavier than *Ff* (89.1±16.8 g) which also differed significantly ($p<0.05$) from the *Nana* (83.2±15.8 g) phenotype. The *dw* recorded a significantly (68.4±18.4 g) lower body weight compared to all other genotypic groups.

The environment under which the experiment was carried out was characterized by moderate temperature and had favourable influence on the *nana* birds to consume more feed resulting in heavier body weight compared to the other genotypic groups.

At six weeks of age body weight of 230 g and 212 g, respectively were recorded for *Nana* and *nana* birds when Singh *et al*. (2004) conducted a study in the tropics to evaluate the growth traits of crossbred chickens. At nine weeks of age the *Nana* recorded 443 g whilst the *nana* weighed 425 g. They reported that due to the reduced feather coverage of the *Nana* birds, they were able to dissipate more heat compared to the *nana* birds and could improve body weight.

Mahrous *et al*. (2008) stated that the *nanaff* recorded a significantly ($p<0.05$) lower body weight (274.36 g) at six weeks of age compared to the *Nanaff* (281.0 g) birds. A similar observation was made at nine (9) weeks of age. At twelve (12) weeks of age they reported average body weight of 1,057.5 g for *Nanaff* (heterozygous naked neck) and 965.66 g for *nana* (normal feathered) ones which were significantly ($p<0.05$) different from each other. The presence of the *Na* gene significantly reduces feather coverage by 30% in *Nanaff* and 40% in *NaNaff*. They attributed the higher body weight of the birds carrying the *Na* genes to their ability to tolerate heat stress owing to the reduced feather coverage compared to the *nana* ones.

Bordas and Mérat (1984) carried out an experiment at $23^0$C (control) and at high temperature ($34^0$C) to evaluate the effect of the environment on the performance of naked neck (*NaNa* and *Nana*) and normal feathered (*nana*) birds. The results showed that at $23^0$C the *NaNa* recorded a significantly ($p<0.05$) lower (655 g) body weight compared to the *Nana* (694 g) and *nana* (717 g) at 12 weeks of age. They concluded that at moderate temperature body weight was reduced by 5.9% for the *Nana* genotype and by 13.9% for *NaN*a ones. However, at high temperature the *NaNa* (636 g) and the *Nana* (645 g) weighed significantly ($p<0.05$) lower compared to the *nana* (662 g). At this temperature the *Na* gene did not positively influence body weight.

An experiment was conducted by Adedeji *et al*. (2006) involving crosses between two (2) indigenous Nigerian sire strains (naked neck × White Leghorn, and indigenous full feathered × White Leghorn) and an exotic purebred (White Leghorn × White leghorn) chickens to evaluate growth traits. The various genes studied influenced body weight of birds differently. The results of the experiment showed that at 12 weeks of age (Along the column), the *Nanaff* (heterozygous naked neck) birds had a significantly ($p<0.05$) higher weight compared to the average body weight of the indigenous full feathered × White Leghorn crossbred and White Leghorn × White Leghorn progeny (Table 1.0). The White Leghorn × White Leghorn progeny also differed significantly ($p<0.05$) from the indigenous full feathered × White Leghorn crossbred ones.

Table 1.0: Body weight (kg) of naked neck and full-feathered crossbred chickens

| | Age | | |
|---|---|---|---|
| Genotype | 12 | 15 | 18 |
| Naked neck × White leghorn | 595.61±5.99[a] | 842.58±11.01[a] | 1,052.25±15.83[a] |
| Indigenous full feathered × White Leghorn | 576.68±6.41[c] | 783.59±11.34[c] | 942.92±17.21[c] |
| White Leghorn × White Leghorn | 585.19±9.72[b] | 797.19±17.49[b] | 966.42±25.41[b] |

Source: Adedeji *et al*. (2006).



At fifteen (15) and eighteen (18) weeks of age a similar trend was observed. They attributed the higher body weight of the crossbred naked necks compared to the full feathered birds to the reduced feather coverage of the former which enhances dissipation heat to its environment. Chickens suffer at high ambient temperature because of their feather coverage and this hinders internal heat dissipation leading to elevated body temperature and consequently a reduction in feed intake, thus ultimately resulting in decrease in growth. Additionally, due to the reduced feather coverage the naked neck is able to save protein for body development, which could have been used in feather growth (Nwachukwu *et al*., 2006).

Nasrollah (2008) studied the performance of pure indigenous naked neck birds and improved Marandy (fully-feathered) strain of chicken in the tropics and stated that the *Nana* (heterozygous naked neck) recorded an average body weight of 855.3±26.7 g which was significantly ($p<0.05$) lower compared to the body weight of the normal feathered Marandy chicken (972.0±34.6) at 15 weeks of age. The conclusion from the study was that pure indigenous birds usually have low body weight because of poor management practices. Such poor management practices include poor nutrition, health care and housing. The indigenous naked neck used for the study had not been selected for any purposive trait.

Yakubu *et al.* (2008) conducted a study using homozygous naked neck (*NaNa*) and normal feathered (*nana*) birds (egg-laying type) and recorded a significantly ($p<0.05$) higher mature body weight for the *NaNa* (1.30 kg) birds compared to the *nana* (1.16 kg) ones.

The superiority of the *NaNa* to the *nana* birds lies in a relatively higher mature body weight for the *NaNa* birds. The favourable effect of the *Na* gene on body weight was attributed to its association with pronounced heat tolerance as a result of reduced feather coverage (30-40% reduction in plumage). This in turn preserved energy that could have been used for thermal homeostasis and this energy is subsequently directed to productive functions including body weight.

Average live weights of 1.55 kg and 1.3 kg were recorded by *Nana* and *nana*, respectively when Mohammed *et al*. (2006) evaluated the growth performance of birds carrying the naked neck gene and fully-feathered birds under tropical conditions. The significantly low body weight recorded by the *nana* birds could be attributed to the high ambient temperature characterizing the study area which was not favourable for the *nana* bird as shown by reduced feed intake as a measure to reduce internal heat.

An experiment was conducted by El-Safty *et al*. (2006) to evaluate the growth performance of heterozygous naked neck (*Nana*) and normal feathered (*nana*) hens. They observed that the *Nana* (1584.3±72.2 g) had higher mature body weight than the *nana* (1453.1±68.1 g) hens and the difference was significant ($p<0.05$). This superiority of hens carrying the *Na* allele was attributed to the hot environmental temperatures to which these hens were exposed, such a condition led to the higher performance of the *Nana* hens compared to the *nana* hens where the former was able to dissipate more heat owning to the reduced feather coverage (20 to 30%).

Table 2.0: Effect of *Na* and *F* genes on the body weight gain (g/week) of birds.

| | Genotypes | |
|---|---|---|
| Age (weeks) | *nanaff* | *Nanaff* |
| 6-9 | 387.6[b] | 414.36[a] |
| 9-12 | 303.7[b] | 362.14[a] |

[a],[b] means with the same letters within the same row did not significantly ($p<0.01$) differ.
Mahrous *et al*. (2008)



Mahrous *et al*. (2008) examined the body weight gains of the *nanaff* and *Nanaff* chickens (Table 2.0) and reported that between 6 to 9 weeks and 9 to 12 weeks of age, the *Nanaff* recorded a significantly ($p<0.05$) higher body weight gain (414.4 and 362.1 g/week respectively) compared to their *nanaff* (387.6 and 303.7 g/week respectively) counterparts. They concluded that the *Nanaff* birds had reduced feather coverage which enhances heat dissipation and hence the bird is able to increase feed intake during heat stress compared to the *nanaff* birds.

Njenga *et al*. (2005) studied the productivity of four phenotypes of local chickens (full-feathered normal size, naked neck, frizzle and dwarf) from four agro-ecological zones of Kenya. The results indicated that the *nana*, *Nana*, *Ff* and *dw* recorded average daily gains of 4.4±1.06, 4.5±1.15, 4.2±1.19 and 3.6±1.04 g/day, respectively from day old to five weeks of age. The naked neck had the highest average daily gain among the four genotypes but the difference was not significant except when compared to the dwarf. They explained that the lower growth rate of the *dw* was as a result of its low body weight compared to all other phenotypes.

Garcês *et al*. (2001) evaluated the productive performance of birds with major genes for feather reduction (naked neck), body size reduction (dwarf) and normal-size full-feathered (*nanaff*) birds.

The study showed that body weight gain for seven days was 540 g/hen for *nanaff*, 502 g/hen for *Nanaff* and 398 g/hen for the *dw* although no significant ($p>0.01$) difference was observed between the *nanaff* bird and birds carrying the *Na* gene. Under the prevailing environmental conditions of the experiment the *nanaff* consumed significantly more food than the birds with feather reduction and body size reduction which might have favoured the *nana* bird to assume a higher body weight gain.

Nthimo (2004) carried out an experiment to evaluate the pre-laying performance of native chickens (naked neck and normal feathered) under tropical conditions. The results of the experiment revealed that from 8 to 12 weeks of age, the *Nana* recorded a significantly ($p<0.05$) higher body weight gain (362.1 g/hen) compared to the *nana* (303.7 g/day) counterparts. The conclusion was that the high environmental temperature under which the experiment was conducted might have led the *Nana* to assume higher body weight gain than the *nana* birds because the former had better heat dissipation mechanism owning to its reduced feather cover compared to the latter.

Adomako *et al*. (2009) conducted a study involving indigenous naked neck and frizzle birds compared to the fully-feathered ones. The results of the study indicated that naked neck birds ($1.71^{a}$g) had significantly ($p<0.05$) heavier body weights than the frizzle ($1.59^{b}$g) and normal feathered ($1.60^{b}$g) counterparts. The conclusion from the study was that the heavier body weight of the naked neck birds could be due to the 9 to 12 percent less feather coverage which reduces considerably the need for dietary nutrition to supply protein input for feather production. Protein which could be used for feather growth is used for body development which might enable the naked neck bird to assume heavier body weight compared to the frizzle and normal feathered ones.

Fayeye *et al*. (2006) studied body weight and body size parameters in the population of local chickens and reported an average shank length of 8.90±1.13 cm among *Nana* which was significantly ($p<0.05$) longer compared to the average shank length of the *nana* (7.12±0.09 cm) birds. Shank length in poultry had high heritability (Rizzi *et al*., 1994). The longer shank lengths of birds carrying the naked neck gene could aid their adaptability to tropical climates (Fayeye and Oketoyin, 2006).



### 2.3.3 Effect of the naked neck (*Na*) gene on sexual maturity

Sexual maturity is the period of onset of lay in avians (Saxena and Ketelaars, 1993). Sexual maturity is affected by a number of external factors such as season (especially in relation to light), housing and nutrition. Attainment of sexual maturity has been reported to be significantly different among or between breeds (Njenga, 2005; Nasrollah, 2008).

Akhtar-Uz-Zaman (2006) confirmed that attainment of sexual maturity varied from breed to breed or strain. The differences in attaining sexual maturity might be due to breed differences which reflect the adaptability of the breeds involved. Crossbreeding results in early sexual maturity in comparison to pure breeding (Wodzinowski, 1945).

A study was conducted by Akhtar-Uz-Zaman (2006) to evaluate the performance of RIR × Fay (Rhode Island Red × Fayoumi), RIR × NN (Naked Neck) and Fay × NN crossbred chickens in the tropics. The results from the study showed that the NN × RIR, NN × Fay and RIR × Fay progeny reached sexual maturity at 200.8, 194.9 and 222.2 days respectively. The offspring resulting from NN × RIR and NN × Fay cross reached sexual maturity significantly ($p<0.05$) earlier than the RIR × Fay progeny. They concluded that the lower body weight (light weight) of the NN × Fay progeny might be the probable cause of early sexual maturity.

Nwachukwu *et al*. (2006) evaluated the effect of main and reciprocal crossbreeding on short term egg production of crossbred normal local (NL), naked neck (*Na*), frizzle (*F*) chickens × exotic broiler breeder stock. The main cross (E × NL, E × *Na* and E × *F*) progeny were produced by mating exotic broiler (E) males to NL, *N*a and *F* females while the reciprocal crossbred (NL × E, *Na* × E and *F*× E) were produced by a reverse order mating. The results showed that in the main crosses the E × NL, E × *Na* and E × *F* reached sexual maturity at 170, 162 and 186.18 days, respectively where the E × *F* significantly attained sexual maturity earlier than the other crossbred progenies. In the reciprocal crosses the NL × E, *Na* × E and *F* × E recorded 158.33, 157 and 182.75 days, respectively. They concluded that the frizzled individuals in both the main and reciprocal crosses had the highest body weight and that within the same level of management, genetically heavier birds attain sexual maturity later than lighter ones.

Ivar and Jan (1968) however, reported that within strains of chickens, there exists a positive correlation between body weight (heavier) and sexual maturity (early maturity).

Bordas and Mérat (1984) conducted an experiment to evaluate the growth performance of birds reared in a control and at high temperature environments. The results from the experiment indicated that age at first ($1^{st}$) egg was 151.5, 153.4 and 151.3 days for *NaNa*, *Nana* and *nana*, respectively where the difference among them was not significant ($p>0.05$). At high temperature however, the *NaNa* attained sexual maturity significantly ($P<0.01$) earlier (158.3 days) compared to the *Nana* (162.6 days) and the *nana* (164.6 days) ones. The *NaNa* could dissipate more heat due to reduced feather coverage (30 to 40%) and could improve feed intake hence growth was not depressed. Sex linked genes and autosomal genes were reported by Greenwood and Blyth (1951) to be involved in the inheritance of sexual maturity. This character is also influenced by many environmental factors such as temperature, nutrition, light intensity etc.

In an experiment to compare the performance of the indigenous heterozygous naked neck under scavenging and cage systems, Hague *et al*. (2001) found that the naked neck (*Nana*) reared in cages reached sexual maturity significantly earlier (163) than those under scavenging system (234) days.

They attributed the earlier sexual maturity of birds under the cage system to the better management practices (lower parasitic infection) which enhanced growth.



### 2.3.4 Effect of the *Na* gene on productivity

In an experiment involving *nana* (normal feathered), *Na* (naked neck), *F* (frizzle) and *dw* (dwarf) genes to evaluate the laying performance of hens Njenga *et al*.(2005) reported that hen-day egg production was 23, 33, 27 and 36% for *nana*, *Na*, *F* and *dw*, respectively. The *Nana*, *Ff* and *dw* birds recorded significantly ($p<0.05$) higher hen day production compared to the *nana* birds. The significantly higher productivity of the naked neck, frizzle and dwarf layers could be due to their adaptability to heat stress. Furthermore, the dwarf with a smaller body size had a better feed efficiency and therefore better egg production.

Cary *et al*. (1993) stated that average egg weight is largely affected by environmental factors, feed restriction and layer body weight. Njenga *et al*. (2005) studied the productivity of *nana*, *Nana*, *Ff* and *dw* phenotypes from four agro-ecological zones and reported that the *Nana* produced significantly ($p<0.05$) heavier eggs (45.8±4.48 g) compared to eggs produced by the *nana* (42.5±3.88 g), *Ff* (43.0±4.94 g) and *dw* (38.1±2.9 g) 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 ($33^0$C). Njenga *et al*. (2005) reported a genetic correlation of 0.384 between egg weight and body weight in naked neck birds. Haque *et al*. (2001) reported a positive correlation between body weight and egg weight and suggested that heavier birds are likely to produce heavier eggs.

Nasrollah (2008) studied the performance of pure indigenous naked neck and crossbred full-feathered marandy strain of Iran. The results of the study indicated that the *Nana* produced eggs, which were significantly ($p<0.05$) heavier (44.9±0.7 g) compared to the marandy strain (44.4±0.6 g) when hen-day egg production was 47.00%.

The conclusion from the study was that at high ambient temperature birds carrying genes tolerant to heat stress are able to improve growth rate owing to less feather cover which resulted in the heavier eggs.

Garcês and Casey (2003) studied the effect of dwarf (*dw*) and naked neck (*Na*) genes on laying performance under tropical conditions and stated that normal-size birds carrying the *Na* gene (*Dw-Nana*) had significantly ($p<0.001$) higher (84.1%) hen-day egg production compared to their normal-size full feathered (80.1%) counterparts. With respect to egg weight, the *Dw-Nana* (63.0 g) produced significantly ($p<0.001$) heavier eggs (57.1 g) than their *Dw-nana* (56.4 g) counterparts (Table 3.0). The *Na* gene has been associated with increased laying rate, egg size and egg mass in hot environments.

Mérat (1990) reported that the association of naked neck and dwarf genes seems advantageous even in moderately warm environments since hen day production is improved and egg weight is increased relative to normal feathered genotypes.

Table 3.0: Laying performance of naked neck and normal feathered chickens

| Genotype | Trait | |
|---|---|---|
| | Rate of lay (hen-day egg production, %) | Egg weight (g) |
| *dw-Nana* | $64.5^{c}$ | $57.1^{c}$ |
| *Dw-Nana* | $84.1^{a}$ | $63.0^{a}$ |
| *dw-nana* | $67.4^{c}$ | $56.4^{d}$ |
| *Dw-nana* | $80.1^{b}$ | $62.7^{b}$ |

Source: Garcês and Casey (2003)

El-Safty *et al*. (2006) conducted a study to evaluate the laying performance of two genotypes; the *nana* (normal feathered) and the *Nana* (heterozygous naked neck) under low ambient temperature and reported that the *Nana* (50.6±0.36 g) produced a significantly ($p<0.05$) heavier average egg weight compared to their *nana* (49.7±0.35 g) counterparts.

It was concluded from the study that the moderate ambient temperature favoured the *nana* compared to the *Nana* genotype. Eggs produced from the *Nana* hens appear to crack more readily rather than those produced from *nana* counterparts.

Akhtar-Uz-Zaman (2006) conducted a study to evaluate the performance of RIR × Fay (Rhode Island Red × Fayoumi), RIR × NN (Naked Neck) and Fay × NN crossbred chickens under semi-scavenging system. The results showed that the RIR × Fay recorded a significantly ($p<0.05$) higher rate of lay than all other genotypes. For egg production the fayoumi recorded 26.4% which was significantly higher compared to the NN × RIR (16.7%) and NN × Fay (12.0%) crossbreds. He reported that the naked neck crossbreds (RIR × NN and Fay × NN) were broody compared to fayoumi crossbred. He concluded from the study that broodiness might be one of the major factors for the low productivity among the naked neck crossbreds.

Galal *et al*. (2007) evaluated the laying performance of egg-type chickens. The different genotypes used in the study were *Dw-nana* (normal feathered), *dw-nana* (dwarf size normal feathered), *Dw-Nana* (normal-size naked neck) and *dw-Nana* (dwarf size naked neck). The results showed that the *Dw-Nana* produced eggs which were (62.12±0.50 g) significantly heavier ($p<0.001$) compared to eggs produced by all other phenotypes. Eggs produced by the *Dw-nana* (60.72±0.68 g) also differed significantly ($p<0.001$) from the *dw-nana* (58.71±0.42 g) and the *dw-Nana* (59.10±0.61 g) birds. They concluded that the sex-linked dwarfing gene (*dw*) could be responsible for the decrease in egg production. The *dw* gene reduced egg weight by 2.0 g compared to the *Dw-nana* counterparts. The small egg size reflects the high

and positive correlations between body weight and egg size and may be associated with smaller reproductive tract of dwarf layers. They suggested that the incorporation of the *Na* gene could compensate the negative effect of the *dw* gene on egg production parameters.

Galal *et al*. (2007) reported a 1.6% lower laying performance under temperate conditions, but 10% more eggs in heat stress conditions in naked neck birds compared to their normal feathered counterparts.

Bordas and Mérat (1984) evaluated the performance of *NaNa* (homozygous naked neck), *Nana* (heterozygous naked neck) and *nana* (normal feathered) at moderate and high temperature environments and reported a reduction in adult body weight by 6.1% for *Nana* and 11.8% for *NaNa* at moderate temperature (Table 4.0). They also observed a considerable advantage of the homozygous naked neck genotype over the normally feathered genotype for mean egg weight (7.1%). Mean egg weight to body weight was higher in the homozygous naked neck compared to the normal feathered birds and the heterozygous naked neck was intermediate. Peak production was reached on the 14$^{th}$ week after onset of lay. The increased feed intake of *NaNa* hens might have contributed to the larger egg size relative to body weight by the supply of additional material for egg formation; this could include protein and possibly lipids in excess of those used for satisfying energy requirements (Bordas and Mérat, 1984). Significant differences ($p<0.001$) were observed between *NaNa* (94.1% of normal) and *Nana* (86.1%) at 28$^0$C in body weight but no significant ($p>0.01$) difference occurred between them at 30$^0$C (Table 4.0). Egg number at moderate temperatures was not significantly affected, but, at high temperature, improved egg production was seen in naked neck layers compared to normal feathered birds. They reported a reduction of 3.7 g between the average egg weight of the *NaNa* and the *nana* genotype.

Table 4.0: Mean values of *NaNa* genotypes as percentage of the values for the normal genotype for the main economic traits.

| | **Genotype** | | |
|---|---|---|---|
| | *NaNa* | *Nana* | |
| **Trait** | **CONTROL ($28^0$C)** | | **Significance of the genotype effect** |
| Body weight | 86.1 | 94.1 | ** |
| Egg number | 96.7 | 102.0 | |
| Mean egg weight | 101.4 | 102.3 | |
| Egg mass/28d | 101.0 | 106.5 | |
| Food utilization | 93.6 | 90.7 | |
| | **HOT GROUP ($30^0$C)** | | **Significance of the genotype effect** |
| Body weight | 100.3 | 100.3 | |
| Egg number | 103.5 | 99.4 | * |
| Mean egg weight | 107.1 | 102.3 | *** |
| Egg mass/28d | 122.9 | 111.6 | *** |
| Food utilization | 88.2 | 93.1 | * |

*,**,*** significant at *P<0.05,0.01.0.001* respectively
Source: Bordas and Mérat (1984)

Egg production, fertility and hatchability are the most important determinants for producing chicks from a given number of breeding stocks within a stipulated period. Fertility and hatchability performance of eggs depend on a number of factors such as genetic and physiological, social and environmental factors (Hutt, 1930). Hatchability of eggs is affected by several factors which include fertility of the eggs, egg quality, handling of eggs, management conditions during incubation and hatching as well as the genetic constitution of parents (Peters, 2005).

Islam and Nishibori (2009) compared the fertility levels of indigenous and exotic chickens under tropical conditions. The results showed that the indigenous normal feathered (*nana*) and naked neck birds (*Nana*) recorded fertility values of 92.70 and 89.60%, respectively whilst the exotic (*nana*) had 84.40% with significant (*p<0.05*) differences between the indigenous strains and exotic breed.

The conclusion from the study was that eggs from indigenous hens show higher fertility and hatchability rates, due to their adaptability than those from exotic breeds under local conditions.

A study was carried out by Yakubu *et al*. (2008) to determine the productivity and egg quality traits of naked neck and full-feathered chickens. The results of the study indicated that *NaNa* (homozygous naked neck) gave a hatchability of 71.49% compared to 72.13 in *nana* (normal feathered) birds but the difference was not significant although the data showed a tendency towards higher hatchability in the normal feathered hens than the naked neck birds. They suggested that this might not be the true reflection of the genetic potential of this ecotype, as most of the embryos died a few days before hatching. Such a late embryonic mortality could be due to non-genetic factors supporting a report by Peters *et al*. (2008).

Islam *et al*. (2001) reported that fertility and hatchability of fertile eggs of indigenous fully-feathered birds and indigenous naked neck ones were 52.4-87.0% and 83.0-92.7%, and 71.5-87.6% and 68.2% respectively. They attributed the lower hatchability of the indigenous naked neck to high mortality during the later days of incubation due to the absence of hair at the back of the neck.

Njenga *et al*. (2005) reported that the *nana* (normal feathered), *Nana* (naked neck), *Ff* (frizzle) and *dw* (dwarf) birds recorded average fertility values of 57.8, 58.5, 65.7 and 65.4%, respectively. No significant difference was observed among the different phenotypes studied.

High temperature (>$30^0$C) decreases fertility of hens but the study showed that this effect is greatly reduced in hens carrying the *Na* gene as shown by lower proportion of abnormal embryos compared to the normal feathered birds. The fertility of the cocks may have been affected by the types of feed used, which had been formulated for egg production.

Peters *et al*. (2008) carried out a study to compare the fertility and hatchability levels of thirty (30) crossbred naked neck and thirty (30) normal feathered chickens for a period of thirty (30) days. The normal feathered sire group produced a significantly ($p<0.05$) higher number of fertile eggs (515) compared to the naked neck (409) birds.

Corresponding percentage hatchability values were significantly ($p<0.05$) higher for the normal feathered (89.75±7.5%) compared to the naked neck (82.63±5.7%) birds. Moreover, percentage fertility and hatchability were lower among eggs sired by the *Na* genetic group. Poultry respond to severe heat stress by minimizing their muscular activity, presumably because this results in less heat which must be dissipated. Reduced muscular activity results in reduced mating activity which lowers percentage hatchability (Ernst, 1995).

Mérat (1990) suggested that an increase in embryonic mortality (up to 10%, in pure strains) found among the *NaNa* and to a lesser extent among the *Nana* counterparts put them at a slight disadvantage to the *nana* birds. Peters *et al*. (2008) also recorded a reduction of 6.1% for *Na* in embryonic survival when compared with *nana* birds and explained that this embryonic mortality was normal during the last stage of incubation (18-21 days). Peters (2005) mentioned that matings involving naked neck birds produced a high percentage of dead-in-shell embryos due to the lethality of the *Na* gene particularly in the homozygous state.

In any commercial use of this gene, this loss will have to be balanced against the positive effects of the gene under hot conditions.

Peters *et al*. (2008) stated that matings between frizzle feathered sires and naked neck dams resulted in relatively lower fertility and hatchability when compared to matings with normal feathered birds. This indirectly indicates that, there is a possibility of low combining ability between the major genes controlling these traits with respect to hatchability and that combining the two genes in a single genotype might be undesirable.

Peters (2005) suggested that hatchability may not entirely be a function of fertility because of some intrinsic factors associated with eggs.

In a main and reciprocal crosses between normal feathered and homozygous naked neck birds, Landauer (1967) reported that hatchability of eggs from homozygous frizzle hens mated to normal feathered cocks was 42.7% which was significantly ($p<0.05$) lower compared to the reciprocal cross (75.3%) He attributed the significant difference to maternal physiology; because of the excessive loss of body heat and the resulting disturbances of temperature regulation and of metabolism (associated with abnormal thyroid activity), the frizzle hens cannot always deposit in their eggs all substances necessary for normal embryonic development, and that this in turn leads to increased embryonic mortality.

Smith and Lee (1977) reported that post-embryonic chick mortality did not differ between indigenous naked neck and indigenous fully feathered birds, except when exposed to heat stress of above $40^0$C, where survival rates of 51.4% for indigenous naked neck and 38.8% for indigenous fully feathered birds were recorded.

Reddy *et al*. (1965) carried out an experiment to evaluate the effect of a holding period of eight days eggs on hatchability among naked neck, frizzle and white rock fowls. The results showed that the naked neck, frizzle and white rocks lost on average 4.36, 2.40 and 1.71 percent, respectively in, hatchability per day. They concluded that loss of weight by evaporation is likely to lead to decline in the hatching quality of eggs during storage.

### 2.3.5 Effect of the *Na* gene on body temperature of birds

Aengwanich (2008) stated that when birds are exposed to a hot environment and/or performing vigorous physical activity, body temperature might rise by $1^0$C or $2^0$C as heat energy is stored and that heat storage cannot continue for extended periods before body temperature increases past the limit that is compatible with life.

Conversely, when birds are exposed to very cold environment, heat escapes from the birds and unless it is replenished by energy from metabolism of food, body temperature will decline until the bird is incapacitated and dies (Gowe and Fairfull, 1995). Light breeds of chickens have higher core temperatures than heavy breeds and were able to withstand hot environments (Saxena and Ketelaars, 1993).

El-Safty *et al*. (2006) conducted a study to evaluate some immunological traits and laying performance of two genotypes (*Nana* and *nana*) and reported that the heterozygous naked neck had a slightly higher ($41.8\pm17.6^0$C) average body temperature compared to the *nana* ($41.6\pm17.7^0$C) ones although the difference was not significant ($p>0.05$). Laan (2002) stated that birds with higher body temperatures have good cell-mediated immune response.

Bordas and Mérat (1984) evaluated the performance of *NaNa* (homozygous naked neck), *Nana* (heterozygous naked neck) and *nana* (normal feathered) at moderate ($23^0$C) and high temperature ($34^0$C) environments and recorded average rectal temperatures of $39.97^0$C, $40.11^0$C and $40.15^0$C for *NaNa, Nana* and *nana*, respectively at moderate temperature where significant difference occurred between the *NaNa* and *nana* but not the *Nana* 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.

Under a high temperature condition ($40.15^0$C, $40.24^0$C and $40.27^0$C for *NaNa*, *Nana* and *nana*, birds respectively), no significant difference occurred among the genotypes studied (Bordas and Mérat, 1984).

### 2.3.6 Effect of the *Na* gene on mortality

Mahrous *et al*. (2008) evaluated the growth performance of *nanaff* (normal) and *Nana* birds (naked neck) under moderate conditions in the tropics and reported that the *nanaff* hens recorded a significantly ($p<0.05$) higher mortality and culling rate than the *Nanaff* birds.

Hagan *et al*. (2009) studied the growth performance of *NanaFf* (double heterozygous frizzled-naked neck), *nanaFf* &*Nanaff* (heterozygous frizzle and naked neck) and *nanaff* (normal feathered) and reported mortality rate of 17.56, 18.22 and 18.89%, respectively although the difference was not significant ($p<0.05$).

Rizzi (1994) reported that the *Na* gene showed lower mortality and weight loss during severe gradual heat stress (28 to $42^0$C) compared to normally feathered birds.

A study was conducted by Yakubu *et al*. (2008) to determine the productivity and egg quality traits of naked neck and full-feathered chickens. The study revealed a significantly ($p<0.05$) lower rate of mortality in *NaNa* birds (28.66%) as against 36.85% in *nana* ones. Mortality rate estimated was based on disease prevalence and weather effect. Mortality due to predation, theft and accidents were excluded. They reported low incidence of pathologies (cloacal cysts, prolapsed, marek's disease, coccidiosis and salmonellosis) in naked neck compared to the normal feathered birds and this suggests a greater disease resistance associated with the *Na* gene.

Kitalyi (1998) reported a higher disease resistance associated with birds carrying the naked neck (*Na*) gene.

El-Safty *et al*. (2006) evaluated some immunological traits and laying performance of two genotypes (heterozygous naked neck and normal feathered chickens) and reported that the naked neck has better ability to secrete Acute Phase Protein (APP) which gives protection to birds against infection of any invasion.

In an experiment involving *nana* (normal feathered), *Na* (naked neck), *F* (frizzle) and *dw* (dwarf) genes under tropical conditions to evaluate the laying performance of hens Njenga *et al*. (2005) reported that the *nanaff* recorded a significantly ($p<0.05$) higher mortality rate (74.4%) compared to all other genotypes. The *Nanaff*, *nanaFf* and *dw* birds recorded mortalities of 45.1, 56.1 and 49.2%, respectively. The conclusion from the study supported the assertion of Kitalyi (1998) that birds carrying the *Na*, *F* and *dw* genes have higher disease resistance compared to those not carrying the genes.

Adomako *et al*. (2009) conducted a survey to evaluate the potentials of indigenous naked neck (*Na*) and frizzle (*Ff*) birds in Ghana. The study showed that naked neck recorded a significantly ($p<0.05$) lower mortality rate than frizzle and normal feathered ones. According to Banga (1996) the naked neck has a higher resistance to coccidiosis-causing protozoa i.e. *E. tanella* and *E. necatrix*.

### 2.3.7 Effect of the *Na* gene on haematological and biochemical indeces of chickens

Blood is a complex fluid containing a large variety of dissolved suspended inorganic and organic substances (Stewart, 1991) or specialized circulating tissues and cells suspended in the intercellular fluid substance (Dellman and Brown, 1976).

Blood circulates in the arteries, veins and capillaries of man and animals (Kronfield and Mediway, 1975), its primary function is to transport oxygen from respiratory organs to body cells (Dukes, 1975), distributing nutrients and enzymes to cells and carrying away waste products (Baker and Silverton, 1982), thereby maintaining homeostasis of the internal environment (Bentrick, 1974).

Aba-Adulugba and Joshua (1990) stated that the various functions of the blood are made possible by the individual and collective actions of its constituents-the biochemical and haematological components.



Onyeyilli *et al* (1992) indicated that packed cell volume (PCV) and haemoglobin (Hb) should range between 23-55% and 7.0-18.6 g/dl respectively. They mentioned that a value less than 7 g/dl in Hb content could be a sign of anaemia in the individual animal (Table 5.0). Aengwanich (2008) reported that birds with higher haemoglobin level could thrive well at a high altitude.

Table 5.0 Normal haematological and serum biochemical values of chickens.

| Measurement/unit | chicken |
|---|---|
| *Haematological components* | |
| Packed Cell Volume (%) | 23-55 |
| Red Blood Cell ($10^6$/µl) | 1.3-4.5 |
| White Blood Cell ($10^3$/µl) | 9-32 |
| Haemoglobin (g/dl) | 7.0-18.6 |
| *Biochemical components* | |
| Total protein (g/dl) | 3.3-5.5 |
| Albumin (g/dl) | 1.3-2.8 |
| Globulin (g/dl) | 1.5-4.1 |
| Total Cholesterol (mg/dl) | 86-211 |

Source: Pollock *et al*. (2001)

Total serum protein has been reported as an indication of the protein retained in the animal body (Akinola and Abiola, 1991; Esonu *et al*., 2001).

Table 6.0: Mean serum biochemical indices of *NaNa* and *nana* of indigenous chickens

| Genotype | Total Protein (g/dl) | Albumin (g/dl) | Globulins (g/dl) | Cholesterol (mg/dl) |
|---|---|---|---|---|
| ***NaNa*** | 4.63 | 3.48 | $1.15^{b}$ | 31.30 |
| ***nana*** | 4.81 | 3.28 | $1.53^{a}$ | 32.45 |

$^{ab}$ means within columns bearing different superscripts differ significantly ($p<0.05$).
Source: Ladokun *et al*. (2008)

Ladokun *et al*. (2008) in a study of haematological and serum biochemical indices of *NaNa* and *nana* indigenous chickens stated that the *nana* birds recorded a non-significantly ($p>0.05$) higher values of total protein and cholesterol compared to the *NaNa* ones (Table 6.0). There was a non-significantly ($p<0.05$) higher albumin level in the *NaNa* compared to the *nana* ones (Table 6.0). Globulin levels were significantly ($p<0.05$) higher in the *nana* compared to the *NaNa* genotype. The explanation given was that the higher values obtained for serum parameters were important in the proper maintenance of osmotic pressure between the circulating fluid and the fluid in the tissue spaces so that exchange of materials between the blood and cells could be facilitated. The higher globulin levels in normal plumage birds aids in better cell-mediated immune response.

Schmidt *et al*. (2007) reported that oviparous females show a marked increase in plasma protein just before egg production. This oestrogen-induced hyperproteinamia is associated with an increase in vitellogenin and lipoprotein, which are necessary for yolk production.

Galal *et al*. (2007) conducted a study to evaluate the effect of sex-linked dwarf (*dw*), autosomal naked neck (*Na*) and double segregation genes on haematological parameters of egg-type chicken under tropical conditions. The genotypes studied were *Dw-nana*, *dw-nana*, *Dw-Nana* and *dw-Nana*.

The *Dw-Nana* and *dw-Nana* recorded a significantly (*p<0.001*) higher albumen levels compared to the *Dw-nana* and *dw-nana* genotypes. The higher albumen level may serve as a major reservoir of protein and is involved in colloidal osmotic pressure, acid-phase balance and that it acted as a transport carrier for small molecules such as vitamins, minerals, hormones and fatty acids Margaret (2001). Galal *et al*. (2007) reported a non-significantly (*p>0.05*) higher total plasma protein in normal-size heterozygous naked neck (8.85±0.89 g/dl) birds compared to normal feathered (9.19±0.13 g/dl) ones.



This might be attributed to the acute phase of an immune response (hyper active of immunity system), where the liver cells produce and secrete Acute Phase Protein (APP), which gives protection to birds against infection or any invasion. Balnave, (2004) stated that the high total plasma protein shows the important role of globulins in terms of immunity.

El-Safty *et al*. (2006) studied the immunological and laying performance of two genotypes (heterozygous naked neck and normal feathered) under tropical conditions and reported that the *Nana* recorded a significantly (*p<0.05*) higher (1.57±0.20 mg/100ml) globulin concentration than their *nana* (1.01±0.16 mg/100ml) genotype. Also, serum parameters contribute to the viscosity and maintenance of normal blood pressure and pH. Globulins are composed of three fractions, designated alpha, beta and gamma. The alpha-globulins are a group of proteins manufactured almost entirely by the liver. Normally these proteins increase with acute nephritis, dehydration, severe active hepatitis, active usually systemic inflammation, malnutrition and in nephritis syndromes (Ladokun *et al*., 2008*).* A decrease in total protein could be attributed to liver disease, exudation due to severe skin lesions (burns) and excess fluid therapy (Margaret, 2001).

Galal *et al*. (2007) stated that the cholesterol level of the *Dw-nana* (201.5±5.69 mg/100dl), *dw-nana* (125.50±6.22 mg/100dl) were significantly (*p<0.001*) higher compared to that of *Dw-Nana* (119.50±6.50 mg/100dl) and *dw-Nana* (117.50±7.33 mg/100dl.

El-Safty *et al*. (2006) stated that the *Nana* had higher haematocrit (PCV) than their *nana* counterparts although the difference was not statistically significant (*p>0.05*). The higher haematocrit may enhance oxygen delivery to the tissues at lower temperature. Situations which decrease PCV concentration include acute or chronic blood loss, immune mediated disease and overzealous fluid therapy. They reported that shock (splenic contraction) and dehydration as factors which can increase PCV concentration.

Ladokun *et al*. (2008) reported that factors such as temperature and wind velocity could cause dehydration in the body cells of exposed body parts of avians.

Table 7.0: Mean haematological values of indigenous chickens.

| Genotype | PCV (%) | Hb (g/dl) | RBC ($\times 10^6$/ml) | WBC ($\times 10^3$/ml) |
|---|---|---|---|---|
| Naked neck, *NaNa* | $41.00^a$ | $13.68^a$ | $4.48^a$ | 4.32 |
| Normally feathered, *nana* | $35.90^b$ | $11.60^b$ | $4.21^b$ | 4.07 |
| SEM | 1.16 | 0.41 | 0.17 | 0.26 |

SEM: Standard error of means, $^{ab}$ means within columns bearing different superscripts differ significantly (*p<0.05*)
Source: Ladokun *et al*. (2008)

Homozygous naked necks (*NaNa*) had a higher average PCV, RBC and Hb values which differed significantly from the normal (*nana*) feathered ones (Table 7.0). Ladokun *et al*. (2008) and Galal *et al*. (2007) reported that the higher values in PCV recorded by the *NaNa* gene were due to the heavier body weights as a result of a reduction in heat load. This could be a boost to the growth and productive life of the *NaNa* birds.

## 2.4 The Frizzle (*F*, *mf*) gene

### 2.4.1 Phenotypic description of the frizzle feathered chicken

Frizzling is caused by a single incompletely dominant autosomal gene, *F*, restricted by an autosomal recessive modifier, *mf* (Hutt, 1949). This gene reduces the insulating properties of the feather cover (reduces feather weight) and makes it easier for the bird to radiate heat from the body (Gowe and Fairfull, 1995).

The frizzle (*F*) gene causes the contour feathers to curve outward away from the body. Unmodified homozygotes exhibit extreme recurving of the rachis of all feathers with extreme curling of barbs. The barbs are much curled so that no feather has a flat vane, and all are narrow. As a result, the adult in full plumage has a somewhat wooly appearance (Hutt, 1930). The feathers are broken off by the crowding of the birds at night and by the treading of the males in the breeding season (Hutt, 1930). Modified heterozygotes have less extreme frizzling in all parts of the body, and at maturity it may even be difficult to distinguish such birds from those not frizzled.

However, most of the barbs still show some curling of the barbs in the outer primaries, and the feathers on the neck are slightly raised, secondaries of such birds are usually almost normal, and the inner ones are least affected (Hutt, 1936). The unmodified heterozygous frizzles have body feathers the shafts of which are recurved so that the feathers curl toward the head or have their apices pointed outward in planes roughly perpendicular to the surface of the body (Hutt, 1949). The modifying gene lessens the extreme aspect of the homozygotes so that some birds are almost indistinguishable from the wild-type (Crawford, 1976).

### 2.4.2 Effect of the frizzle (*F*) gene on productivity

Adedeji *et al*. (2006) evaluated the growth performance of crossbred frizzle, normal feathered and exotic purebred (white leghorn) chickens under high temperature. The result of the study is shown in the Table 8.0.

Table 8.0: Effect of the frizzle (*F*) gene on body weight (g).

| Genotype | Age (weeks) | | | | |
|---|---|---|---|---|---|
| | Day old | 6 | 9 | 12 | 15 |
| Frizzle × White Leghorn | 35.10±0.75$^{b}$ | 169.03±8.42$^{a}$ | 366.46±4.11$^{a}$ | 625.52±5.93$^{a}$ | 1,030.43±15.86$^{a}$ |
| Full feathered × White Leghorn | 35.30±0.75$^{b}$ | 150.24±8.30$^{c}$ | 351.31±4.45$^{b}$ | 576.68±6.41$^{d}$ | 942.92±17.21$^{c}$ |
| White Leghorn× White Leghorn | 30.18±0.90$^{c}$ | 152.35±12.89$^{b}$ | 351.22±6.65$^{c}$ | 585.19±9.72$^{c}$ | 966.42±28.41$^{b}$ |

Source: Adedeji *et al*. (2006)

The frizzle significantly ($p<0.05$) recorded a significantly ($p<0.05$) heavier body weights at all ages compared to all other phenotypic groups with the exception of day old body weight They attributed the higher body weights of the frizzle birds to their feather structure which enhances heat dissipation. Chickens suffer at high ambient temperature due to the feather cover. The feather structure of the frizzle birds permits heat dissipation by allowing cool air to pass over the exposed body surface to reduce internal heat. As a result the frizzle bird is able to feed more compared to those stressed by heat and hence improve body weight.

In a related experiment to evaluate the growth performance of *nana* (normal feathered) and *nanaFf* (frizzle) chickens under moderate conditions, Mahrous *et al*. (2008) reported that *nana* birds recorded a significantly ($p<0.05$) lower day old body weight (28.25 g) compared to the *nanaFf* birds (29.63 g). At six weeks of age they reported that the *NanaFf* (289.27 g) weighed significantly ($p<0.05$) more than the frizzle (273.36 g) which weighed non-significantly ($p>0.05$) more than the normal feathered (274.36 g) ones.

Nasrollah (2008) studied the performance of pure indigenous strains in the tropics and reported that the heterozygous *Ff* (frizzle) had a significantly ($p<0.05$) higher average weight (625.52±5.93 g) at 12 weeks of age compared to the *nanaff* (607.85± 5.90). He concluded that the superiority of the frizzle birds over the normal feathered ones could be attributed to their feather distribution which aids in heat dissipation. At high ambient temperature chickens suffer from heat stress due to difficulty in heat dissipation. This consequently affects feed consumption and ultimately results in decrease in growth and productivity.

Garcês *et al*. (2001) evaluated the productive performance of birds with major feather genes and body size reduction *dw* (dwarf) in a dual-purpose strain under tropical conditions.

The results showed that at 18 weeks the *nana* recorded a non-significantly ($p>0.05$) higher (1,361 g) body weight compared to the *Ff* (1,329 g) bird. The two genotypes reached sexual maturity at the same age (156 days).

They concluded that the cooler nocturnal temperatures eased the effect of diurnal heat strain, to the effect that birds with major feather genes (frizzle) had no significant productive advantage over the normal ones.

Egg weight was, however, significantly ($p<0.05$) higher in *Ff* (58.7 g) birds compared to the normal feathered (57.3 g) ones. The higher egg weight of the frizzle layers was associated with its heavier body weight rather than an increase in synthesis of egg components.

With respect to body measurements, Fayeye *et al*. (2006) conducted a study to evaluate the effect of major feather genes on the body-size parameters. The results of the study showed that frizzle (10.2 cm) birds recorded significantly ($p<0.05$) longer shanks compared to naked neck (9.7 cm) and heterozygous frizzled-naked neck (9.7 cm) ones. A similar trend was observed for shank diameter. Frizzle birds were superior to their naked neck counterparts in all body size parameters except for body length and girth.

Peters *et al*. (2008) carried out a study to compare the fertility and hatchability levels of thirty (30) crossbred frizzle and thirty (30) normal feathered chickens under the prevailing conditions of Nigeria for a period of one month. The frizzle feathered sire group produced a significantly ($p<0.05$) high number of fertile eggs (620) compared to the normal feathered (515). Percent hatchability and fertility were, however, not significant ($p<0.05$) between the two genotypes. They attributed the better performance (high number of fertile eggs) of the frizzle feather (*Ff*) chickens to the positive adaptive genes affecting its thermoregulation ability.



Mérat (1990) reported the combination of the naked neck-frizzle genes showed best performance for all biological and economic efficiency traits. The advantage of the combination of naked neck and frizzle genes showed that egg weight was increased by 1.6% compared to the normal feathered chicken. The superior performance of the combination type under heat stress was explained by the additive effects of the two major feather genes.

The naked neck reduces feather cover by 20 to 30% together with curling of the feathers both of which aid in heat dissipation.

Adomako *et al*. (2009) compared the performance of naked neck, frizzle (*Nana* and *Ff*), normal feathered (*nanaff*) and *NanaFf* (heterozygous frizzled-naked neck) birds in the tropics. The results from the study revealed that the *NanaFf* recorded a significantly ($p<0.05$) higher feed conversion efficiency (FCE) compared to the *Nana* and *Ff* as well as the *nanaff* genotypes. They concluded that this was due to the effect of thermo-regulatory genes which improved conversion of feed into body tissues than their normal feathers counterparts.

### 2.4.3 Effect of the frizzle (*F*) gene on Feather pecking

Feather pecking is defined as pecking at and pulling out of feathers of other birds. Circulating hormone concentrations may play a role in the initiation of feather pecking and cannibalism (Ivar and Jan, 1968). Njenga *et al*. (2005) studied the behaviour of four local chicken of different genetic backgrounds; *nana* (normal feathered), *Na* (naked neck), *F* (frizzle) and *dw* (dwarf) and reported that frizzles were the only group of birds being pecked. They were severely pecked on the back and wings. Some frizzle birds lost the entire extreme part of the wing. The frequency of attack increased when the bird was bleeding. The susceptibility of the frizzle to be pecked was explained by the extreme exposure of the body surfaces of these birds. Homozygous frizzles are known to have extremely recurved rachis and barbs in all feathers, which are easily broken (Somes, 1990). Njenga *et al*. (2005) reported that birds with damaged feathers are more susceptible to feather pecking and injurious pecking.

Some researchers (Nthimo, 2004; Garcês *et al*., 2001) advocate the incorporation of the frizzle gene in commercial lines due to its heat tolerance in hot-humid climates, however, this might promote feather pecking and hence cannibalism.

## 2.5 The dwarf (*dw*) gene

### 2.5.1 Phenotypic description of the dwarf (*dw*) gene

The dwarf gene (*dw*) causes a reduction in body size and is an important factor of acclimatization to warm environments through heat loss by radiation on one hand and endogenous heat production on the other (Fairfull and Gowe, 1995). Dwarfism can be either sex-linked dwarfism, with three different alleles (*dw*, $dw^B$, $dw^M$) and autosomal dwarfism, (*adw*).

The sex-linked dwarfism, *dw*, is a recessive gene closely linked to the gold-silver and slow-feathering loci (Somes, 1990). Bantam dwarfism ($dw^B$) is a size reducing sex-linked

recessive gene, closely related to the sex-linked feathering locus and the effect of this gene is less than observed for sex-linked dwarfism. It reduces the female size by 5-11% when compared to normal (*Dw*) females (Njenga *et al*., 2005). Heterozygous males (*Dw-dw*$^{B}$) are reduced by about 5% while the homozygous dwarf males (*dwdw*) are reduced by 14%, when compared to normal size birds. MacDonald dwarfism (*dw*$^{M}$) gene is a single sex-linked recessive gene belonging to the same locus as *dw*, it is different from the *dw*$^{B}$, as the *dw*$^{B}$ gene only reduces female body weights by 10%, shank length by 5%, with birds generally appearing normal (Njenga *et al*. 2005). The *dw*$^{M}$ gene reduces female body weight by 13.5%, shank length by 9%, with birds being definitely distinguishable from the normal by their smaller sizes. The dominance relationship between the *dw*$^{M}$ and the other two recessive alleles is unknown (Somes, 1990). Gowe and Fairfull (1995) indicated that the main effect of the dwarf gene (*dw*) is to reduce the body weight of homozygous males by about 43% and that of homozygous females by 26 to 32%.

The autosomal gene for dwarfism, a*dw*, (Hutt, 1949; 1959) substantially reduces body size without adversely affecting viability or efficiency of reproduction.

The effect of this gene (*adw*) can be recognized during embryonic development (Cole, 2000). The adult dwarf is normal, except for a 30% reduction in body weight; whilst at the early age of 10 weeks, the dwarfs can usually be recognized by a combination of three criteria. These include low body weight, a somewhat shortened shank, and a compact conformation of the body (Hutt, 1959).

### 2.5.2 Effect of the dwarf (*dw*) gene on productivity

Yeasmin and Howlider (2002) conducted a study to examine the growth performance of autosomal dwarf chickens in the tropics.

They reported that the Deshi dwarf recorded a non-significantly ($p<0.05$) lower day old body weight (27.50 g) compared to the Deshi normal (30.30 g). They attributed the difference in day old body weight to the differences in the stock used in the matings.

The *dw* gene had no detectable effect on the weight of the day old chick (Hutt, 1949). Yeasmin and Howlider (1998) reported that birds with shank length of 6 cm or below are considered dwarfs whilst those with shanks above 6 cm are considered to be normal size.

Brody *et al*. (1984) showed that the reduction of live weight due to the *dw* gene in high and low body weight groups of chicken were 16.83% and 43.73%, respectively at 46 days of age indicating higher growth depression effect of *dw* gene in smaller breeds than that in heavier breeds. Significant differences were observed in shank length (cm) at 0, 4, 18 and 46 weeks between Deshi normal (1.96, 2.77, 7.64 and 7.89 cm) and Deshi dwarfs (1.25, 2.10, 4.47 and 4.55 cm), respectively. Mortality rate (%) was found to be significantly ($P<0.05$) less in Deshi dwarfs (15.20) compared to Deshi normal (16.65%) birds. The autosomal dwarf with a lower growth rate has a better chance to survive.

Yeasmin and Howlider (2002) found a reduced feed intake (7.75-39.20%) in pure breed × deshi dwarf crossbreds in comparison with pure breeds. They reported that the *dw* chicken ate 11.2-30.7% less feed than normal Starbro-4 between 9 and 65 weeks of age.

In general, the effect of the *adw* gene on body weight is similar in males and females, and results in a reduction of approximately 30% (Cole, 2000). The autosomal dwarfs perform similarly to the sex-linked dwarfs when compared with normal-sized controls.

Galal *et al*. (2007) evaluated the laying performance of egg-type chickens under prevailing conditions in the tropics and reported that the presence of the *dw* gene significantly ($p<0.01$) reduced egg mass, egg number and egg weight in dwarf birds compared to normal feathered birds. This was attributed to the lower body weight at sexual maturity.

However, the presence of the *dw* gene in a single manner or combined with the naked neck gene exhibited better effect on feed conversion ratio (Galal *et al*., 2007). Both types of dwarfs require a few extra days to reach maturity as measured by age at first egg. Consequently, body weight taken at a common age just prior to commencement of production would tend to decrease the estimated relative size of the dwarf, because the ovary and oviduct need further development (Cole, 2000).

The effect of the dwarfing gene on growth is clearly expressed by 6 weeks of age, when the dwarfs are reduced in weight compared with their normal but heterozygous sibs. The dwarfing gene significantly reduces body weight, shank length and keel length compared with normal feathered hens. The reduction in these body measurements was due to physiological and biochemical effects of the gene. Galal *et al*. (2007) discovered that the concentration of triiodothyronine (T3) circulating in the plasma of dwarf hens is significantly lower than in normal size birds. They recommended the introduction of the *Na* gene into dwarfing stock in order to improve body weight particularly at high environmental temperatures for the improvement of egg production.

# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

Two experiments (1 and 2) were conducted in the study. Experiment 1 was on the effect of genotype and length of storage on the fertility and hatchability of eggs produced from naked neck (*Nanaff*), frizzle (*nanaFf*), normal (*nanaff*) and double heterozygous frizzled-naked neck (*NanaFf*) hens. Experiment 2 examined the effect of these genotypes on body weight, egg production, haematological and serum biochemical parameters.



### 3.1Experiment 1

#### 3.1.1 Duration and Location of study

The experiment was conducted for a period of 17 weeks at the Poultry Section of the Department of Animal Science at the Kwame Nkrumah University of Science and Technology, Kumasi-Ghana. The area is located within the semi-deciduous humid forest zone of Ghana with an altitude of 261.4 m above sea level. The zone is characterized by a bimodal rainfall pattern with an annual rainfall of 1300 mm. The rainy season (62% of total precipitation) occurs from March to July and the dry season (38% of total precipitation) from November to February. Daily temperatures range from $20^0$C to $35^0$C with a mean of $26^0$C. The relative humidity varies from 97% during the early morning in the wet season to as low as 20% during the late afternoon in the dry season. The average photoperiod is 12 h. (Osafo, 1976).

#### 3.1.2 Genetic stock and management

At 36 weeks of age, thirty-three (33) crossbred $F_3$ females made up of three normal feathered (*nana*), four heterozygous frizzles (*Ff*), four heterozygous naked neck (*Nana*) and twenty two double heterozygous frizzled-naked neck (*Nana Ff*) birds were housed in four (4) separate deep litter pens provided with nests.

The chickens used in this study were the offspring of crosses between indigenous heterozygous naked neck (*Nana*), heterozygous frizzle (*Ff*) males and commercial Lohmann hybrid layers (Figure 1.0). Both the naked neck heterozygotes (*Nana*) and frizzle heterozygotes (*Ff*) were crossed with normal feathered (*nana*) Lohmann Brown classic layers in two separate matings producing offspring that were heterozygous for the naked neck gene (*Nanaff*), heterozygous for the frizzle gene (*nanaFf*) and those that had normal feathers (*nanaff*) in the first filial ($F_1$) generation (Figure 2.0).



Parents ♂ *Nanaff* × ♀ *nanaff*

$F_1$ generation

| | | male gamete | |
|---|---|---|---|
| | | *Naf* | *naf* |
| female gamete | *naf* | *Nanaff* | *nanaff* |
| | *naf* | *Nanaff* | *nanaff* |

Parents ♀ *nanaff* × ♂ *nanaFf*

$F_1$ generation

| | | male gamete | |
|---|---|---|---|
| | | *naF* | *naf* |
| | *naf* | *nanaFf* | *nanaff* |
| | *naf* | *nanaFf* | *nanaff* |

Figure 1.0: A diagrammatic illustration of $F_1$ generation

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.

Parent

♀ *nanaFf* × ♂ *Nanaff*

$F_2$ generation

| | | male gamete | |
|---|---|---|---|
| | | *Naf* | *naf* |
| female gamete | *naF* | *NanaFf* | *nanaFf* |
| | *naf* | *Nanaff* | *nanaff* |

Parent

♂ *nanaFf* × ♀ *Nanaff*

$F_2$ generation

| | male gamete | |
|---|---|---|
| | *naF* | *naf* |
| *Naf* | *NanaFf* | *Nanaff* |
| *naf* | *nanaFf* | *nanaff* |



Figure 2.0: A diagrammatic illustration of $F_2$ generation

The naked neck (*Nanaff*), frizzle (*nanaFf*), normal feathered (*nanaff*) and double heterozygous frizzled-naked necks (*NanaFf*) of the second filial generation ($F_2$) were selected and mated *inter se* (Figure 3.0), producing homozygous naked neck (*NaNaff*), heterozygous naked neck (*Nanaff*), homozygous frizzles (*nanaFF*), heterozygous frizzle (*nanaFf*), normal feathered (*nanaff*) and frizzled naked neck birds (*NaNaFf, NanaFF, NanaFf* and *NaNaFF*) as the third filial ($F_3$) generation.

The homozygous naked neck (*NaNaff*), heterozygous naked neck (*Nanaff*), homozygous frizzle (*nanaFF*), heterozygous frizzle (*nanaFf*), normal feathered birds (*nanaff*), double homozygous frizzled-naked neck (*NaNaFF*) and double heterozygous frizzled-naked neck (*NanaFf*) birds of the $F_3$ generation were selected for the research.

Heterozygous naked neck parents

♂ ♀

*Nanaff* × *Nanaff*

$F_3$ generation

| | | male gamete | |
|---|---|---|---|
| | | *Naf* | *naf* |
| female gamete | *Naf* | *NaNaff* | *Nanaff* |
| | *naf* | *Nanaff* | *nanaff* |

Heterozygous frizzle parents

♀ ♂

*nanaFf* × *nanaFf*

$F_3$ generation

| | | male gamete | |
|---|---|---|---|
| | | *naF* | *naf* |
| female gamete | *naF* | *nanaFF* | *nanaFf* |
| | *naf* | *nanaFf* | *nanaff* |

Heterozygous frizzled-naked neck parents

♂ ♀

*NanaFf* × *NanaFf*

$F_3$ generation

| | | male gamete | | | |
|---|---|---|---|---|---|
| | | *NaF* | *Naf* | *naF* | *naf* |
| female gamete | *NaF* | *NaNaFF* | *NaNaFf* | *NaNaFF* | *NanaFf* |
| | *Naf* | *NaNaFf* | *NaNaff* | *NanaFf* | *Nanaff* |
| | *naF* | *NanaFF* | *NanaFf* | *nanaFF* | *nanaFf* |
| | *naf* | *NanaFf* | *Nanaff* | *nanaFf* | *nanaff* |

Normal feathered parents

♂ ♀

*nanaff* × *nanaff*

$F_3$ generation

| | | male gamete | |
|---|---|---|---|
| | | *naf* | *naf* |
| female gamete | *naf* | *nanaff* | *nanaff* |
| | *naf* | *nanaff* | *nanaff* |



Figure 3.0: A diagrammatic illustration of $F_3$ generation

### 3.1.3 Feeding and water provision

Feed and water were provided *ad libitum*. Commercial concentrate was obtained from AGRICARE Ghana Limited, a commercial feed mill company based in Kumasi. Chicks, growers and laying birds were fed diet containing 20%, 15% and 17% CP and 2900, 2650 and 2,700ME (Kcal/kg) respectively from day old to the 36$^{th}$ week of age. The birds were allowed a two (2) week adjustment period before egg collection began. Table 9.0 shows the rate of inclusion of the experimental diets.

Table 9.0: Composition of experimental diets

| Ingredient | Phase of growth | | |
|---|---|---|---|
| | Chick | Grower | Layer |
| Concentrate (20%) | | | 20 |
| Concentrate (30%) | 30 | 30 | |
| Maize | 55 | 45 | 50 |
| Wheat bran | 15 | 25 | 20 |
| Oyster shells | | | 10 |
| Total | 100 | 100 | 100 |

### 3.1.4 Egg collection and incubation

Eggs were collected and selected daily (discarding small, very small, very large, crack, blood stained or dirty eggs) from all the genotypes and stored under room temperature. Storage room temperature was recorded using a dry bulb thermometer. Eggs collected were identified using a marker so that eggs from each cross could be traced and set in their respective trays in the incubator. The eggs were incubated and hatched at Fairway hatchery Limited (private hatchery) based in Kumasi. The incubation was done weekly for fifteen consecutive times. Proper cleaning, disinfection and fumigation were carried out before setting of eggs in the chick master incubators (Model 99, USA). Eggs were placed in the incubators with the broad ends up. The temperature and relative humidity were automatically maintained at $37^0$C and 60-65% respectively.

The eggs were turned automatically through $90^0$ in the setter. On the $18^{th}$ day of incubation the eggs were candled to identify and remove infertile eggs. The remaining eggs were transferred to the hatcher.

The records kept were

1) Percentage fertility
2) Percentage hatchability of fertile eggs
3) Percentage hatchability of total eggs set

(%) fertility as determined by candling was calculated as: $\frac{\text{Total number of fertile eggs}}{\text{Total number of eggs set}} \times 100$

(%) hatchability of fertile eggs was calculated as: $\frac{\text{Total chicks hatched}}{\text{Total number of fertile eggs}} \times 100$

(%) Hatchability of total eggs set was calculated as: $\frac{\text{Total chicks hatched}}{\text{Number of total eggs set}} \times 100$

### 3.1.5 Data Analysis

The following model was used to determine the effect of genotype (4) and length of storage (days) and their interaction on fertility and hatchability.

$Y_{ijk} = \mu + G_i + L_j + (G \times L)_{ij} + e_{ijk}$

Where:

$Y_{ijk}$ is the observation of the $k^{th}$ population of $i^{th}$ genotype and $j^{th}$ batches.

$\mu$ is the overall general mean

$G_i$ is the fixed effect of $i^{th}$ genotype (I = 1, 2, 3, 4)

$L_j$ is the random effect of $j^{th}$ batch (j = 1, 2, 3, 4, 5, 6, 7)

G×L is interaction effect on fertility and hatchability

$e_{ijk}$ is the random error

### 3.1.6 Experimental Design and Statistical Analysis

The experimental design was a four (4) by seven (7) factorial in a randomized complete block design (RCBD) with 15 hatches as blocks. Means and associated standard errors for measured parameters were computed. Analysis of variance (ANOVA) was carried out using GenStat (2008) version 7.22 DE for windows and differences between means were detected using the Least Significance Difference (LSD) at a probability of 5%.

## 3.2 Experiment 2

### 3.2.1 Duration and location of experiment

Experiment 2 was conducted for a period of 35 weeks at the department of Animal Science, Kwame Nkrumah University of Science and Technology, Kumasi. The data used in this study were obtained from Experiment 1.

### 3.2.2 Climate and Relative Humidity of study area

Daily ambient temperature and Relative Humidity (RH) values were obtained from the Kwame Nkrumah University of Science and Technology meteorological station situated on the premises of the Poultry Section of the Department of Animal science from the beginning to the end of the experimental period. Both ambient temperature and relative humidity values were read at 9:00am and 15:00 pm daily.



### 3.2.3 Experimental flock

A total 199 day-old pullets hatched in six (6) weekly batches and wing banded were utilized in the study. The genetic groups contributed different numbers of chicks thus resulting in unequal sample sizes (Table 10.0).

Comb sexing was employed from the third to the sixth week. Data were collected on the females from day old till they were 35 weeks old.

Table 10.0 Genetic structure and sizes of experimental flock

| Phenotypic classification | Genetic specification | Number of birds |
|---|---|---|
| Normal feathered | *nanaff* | 29 |
| Homozygous Frizzle | *nanaFF* | 27 |
| Heterozygous Frizzle | *nanaFf* | 28 |
| Homozygous naked neck | *NaNaff* | 31 |
| Heterozygous naked neck | *Nanaff* | 28 |
| Double homozygous frizzled-naked neck | *NaNaFF* | 29 |
| Double heterozygous frizzled-naked neck | *NanaFf* | 27 |
| Total | | 199 |

### 3.2.4 Management of flock

#### 3.2.4.1 Chick Rearing

After hatching, each batch was brooded Electric bulbs (150W) were used to provide light and heat for chicks. Glucose was administered via drinking water. Temperature (28-33$^0$C) and ventilation were regulated. Prophylactic treatment against bacterial infections (antibiotics) were administered using Enrofloxacin (Hipra, Spain) for three (3) days. After brooding chicks were housed in six deep litter pens measuring 2 m × 1.1 m with a floor space of 2.2 m$^2$ for the growing phase. Thirty (30) birds were allotted to a pen. The pens were thoroughly cleaned and disinfected. Wood shavings were spread on the floor (10-15cm) to serve as litter for the birds. At 20 weeks of age the birds were transferred to battery cages where two (2) hens were put in a cell.

#### 3.2.4.2 Feeding of experimental birds

*Ad libitum* feeding using a commercial starter concentrate was employed during the first 8 weeks of age. Maize and wheat bran were added to the concentrate based on the recommended proportions of inclusion (Agricare Feed Mills Limited, Kumasi) to form a starter diet of (20% CP). During the growing and laying phases, the hens were fed diets containing 15% and 17% CP respectively after recommended proportions of maize and wheat bran have been added to a commercial concentrate.

#### 3.2.4.3 Disease and parasitic control

The birds were vaccinated against Gumboro, Newcastle and Fowl pox diseases. Coccidiostats were administered for three (3) consecutive days every week until the 12$^{th}$ week. Antibiotics were also offered for three consecutive days every month during the same period. Vitamins were also offered during periods of stress (mostly when the birds were transferred or vaccinated). Lice and worms were controlled using ivermectin (kepromec, Netherlands).

### 3.2.5 Parameters measured

#### 3.2.5.1 Body weight, Body measurements and body temperature measurement

Body weight (grams), shank length (cm) and shank diameter (mm) were individually recorded for each hen of each genotype from day-old to the 18$^{th}$ week at 3 week intervals. Body weight was measured using a sensitive 5kg Japanese (CS-2000WP) made kitchen scale (sensitivity of 0.01 g).

The wings of the bird were twisted and placed on the top of the scale. The measured weight was recorded for each of the birds.

Body weight gain was calculated at three week intervals. Shank length was determined on live birds by measuring the length of the tibio-tarsus (from the top of the hock joint to the foot pad) with a pair of dividers and the measurement read from a ruler as described by (Nwachukwu *et al*., 2006). Shank diameter was measured, as the diameter of the tarso-metatarsus just below the spur, with a vernier caliper. As shank diameter is not cylindrical, two shank diameters were measured-one from the front of the shank and the other from its sides and the average calculated. Also, rectal temperature was measured by inserting the rod of a digital thermometer 3 mm inside the cloaca.

#### 3.2.5.2 Age at sexual maturity

The age at first egg per each genotypic group was considered as the age at sexual maturity.

#### 3.2.5.3 Egg production

Hen day production was recorded over a period of 15 weeks of laying (from 20$^{th}$ to 35$^{th}$ week). The eggs were individually weighed to the nearest 0.1g for each genotypic group throughout the experimental period of 15 weeks.

Hen-Day egg production was also calculated for each genotypic group during the experimental period. Culled birds as well as mortalities were also taken into consideration.

Hen day production = $\frac{\text{No. of eggs produced}}{\text{No. of live hens}} \times 100$

**3.2.5.4 Determination of blood parameters**

At 20 weeks of age, two (2) birds per genotypic group (7) were randomly selected from the six (6) hatches. Some blood parameters were determined on a total of 84 hens (12 per genotypic group, normal feathered (*nana*), homozygous naked neck (*NaNa*), heterozygous naked neck (*Nana*), homozygous frizzle (*FF*), heterozygous frizzle (*Ff*), double homozygous frizzled-naked neck (*NaNaFF*) and double heterozygous frizzled-naked neck (*NanaFf*). The birds were given neither food nor water for a period of 24 hours. After removal of feathers around the wing vein, a sterile cotton swab soaked in 70% ethanol was used to slightly dilate the vein prior to bleeding.

Blood samples were obtained by puncturing the brachial vein of the underside of the web of the wing and 1.0 ml blood was drawn from each hen using syringes and transferred rapidly into appropriate blood tubes pretreated with EDTA (Ethylene-diamine-tetra acetic acid) an anticoagulant.

All haematological parameters were determined within an hour of sample collection. Red blood cell (RBC), white blood cell (WBC), haemoglobin (Hb) and packed cell volume (PCV) values were determined using a haemoanalyzer.

A portion of each blood sample was drawn onto a glass slide to make thick and thin films for the examination of blood parasites. The blood films were fixed with methylated spirit to preserve the structures in the blood film. The films were then stained with Geimsa stain for 10 minutes, washed under slow running tap water and dried. The blood films were examined under a microscope for blood parasites. The blood samples were centrifuged at 500 rpm (revolution per minute) for 3 minutes in a macro centrifuge to generate serum for biochemical analysis. The serum was kept frozen until further analysis.

The frozen plasma was allowed to thaw prior to analysis and the thawed plasma was pipetted into dry clean bottles and stored at -20$^0$C. Total protein, albumin, globulins and total cholesterol were analyzed using a spectrophotometer at a wavelength of 500nm. Globulin level was calculated as the difference between total plasma protein and albumin. The procedure used for blood sample collection was described by Schmidt *et al* (2007).

### 3.2.6 Data Analysis

The following linear model was used to determine the effect of genotype and month of lay on rate of lay and average egg weight.

$Y_{ijk} = \mu + G_i + L_j + (G \times L)_k + e_{ijk}$

Where:

$Y_{ijk}$ is the observation of the $k^{th}$ population of $i^{th}$ genotype and $j^{th}$ months.

$\mu$ is the overall general mean

$G_i$ is the fixed effect of $i^{th}$ genotype (I = 1, 2, 3, 4)

$L_j$ is the fixed effect of $j^{th}$ month (j = 1, 2, 3, 4)

G×L is the fixed effect of $k^{th}$ interaction of average egg weight or rate of lay.

$e_{ijk}$ is the random error

### 3.2.7 Experimental Design and Statistical Analysis

A Randomized Complete Block Design (RCBD) was used with genetic groups as treatment and hatches as blocks. Analysis of variance (ANOVA) for RCBD was carried out using GenStat (2008) version 7.22 DE for windows and differences between means were detected using the Least Significance Difference (LSD).

# CHAPTER FOUR

## 4.0 RESULTS

### 4.1 Experiment one (1)

#### 4.1.1 The effect of the *Na* and *F* genes on fertility and hatchability

Table 11.0 shows the fertility and hatchability of eggs as affected by the various genotypes studied.

Table 11.0: The effect of *Na* and *F* genes on fertility and hatchability.

| Genotype | Fertility (%) | Hatchability of fertile eggs (%) | Hatchability of egg set (%) |
|---|---|---|---|
| *Na_F_* | 90.48[a] | 79.90[ab] | 69.20[b] |
| *Na_* | 91.67[a] | 77.00[b] | 69.00[b] |
| *nanaff* | 86.48[b] | 81.60[ab] | 75.90[ab] |
| *F_* | 94.39[a] | 86.70[a] | 82.40[a] |
| SEM | 5.13 | 6.98 | 7.12 |
| LSD | 5.40 | 7.34 | 7.48 |

[a, b,] and [ab] means within the same column bearing different superscripts are significantly different ($p<0.05$); LSD: Least Significance Difference; SEM: Standard Error of Means

The *F_* (frizzle), *Na_* (naked neck) and *Na_F_* (homozygous frizzled-naked neck) hens recorded significantly ($p<0.05$) higher mean percent fertility values (Table12.0) than their normal feathered counterparts.

Average values for hatchability of fertile eggs were significantly ($p<0.05$) higher for *F_* (frizzle) hens than for birds carrying the *Na_* gene (naked neck) but the differences between these two and the other genotypes were not statistically significant ($p>0.05$).

The average value for hatchability of eggs set was significantly ($p<0.05$) higher for *F_* (frizzle) hens than for both the *Na_* (naked neck) and the *Na_F_* (frizzled-naked neck) hens

but it was not significantly ($p<0.05$) different from the value for their *nanaff* (normal feathered) counterparts.

### 4.1.2 Fertility of eggs as affected by genotype and length of storage

There was generally a decline in percentage fertility with an increase in the length of storage period of eggs (Table 12.0). The average fertility of eggs that were stored for more than three (3) days did not significantly ($p>0.05$) differ among the genotypes.



Table 12.0: Percentage fertility of eggs as affected by genotype and length of storage.

| Genotype | Length of egg storage (days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Av. value |
| *Na_F_* | 92.07$^{ab}$ | 86.97$^{a}$ | 86.13$^{ab}$ | 87.09$^{a}$ | 88.79$^{a}$ | 81.03$^{a}$ | 79.90$^{a}$ | 85.9$^{a}$ |
| *Na_* | 78.57$^{b}$ | 96.43$^{a}$ | 83.93$^{b}$ | 88.09$^{a}$ | 85.12$^{a}$ | 89.29$^{a}$ | 83.93$^{a}$ | 86.4$^{a}$ |
| *nanaff* | 90.48$^{ab}$ | 88.09$^{a}$ | 100$^{a}$ | 97.62$^{a}$ | 90.48$^{a}$ | 94.05$^{a}$ | 80.95$^{a}$ | 91.6$^{a}$ |
| *F-* | 100$^{a}$ | 100$^{a}$ | 97.62$^{ab}$ | 96.43$^{a}$ | 92.86$^{a}$ | 94.05$^{a}$ | 79.76$^{a}$ | 94.3$^{a}$ |
| SEM | | | | 5.14 | | | | |
| LSD | | | | 14.29 | | | | |

$^{a, b,}$ and $^{ab}$ means within the same column bearing different superscripts are significantly different ($p<0.05$); LSD: Least Significance Difference; SEM: Standard Error of Means, Av= Average

The *nanaff* (normal feathered) birds produced eggs with a significantly ($p<0.05$) higher mean fertility value than those produced by the *Na_* (naked neck) hens when the eggs were stored for three days (Table 13.0). A significant ($p<0.05$) difference was also observed between *F_* (frizzle) and *Na_* (naked neck) birds in terms of fertility of eggs stored for a day. However, differences that were observed between frizzle (*F_*) and their frizzled-naked neck (*Na_F_*) counterparts were statistically not significant ($p>0.05$).

### 4.1.3 Hatchability of eggs set as affected by genotype and length of storage

The effect of genotype and length of storage on the hatchability of eggs set are indicated in Table 13.0.

Table 13.0: Hatchability (%) of eggs as affected by genotype and length of storage

| Genotype | Length of storage of eggs (days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Av. value |
| *Na_F_* | 79.1[a] | 75.9[a] | 69.5[b] | 72.4[b] | 68.1[a] | 67.0[bc] | 51.5[ab] | 69.0[a] |
| *Na_* | 72.0[a] | 83.3[a] | 75.6[ab] | 70.2[b] | 67.3[a] | 55.4[c] | 59.5[a] | 69.0[a] |
| *nanaff* | 69.0[a] | 78.6[a] | 94.0[a] | 95.2[a] | 79.8[a] | 77.4[ab] | 36.9[b] | 75.8[a] |
| *F-* | 78.6[a] | 94.6[a] | 88.1[ab] | 88.1[ab] | 76.2[a] | 92.3[a] | 58.9[a] | 82.4[a] |
| SEM | 7.12 | | | | | | | |
| LSD | 19.80 | | | | | | | |

[a, b and ab] means within the same column bearing the same superscripts are significantly different ($p<0.05$);LSD: Least Significance Difference; SEM: Standard Error of Means, Av= Average

With respect to hatchability of eggs set the average values produced by the *F_* (frizzle) and *Na_* (naked neck) hens differed significantly ($p<0.05$) from the average hatchability values recorded for the *nanaff* (normal feathered) hens for eggs stored for seven (7) days (Table 14.0).

When the eggs were stored for six (6) days, the average hatchability values of eggs set was significantly ($p<0.05$) higher for *F_* (frizzle) birds than for the *Na_* (naked neck) and the *Na_F_* (frizzle-naked neck) genotypes. For the same period, there was also a significant ($p<0.05$) difference between the average hatchability of eggs set obtained for the *nanaff* (normal feathered) and the *Na_* (naked neck) hens but the values for these two genotypes were not significantly ($p>0.05$) different from the mean value recorded for *Na_F_* (frizzled-naked neck) eggs.

The mean hatchability of eggs set values recorded for the *nanaff* birds (95.2%) were significantly higher than the values for both the *Na_* (70.2%) and *Na_F_* (72.4%) birds for eggs stored for four days (Table 14.0). Eggs from the *nanaff* birds stored for three days had significantly ($p<0.05$) higher hatchability values than eggs from *Na_F_* hens. No significant ($p>0.05$) differences were observed in hatchability values among all the genotypes regarding eggs stored for one (1), two (2) or five (5) days.

### 4.1.4 Hatchability of fertile eggs as affected by genotype and length of storage

Generally, hatchability of fertile eggs was higher in eggs produced by the *F_* (frizzle) and *nanaff* (normal feathered) hens compared to *Na_* (naked neck) and *Na_F_* (frizzled-naked neck) hens (Table 14.0). Eggs produced by the *F_* hens had a significantly ($p<0.05$) higher average hatchability level than eggs produced by the *Na_* (naked neck) hens when stored for six (6) days but the value did not differ significantly ($p<0.05$) from those of the other genotypes.

The average hatchability of fertile eggs values was significantly ($p<0.05$) higher for *nanaff* hens than for *Na_* hens for eggs stored for four (4) days. Eggs produced by hens of the various genotypes studied did not significantly differ from each other in average hatchability values when the eggs were stored for 1, 2, 3 or 5 days.

Table14.0: Hatchability (%) of fertile eggs as affected by genotype and length of storage.

| Genotype | Length of storage of eggs (days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Av. value |
| *Na_F_* | 84.7[a] | 87.1[a] | 80.8[a] | 83.3[ab] | 77.1[a] | 83.2[ab] | 63.4[ab] | 79.9[a] |
| *Na_* | 84.5[a] | 85.7[a] | 84.5[a] | 75.0[b] | 73.8[a] | 66.1[b] | 69.0[a] | 76.9[a] |
| *nanaff* | 78.6[a] | 90.5[a] | 94.0[a] | 97.6[a] | 83.3[a] | 82.1[ab] | 45.2[b] | 81.6[a] |
| *F-* | 78.6[a] | 94.6[a] | 90.5[a] | 91.7[ab] | 83.3[a] | 98.2[a] | 70.2[a] | 86.7[a] |
| SEM | 6.98 | | | | | | | |
| LSD | 19.42 | | | | | | | |

[a, b and ab] means within the same column bearing the same superscripts are significantly different ($p<0.05$); LSD: Least Significance Difference; SEM: Standard Error of Means, Av= Average

## 4.2 Experiment two

### 4.2.1 Body Weight (g)

Table 15.0 shows the body weights of birds of the various phenotypic groups from day old to the eighteenth (18) week of age.

Table15.0: Effect of the naked neck (*Na*) and frizzle (*F*) genes on body weight (g).

| Parameters | Genotype | | | | | | | SEM | LSD |
|---|---|---|---|---|---|---|---|---|---|
| | *nanaff* | *nanaFF* | *nanaFf* | *NaNaff* | *Nanaff* | *NaNaFF* | *NanaFf* | | |
| Body weight at day-old | 33.57[b] | 30.74[c] | 30.55[c] | 34.07[ab] | 35.86[a] | 32.84[b] | 33.02[b] | 0.74 | 2.07 |
| Body weight at 3 weeks | 114.7[a] | 106.5[ab] | 106.2[ab] | 110.1[ab] | 113.9[a] | 103.1[b] | 107.8[ab] | 3.16 | 8.84 |
| Body weight at 18 weeks | 1127.0[a] | 900.0[c] | 982.0[b] | 1062.0[a] | 1080.0[a] | 928.0[bc] | 1063.0[a] | 26.70 | 74.7 |

[a, b, c and abc,] means within the same row bearing the same superscripts are significantly different ($p<0.05$); LSD: Least Significance Difference; SEM: Standard Error of Means

#### 4.2.1.1 Day-old Body Weight

At day-old, the *Nanaff* (heterozygous naked neck) chicks had a significantly ($p<0.05$) higher average body weight compared to the other genotypes except the *NaNaff* (homozygous naked neck) chicks but the *NaNaff* chicks did not significantly differ from the *nanaff* (normal feathered) ones (Table 15.0) and any of the chicks that showed the naked neck and frizzle phenotypes together (*NaNaFF* and *NanaFf*).

The *nanaff* chicks and the chicks that showed naked neck and frizzle phenotypes together also differed significantly ($p<0.05$) from birds carrying only the frizzling genes (Table 15.0).

#### 4.2.1.2 Body weight at three weeks of age

At three weeks of age, the *nanaff* (normal feathered) and *Nanaff* (heterozygous naked neck) birds recorded a significantly ($p<0.05$) higher body weights (Table 15.0) than their double homozygous frizzled-naked neck (*NaNaFF*) birds.

Table 16.0 shows the maximum and minimum temperatures as well as the relative humidity (RH) values recorded during the 18-week period of growth.

Table 16.0: Ambient temperature and relative humidity during growing period

| Parameter | 3 weeks | 6 weeks | 9 weeks | 12 weeks | 15 weeks | 18 weeks |
|---|---|---|---|---|---|---|
| Average Temperature ($^{o}$C) | 28.1 | 27.5 | 26.8 | 26.3 | 25.8 | 25.4 |
| Maximum Temperature ($^{o}$C) | 33.3 | 32.4 | 31.1 | 30.2 | 29.8 | 29.7 |
| Minimum Temperature ($^{o}$C) | 22.9 | 22.7 | 22.4 | 22.3 | 21.8 | 21.0 |
| Relative Humidity (%) | 81 | 83 | 85 | 88 | 88 | 88 |

### 4.2.1.3 Body weight gain (BWG)

The body weight gains (BWG) of the various phenotypic groups have been indicated in Table 17.0.

Table 17.0: Body weight gains of birds as affected naked neck (*Na*) and frizzle (*F*) genes

| Parameters | ***nanaff*** | ***nanaFF*** | ***nanaFf*** | ***NaNaff*** | ***Nanaff*** | ***NaNaFF*** | ***NanaFf*** | SEM | LSD |
|---|---|---|---|---|---|---|---|---|---|
| Average Daily weight gain (g) | $8.68^{a}$ | $6.90^{d}$ | $7.55^{bc}$ | $8.13^{ab}$ | $8.29^{a}$ | $7.10^{cd}$ | $8.18^{a}$ | 0.21 | 0.59 |
| Weight gain (day 1- 3rd wk) | $81.2^{a}$ | $75.7^{ab}$ | $75.6^{ab}$ | $76.0^{ab}$ | $78.0^{ab}$ | $70.3^{b}$ | $74.8^{ab}$ | 2.93 | 8.20 |
| Weight gain (3rd-6th wk) | $169.0^{a}$ | $143.1^{b}$ | $154.8^{ab}$ | $168.5^{a}$ | $170.8^{a}$ | $153.2^{ab}$ | $160.7^{ab}$ | 8.46 | 23.70 |
| Total weight gain (day1-18th wk) | $1093.5^{a}$ | $869.1^{c}$ | $951.6^{b}$ | $1027.9^{a}$ | $1044.1^{a}$ | $895.3^{bc}$ | $1030.0^{a}$ | 26.45 | 74.11 |

a, b, c,ab, and bc, means within the same row bearing the different superscripts are significantly (*p<0.05*) different; LSD: Least Significance Difference; SEM: Standard Error of Means

### 4.2.1.4 Average Daily Weight Gain

Average Daily Weight Gain (ADWG) was significantly (*p<0.05*) better in *nanaff* (normal feathered), *NaNaff* (homozygous naked neck), *Nanaff* (heterozygous naked neck) as well as the *NanaFf* (double heterozygous frizzled-naked neck ) birds compared to all other genotypes except the *nanaFf* (heterozygous frizzle) whose ADWG did not differ significantly (*p<0.05*) from that of the *NaNaff* (Table 17.0). Differences that were observed among all other genotypes were not-significant (*p<0.05*). Average Daily Weight Gain was statistically higher (*p<0.05*) in *nanaFf* (heterozygous frizzle) than *nanaFF* (homozygous frizzle) but neither of them differed significantly (*p<0.05*) from the *NaNaFF* (double homozygous frizzled-naked neck) birds.

### 4.2.1.5 Body weight gain from day one to third week

The *nanaff* (normal feathered) birds recorded a significantly (*p<0.05*) better weight gain from day 1 to three (3) weeks of age compared to the *NaNaFF* ones (Table 17.0).

#### 4.2.1.6 Body weight gain from day one to eighteen weeks of age

No significant ($p>0.05$) differences were observed among *nanaff* (normal feathered) , *NaNaff* (homozygous naked neck), *Nanaff* (heterozygous naked neck) and *NanaFf* (double heterozygous frizzled-naked neck) in body weight gains between day old and 18 weeks of age although the *nanaff* had the highest body weight gain. These genotypes however, differed significantly ($p<0.05$) from all other genotypic groups. There was a significant ($p<0.05$) difference between *nanaFF* and *nanaFf* but the latter did not differ significantly ($p<0.05$) from the *NaNaFF* (double homozygous frizzled-naked neck) (Table 17.0).



### 4.2.2 Body measurement

#### 4.2.2.1 Shank length and diameter of naked neck and frizzle birds

Table 18.0 shows the shank length and diameter measurement for the genotypic groups from the 9th to the 18th week of age.

Table 18.0: Shank length and diameter of birds as affected by naked neck (*Na*) and frizzle (*F*) genes

| | week | *nanaff* | *nanaFF* | *nanaFf* | *NaNaff* | *Nanaff* | *NaNaFF* | *NanaFf* | SEM | LSD |
|---|---|---|---|---|---|---|---|---|---|---|
| Shank length (cm) | 9 | $6.53^{a}$ | $6.07^{b}$ | $6.30^{ab}$ | $6.42^{a}$ | $6.55^{a}$ | $6.35^{a}$ | $6.44^{a}$ | 0.09 | 0.25 |
| | 12 | $7.29^{a}$ | $6.64^{b}$ | $6.75^{b}$ | $7.15^{a}$ | $7.12^{a}$ | $7.16^{a}$ | $7.22^{a}$ | 0.09 | 0.26 |
| | 15 | $8.03^{a}$ | $7.36^{d}$ | $7.68^{c}$ | $7.96^{ab}$ | $7.96^{ab}$ | $7.77^{bc}$ | $8.00^{a}$ | 0.11 | 0.21 |
| | 18 | $8.2^{ab}$ | $7.70^{d}$ | $7.95^{c}$ | $8.25^{ab}$ | $8.31^{a}$ | $8.05^{bc}$ | $8.29^{a}$ | 0.08 | 0.22 |
| Shank Diameter | 9 | $0.66^{ab}$ | $0.61^{c}$ | $0.63b^{c}$ | $0.66^{ab}$ | $0.68^{a}$ | $0.67^{a}$ | $0.67^{a}$ | 0.01 | 0.03 |
| | 12 | $0.77^{a}$ | $0.70^{c}$ | $0.73^{bc}$ | $0.76^{ab}$ | $0.77^{a}$ | $0.76^{ab}$ | $0.77^{a}$ | 0.01 | 0.03 |
| | 15 | $0.84^{a}$ | $0.78^{c}$ | $0.80^{bc}$ | $0.82^{ab}$ | $0.83^{ab}$ | $0.82^{ab}$ | $0.85^{a}$ | 0.01 | 0.03 |
| | 18 | $0.89^{a}$ | $0.88^{c}$ | $0.85^{bc}$ | $0.87^{ab}$ | $0.90^{a}$ | $0.87^{ab}$ | $0.90^{a}$ | 0.001 | 0.03 |

$^{a,b,ab,bc}$ means within the same row bearing different superscripts are significantly different ($p<0.05$); LSD: Least Significance Difference; SEM: Standard Error of Means

#### 4.2.2.2 Shank length and diameter at nine weeks of age

At 9 weeks of age, there were significant ($p<0.05$) differences in shank length between *nanaFF* (homozygous frizzle) and all other genotypes except the *nanaFf* (heterozygous frizzle). With respect to shank diameter values, the *nanaFF* differed significantly ($p<0.05$) from all other genotypes except the *nanaFf* which also differed significantly ($p<0.05$) from all other genotypes except the *nanaff*, and the *NaNaff* genotypes (Table 18.0).

#### 4.2.2.3 Shank length and diameter at twelve weeks of age

Shank length was significantly ($p<0.05$) shorter in both the *nanaFF* and *nanaFf* (homozygous and heterozygous frizzles) compared to all other genotypes. All other genotypes had similar ($p>0.05$) shank lengths. There was a significant difference between the *nanaFF* and all other genotypes except the *nanaFf* with respect to average shank diameter values but the differences between the latter and the *NaNaff* as well as the *NaNaFF* genotypes were not significantly ($p>0.05$) different (Table 18.0).

#### 4.2.2.4 Shank length and diameter at fifteen weeks of age

Shank length differed significantly ($p<0.05$) between the *nanaFf* and all other genotypes except the *NaNaFF* hens which also differed significantly from the *nanaff* and *NanaFf* ones (Table 18.0). Differences that were observed between the *nanaFF* (homozygous frizzle) and all other genotypes were statistically ($p<0.05$) significant. A similar trend was observed for shank diameter but in this case the *nanaFF* did not differ significantly from the *nanaFf*. There was a significant ($p<0.05$) difference between *nanaFf* and *nanaff* as well as *NanaFf* hens.

#### 4.2.2.5 Shank length and diameter at eighteen weeks of age

At 18 weeks of age the average shank length of the *nanaFf* (heterozygous frizzle) hens were significantly ($p<0.05$) shorter than all other genotypes except *NaNaFF* (double homozygous frizzled-naked neck) birds which did not differ from the *nanaff* and *NaNaff* genotypes.

The *nanaFf* however, recorded a significantly ($p<0.05$) longer shank lengths than the *nanaFF* hens which had significantly shorter shank lengths than all other birds.

The *nanaff* (normal feathered), the *Nanaff* (heterozygous naked neck) and the *NanaFf* (double heterozygous frizzled-naked neck) birds recorded significantly ($p<0.05$) longer shank lengths than the *nanaFF* and the *nanaFf* but the latter did not significantly ($p<0.05$) differ from the *NaNaff* and the *NaNaFF* ones (Table 18.0).

### 4.2.3 Egg Production Parameters

Egg production parameters of the different phenotypic groups are shown in figures 4.0 to 6.0.

The *nanaff* (normal feathered) birds laid eggs significantly ($p<0.05$) earlier than all the genotypes. The *Na_* (naked neck) birds also reached dropped eggs significantly earlier than the *F_* (frizzles) but not significantly ($p<0.05$) earlier than the *Na_F_* birds (Figure 4.0).

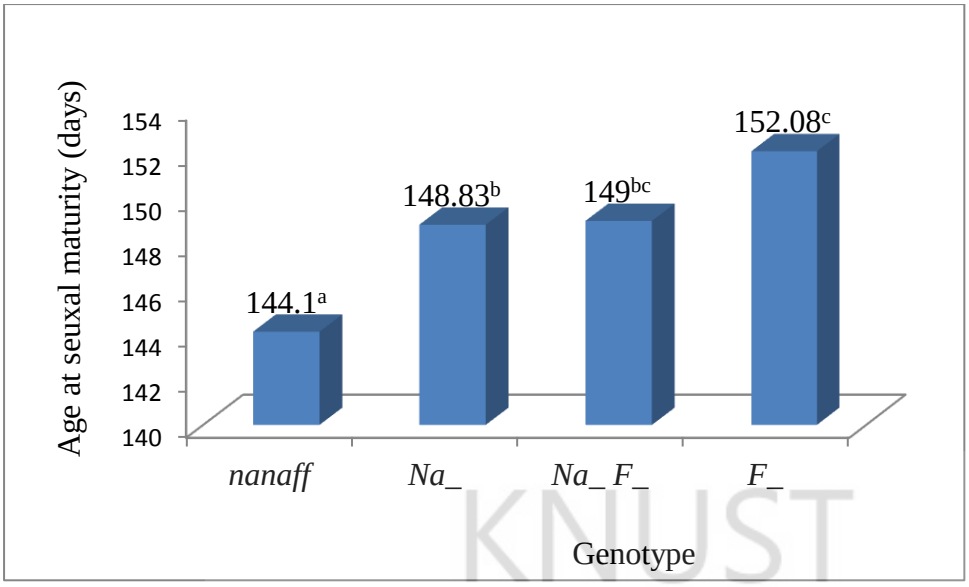


Figure 4.0: Effect of naked neck (*Na*) and frizzle (*F*) genes on age at first egg.

With respect to egg production, *nanaff* (normal feathered) birds had a significantly ($p<0.05$) higher average hen day production compared to all other genotypes. The *Na_* (naked neck) birds also had a significantly ($p<0.05$) higher average hen day productiion than the *F_* (frizzle) and *Na_F_* (frizzled-naked neck) contemporaries. The *F_* birds also had a significantly ($p<0.05$) lower rate of lay than their counterparts that showed the naked neck and frizzle genes together (Figure 5.0).

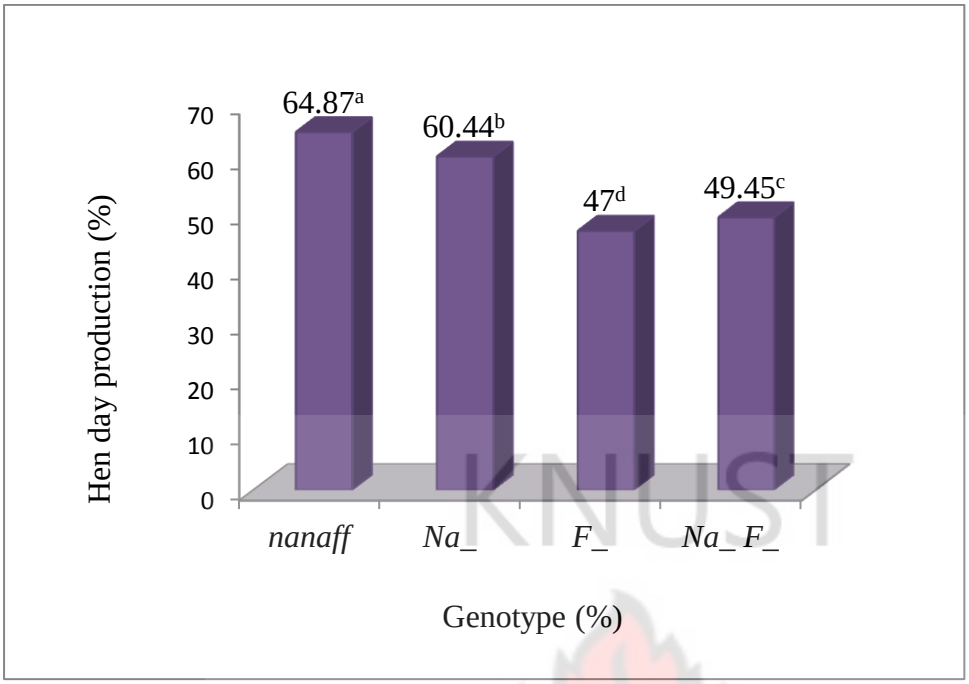


Figure 5.0: Effect of naked neck (*Na*) and frizzle (*F*) genes on hen day egg production (%)

The highest ($p<0.05$) egg weight was obtained in *nanaff* birds (Figure 6.0). The *Na_* (naked neck) birds had a slightly higher average egg weight than both *F_* and *Na_F_* (frizzled-naked neck) birds but the differences were not statistically significant ($p>0.05$).

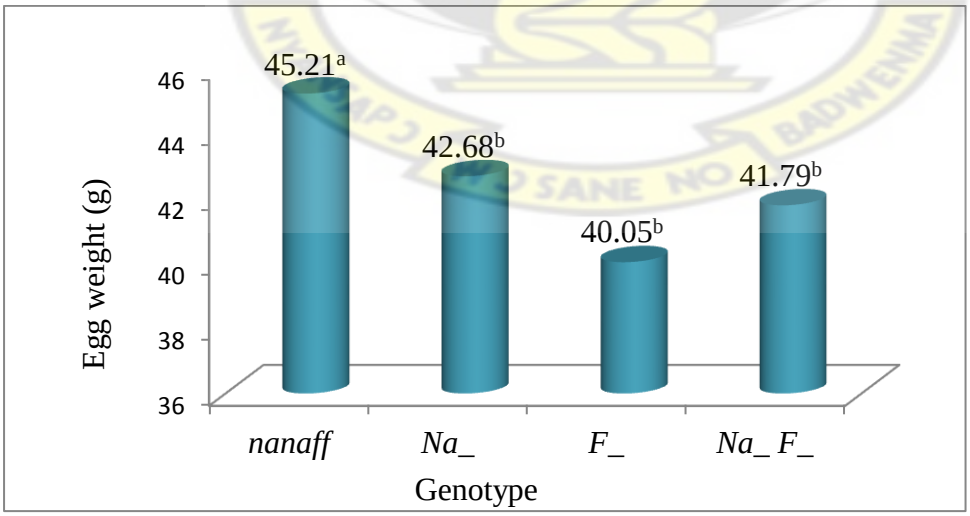


Figure 6.0: Effect of naked neck (*Na*) and frizzle (*F*) genes on egg weight (g).

Table 19.0 shows hen day egg production (%) and egg weight (g) as affected by naked neck and frizzle genes for a period of four months (16 weeks).

Table 19.0: Effect of *Na* and *F* genes on hen day production (%) and egg weight (g).

| | Hen day production | | | | Egg weight (g) | | | |
|---|---|---|---|---|---|---|---|---|
| | *Genotype* | | | | | | | |
| Age (Months) | *nanaff* | *F_* | *Na* | *Na_F_* | *nanaff* | *F_* | *Na* | *Na_F_* |
| 1 | $37.82^{a}$ | $15.21^{c}$ | $34.00^{a}$ | $24.62^{b}$ | $38.58^{a}$ | $23.46^{c}$ | $29.41^{b}$ | $31.14^{b}$ |
| 2 | $74.65^{a}$ | $44.87^{c}$ | $70.11^{a}$ | $55.39^{b}$ | $45.46^{a}$ | $42.93^{a}$ | $44.31^{a}$ | $44.37^{a}$ |
| 3 | $70.29^{a}$ | $60.59^{bc}$ | $67.30^{ab}$ | $58.36^{c}$ | $47.14^{a}$ | $45.54^{a}$ | $45.30^{a}$ | $46.45^{a}$ |
| 4 | $76.69^{a}$ | $67.34^{b}$ | $70.34^{ab}$ | $59.40^{c}$ | $49.68^{a}$ | $48.28^{a}$ | $48.16^{a}$ | $48.75^{a}$ |

$^{a,b,ab}$ and $^{bc}$ means for a parameter within the same row followed by different superscripts are significantly different ($p<0.05$); LSD: Least Significance Difference; SEM: Standard Error of Means

Hen day production did not statistically ($p>0.05$) differ throughout the experimental period of four month of lay between the *nanaff* (normal feathered) birds and the *Na_* (naked neck) ones but the former differed significantly from the *F_* and *Na_F_* genotypes (Table 19.0).

A similar trend was observed between the *Na_* (naked neck) birds and *Na_F_* (frizzled-naked neck) genotypes. A significantly ($p<0.05$) higher rate of lay was recorded by *Na_F_* (frizzled-naked neck) birds than their *F_* (frizzle) counterparts for 1st, 2nd and 4th months of laying.

In terms of average egg weight (g), differences were observed among the genotypes only in the first month of lay. The *nanaff* (normal feathered) birds produced significantly heavier egg weights compared to the all other genotypic groups.

The eggs produced by both the *Na_* (naked neck) and hens carrying the naked neck and frizzle genes together (*Na_F_*) were also significantly heavier than egg produced by the *F_* (frizzle) hens.

### 4.2.4 Blood parameters of naked neck and frizzle chickens

#### 4.2.4.1 Haematological components

Table 20.0 shows the haematological values of hens carrying the naked neck and frizzle genes.

Table 20.0: Average haematological values of hens as affected by *Na* and *F* genes.

| Genotype | RBC ($x10^{12}$/ml) | WBC ($x10^{9}$/ml) | Hb (g/dl) | PCV (%) |
|---|---|---|---|---|
| *nanaff* | $2.247^{a}$ | $143.5^{bc}$ | $12.38^{c}$ | $28.04^{b}$ |
| *NaNaff* | $2.323^{a}$ | $146.5^{b}$ | $13.48^{ab}$ | $32.06^{a}$ |
| *Nanaff* | $2.470^{a}$ | $159.7^{a}$ | $13.48^{a}$ | $32.07^{a}$ |
| *nanaFF* | $2.333^{a}$ | $145.5^{bc}$ | $12.48^{bc}$ | $30.30^{a}$ |
| *nanaFf* | $2.179^{a}$ | $138.4^{c}$ | $12.08^{c}$ | $28.18^{b}$ |
| *NaNaFF* | $2.328^{a}$ | $143.9^{bc}$ | $12.42^{c}$ | $30.04^{a}$ |
| *NanaFf* | $2.377^{a}$ | $149.8^{b}$ | $12.85^{abc}$ | $30.01^{a}$ |
| SEM | 0.14 | 2.76 | 0.33 | 0.80 |
| LSD | 0.3947 | 7.77 | 0.932 | 2.261 |

a, b, ab, bc and abc means within the same column bearing different superscripts are significantly different. LSD: Least Significance Difference; SEM: Standard Error of Means

#### 4.2.4.2 Red Blood Cell (RBC) count

There was no significant ($p>0.05$) difference among genotypes in terms of red blood cell count (Table 20.0).

#### 4.2.4.3 White Blood Cell (WBC) count

Significant ($p<0.05$) differences were observed in white blood cell count between the *Nanaff* and all other genotypes. The *Nanaff* (heterozygous naked neck) had a significantly ($p<0.05$) higher white blood cell count than the *NaNaff* (homozygous naked neck) counterparts. The *nanaFf* (heterozygous frizzle) significantly differed from all other genotypes except *nanaff* (normal feathered), *nanaFF* (homozygous frizzle) and *NaNaFF* (double homozygous frizzled-naked neck) birds (Table 20.0).

#### 4.2.4.4 Haemoglobin (Hb) concentration

The *Nanaff* (heterozygous naked neck) had a significantly ($p<0.05$) higher haemoglobin concentration than all other genotypes except the *NaNaff* and the *NanaFf* (double heterozygous frizzled-naked neck). The lowest haemoglobin concentration was observed in the *nanaFf* (heterozygous frizzles) although it did not significantly differ from values obtained for *nanaff* (normal feathered), *nanaFF* (homozygous frizzle), as well as both *NaNaFF* and *NanaFf* (frizzled-naked necks).



#### 4.2.4.5 Packed Cell Volume (PCV) content

The Packed Cell Volume (PCV) content ranged between 28.08-32.07% (Table 20.0). Birds carrying major thermo-regulatory genes with the exception of the *nanaFf* (heterozygous frizzle) recorded significantly ($p<0.05$) higher PCV levels than the *nanaff* (normal feathered) birds.

#### 4.2.4.6 Serum biochemical indices of hens

The serum total protein, albumin, globulin and total cholesterol content of the hens are indicated in the Table 21.0.

Table 21.0: Average serum biochemical values of hens as affected by *Na* and *F* genes.

| Genotype | Total Protein (g/dl) | Albumin (g/dl) | Globulin (g/dl) | Total Cholesterol (g/dl) |
|---|---|---|---|---|
| *nanaff* | 45.83$^{b}$ | 20.00$^{ab}$ | 25.83$^{b}$ | 12.38$^{c}$ |
| *nanaFF* | 49.67$^{ab}$ | 18.25$^{b}$ | 31.42$^{a}$ | 12.48$^{bc}$ |
| *nanaFf* | 50.33$^{ab}$ | 19.88$^{ab}$ | 30.46$^{ab}$ | 12.08$^{c}$ |
| *NaNaff* | 53.00$^{a}$ | 22.83$^{a}$ | 32.83$^{a}$ | 13.38$^{ab}$ |
| *Nanaff* | 50.33$^{ab}$ | 18.50$^{b}$ | 31.83$^{a}$ | 13.48$^{a}$ |
| *NaNaFF* | 51.50$^{ab}$ | 19.79$^{ab}$ | 31.71$^{a}$ | 12.42$^{c}$ |
| *NanaFf* | 51.67$^{a}$ | 20.54$^{ab}$ | 31.12$^{ab}$ | 12.85$^{abc}$ |
| SEM | 2.05 | 1.21 | 1.89 | 0.21 |
| LDS | 5.772 | 3.417 | 5.317 | 0.952 |

a, b, ab and abc means within the same column bearing different superscripts are significantly ($p<0.05$) different. LSD: Least Significance Difference; SEM: Standard Error of Means



### 4.2.4.7 Total protein concentration

In terms of total protein, *NaNaff* (homozygous naked neck) and *NanaFf* (double heterozygous frizzled-naked neck) had significantly ($p<0.05$) higher total protein concentration than the *nanaff* (normal feathered). No significant ($p<0.05$) differences were observed among all the other genotypes (Table 21.0).

### 4.2.4.8 Albumin concentration

Albumin level was significantly ($p<0.05$) higher in *NaNaff* (homozygous naked neck) than *nanaFF* (homozygous frizzle) and *NanaFf* (heterozygous naked neck). All other genotypes did not significantly ($p<0.05$) differ from each other.

#### 4.2.4.9 Globulin concentration

In terms of globulins, significant ($p<0.05$) differences were observed between the *nanaff* (normal feathered) birds and all other genotypes studied except the *nanaFf* (heterozygous frizzle) and the *NanaFf* (double heterozygous frizzled-naked neck).

#### 4.2.4.10 Cholesterol level

Cholesterol levels ranged from 12.08 g/dl in *nanaFf* (heterozygous frizzle) to 13.48 g/dl in *Nanaff* (heterozygous naked neck). Significant ($p<0.05$) differences were observed between the *Nanaff* (heterozygous naked neck) and all other genotypes except the *NaNaff* (homozygous naked neck) and *NanaFf* (double heterozygous frizzled-naked neck) genotypes.

# CHAPTER FIVE

## 5.0 DISCUSSION

### 5.1Experiment one

Fertility determines the number of offspring that can be obtained from a given number of eggs and is judged by candling or microscopy. The significantly ($p<0.05$) lower mean fertility recorded by the *nanaff* (normal feathered) birds (Table 12.0) could be attributed to the effect of high ambient temperature (29. $56^0$C) characterizing the study area (Table 16.0). It is probable that due to heat stress, feed intake might have been reduced in the *nanaff* birds compared to birds carrying the major feather genes singly or in combination (*Na, F* and *NaF*). Chickens suffer at high temperature, because of their feather coverage and this hinders internal heat dissipation leading to elevated body temperature and consequently a reduction in feed intake and thus nutrient intake. Hence, eggs produced by the *nanaff* hens may not contain all the essential elements necessary for embryonic development to take place. The *nanaff* could not deposit in their eggs the necessary elements for normal embryonic growth and development. The significantly ($p<0.05$) higher fertility levels recorded by the *Na_* in this study supports the report of Njenga *et al*. (2005) that the detrimental effect of high temperature (>$30^0$C) was greatly reduced in hens carrying the *Na* gene as shown by a lower proportion of abnormal embryos compared to the normal feathered hens. The mean fertility values reported in this study are above what Njenga *et al*. (2005) reported.

Hatchability is the percentage of fertile eggs hatched or percentage of chicks hatched from all eggs placed in the incubator. Hatchability of eggs is affected by several factors which include fertility of the eggs, egg quality, handling of eggs, management conditions during incubation and hatching as well as the genetic constitution of parents (Peters, 2005).

The lethality of the *Na* gene could explain the lower hatchability level associated with the *Na_* and *Na_F_* birds in this study. The absence of feathers at the back of the neck might impair movement during the embryonic development stage resulting in mortality. Additionally, the significantly ($p<0.05$) lower percent hatchability recorded by the *Na* compared to the *F_* may be attributed to other factors associated with the eggs. Since fertility was significantly high in these genotypes, hatchability of eggs may not be a function of only fertility but other unknown factors.



**5.2 Experiment two**

The significantly ($p<0.05$) higher day-old body weight recorded by the *Nanaff* (heterozygous naked neck) birds in this study may be attributed to the heavier body weight of the dams used to produce these chicks. This may indicate evidence of genetic influence of parental body weight on the progeny. The hatching eggs produced by these dams may be heavier compared to eggs produced by other genotypic groups and this might be a contributory factor for the heavier day-old body weight of the *Nanaff* chicks.

As a general rule of thumb, egg weight and body weight are positively correlated, the heavier eggs produced by these dams might have resulted in heavier day old body weight of their progeny. The significantly ($p<0.05$) higher day old body weight recorded by the *Nanaff* birds agrees with the finding of Mahrous *et al.* (2008) that a significantly heavier day-old body weight was recorded for *Nanaff* compared to the *nanaff* birds.

The nonexistence of significant ($p<0.05$) differences among most of the genotypes at 3 weeks of age may be due to the strict brooding conditions ($33^0$C) under which the birds were raised. Brooding conditions such as heat supply, relative humidity, ventilation, and nutrition were favourable for the *nanaff* birds. The significantly ($p<0.05$) lower body weight of the *NaNaFF* at 3 weeks of age could be linked to the relatively low body weight at hatch.

Additionally, the significantly ($p<0.05$) lower body weight recorded could be explained by the extremely exposed body surfaces coupled with extreme modification (curling) of the feather than normal feathered birds and this might suggest that these birds should have been reared under a higher brooding temperature to be able to perform to expectation.

The nonexistence of significant differences among the *Nanaff, NaNaff* and *NanaFf* and *nanaff* birds in this study at 18 weeks of age indicates that at moderate temperature these genotype did not have any influence on development and body weight. The significantly higher body weight of birds carrying the *Na* in a single state compared to the frizzles may suggest their ability to save protein for body development which could have been used for feather growth.

The high Average Daily Gain (ADG) of the normal feathered birds may be attributed to the moderate environmental temperature ($26.65^0$C) under which the experiment was carried out. The birds with the major thermo-regulatory genes that recorded lower ADG would have performed better at high temperature because of their ability to tolerate heat stress under high ambient temperature. This is in line with Saxena and Ketelaars (1993) who concluded that the benefits of birds carrying feather genes is much felt above $30^0$C. Even at moderate temperature the *NaNaff*, *Nanaff* and *NanaFf* birds were able to endure to make a gain that did not differ significantly ($p<0.05$) from the *nanaff* bird. The high ADG recorded by the *nanaff, NaNaff, Nanaff* and *Nanaff* birds means that these birds can achieve a higher body weight in a short time than their *nanaFF*, *nanaFf* and *NaNaFF* counterparts. The significantly ($p<0.05$) lower body weight gain recorded by the *nanaFF*, *nanaFf* and *NaNaFF* birds compared to the *NaNaff, Nanaff* and *nanaff* counterparts may be attributed to their feather structure which exposes the body surfaces to pecking from other birds.

Some researchers (Nthimo, 2004; Garcês *et al*., 2001) advocate the incorporation of the frizzle gene in commercial lines due to its heat tolerance in hot-climates, however, it might

promote feather pecking and hence cannibalism. The study revealed that the pecked birds isolated themselves from the group and this could have resulted in a reduction in feed and nutrient intake and further consequently reduce body weight gain especially in the *NaNaFF* and *nanaFF* birds which possess extremely naked body surfaces.

The generally and significantly ($p<0.05$) shorter and thinner shanks of the frizzle compared to the other genotypes could be attributed to the lower body weight and weight gain. This observation contradicts a report by Fayeye *et al*. (2006) who stated that frizzle birds were superior to naked neck ones in all body size parameters except body length and girth.

There was significant ($p<0.05$) difference in the age of attainment of sexual maturity among the genotypes studied. The significantly ($p<0.05$) earlier sexual maturity of the *nanaff* birds may be attributed to the faster growth rate compared to other the genotypes. The earlier sexual maturity of the *nanaff* bird in this study also supports the report of Ivar and Jan (1968) that genetically and environmentally, within strains the relationship between body weight and sexual maturity are positive. The observation of this study however, contradicts the finding of Nwachukwu *et al*. (2006) that with the same level of management, heavier birds attain sexual maturity later in life than light ones. In this study, the *Na_* and *nanaff* birds did not significantly ($p<0.05$) differ in terms of body weight but differed significantly in the attainment of sexual maturity might be attributed to other unknown factors.

The *nanaff* birds were found to record the highest hen day production (%) among all the genotypic groups studied. The lower hen day production among the *F_* and *Na_F_* birds may be attributed to the higher incidence of broodiness observed during the study which supports the conclusion by Njenga (2005) that hens with broody character cannot be good egg producers. Additionally, feather pecking could be a probable cause of lower hen day

production among the *Na_F_* and *F_* birds. These birds therefore use nutrients that would have been used for egg production in generating new cells for re-growth of damaged body parts and development of new feathers.

The significantly ($p<0.05$) higher depression in egg weight recorded by the frizzle feathered birds may be attributed to the significantly ($p<0.05$) lower body weight. The moderate environmental temperature prevailing during the conduct of the experiment did not favour the *F_* birds. This finding supports the report of Cary *et al*. (1993) that average egg weight is largely affected by environmental factors, feed restriction and parental body weight. The observation of this study again supports the report of Haque *et al*. (2001) that a positive correlation exists between body weight and egg weight and suggested that lighter birds are likely to produce lighter eggs. The significantly lower average rate of lay and egg weight recorded by the *F_* genotype may definitely lead to lower egg masses. The egg weight reported by Galal *et al*. (2007) for *Dw-Nana* (62.12±0.50 g) and *Dw-nana* (60.72±0.68 g) are heavier than what has been reported in this study for *Na_* (42.68 g) and *nanaff* (45.21 g) birds. Genotype did not cause significant ($p<0.05$) differences in egg weight during the last three months of the laying period (Table 21.0). The favourable influence of moderate environmental climate during the first four months of production together with the beneficial effect of early sexual maturity and heavier body weight resulted in higher rate of lay by the *nanaff* and *Na_* birds. The nonexistence of significant difference between the *nanaff* and *Na* in the single state demonstrates the advantage of the latter even at moderate temperature.

Feather pecking defined as pecking at and pulling out of feathers of other birds was observed in all genotypic groups. When the different phenotypic groups were reared together no feather pecking and cannibalism were observed until 8 weeks of age. Pecking and cannibalism were due to the extremely exposed body surfaces of the *NaNaFF* (double

homozygous frizzled-naked neck) and *nanaFF* (homozygous frizzle) birds. It was observed that birds with damaged feathers received significantly more severe pecks than those with undamaged feathers.

When the follicle of the damaged feather is exposed it becomes an attractive target for pecking. The *nanaFF* (homozygous frizzle) birds are known to have extremely recurved rachis and barbs in all feathers, which are easily broken (Somes, 1990). The high incidence of pecking in the *nanaFF* and *NaNaFF* groups was due to the fact that the barbs on the shaft of the feathers were wearing off exposing greater portion of the body surface to other birds. The observation supports the finding of Njenga (2005) that birds with damaged feathers are more susceptible to feather and injurious pecking. Ivar and Jan (1968) reported that circulating hormone concentrations may play a role in the initiation of feather pecking and cannibalism.

Pause in egg laying caused by broodiness is as a result of activities of prolactin. The high incidence of broodiness among the birds with heat tolerance genes in this study might show evidence of good maternal ability as an instinct to protect their eggs and offspring (Akhtar-Uz-Zaman, 2006). As laying hens come towards the end of a cycle of laying, the level of luteinizing hormones (LH) in their blood begins to fall while that of prolactin rises and their tendency to incubate eggs increases. LH concentrations then remain low and prolactin high for as long as broodiness persists (Ivar and Jan, 1968).

All haematological values were within the normal physiological range reported by Pollock *et al*. (2001).The nonexistence of significant difference in RBC count demonstrates that there was no difference among the genotypes studied with respect to this trait (Table 24.0). The reason could be that iron absorption and release from storage organs into blood plasma for its utilization in haemoglobin formation was normal in all genotypic groups. The study revealed

that none of the various genotypes proved to be anaemic or to suffer from any physiological disorders since all haemoglobin concentrations were not below 7 g/dl.

Pollock *et al*. (2001) stated that a haemoglobin concentration below 7 g/dl is an evident sign of anaemia in chickens. The higher Hb concentrations could help these genotypes to thrive well at high altitudes (Aengwanich, 2008). Also, an increase in haemoglobin concentration could be related to an increase in metabolic activity necessary to satisfy the energy demands for maintenance under stress conditions.

Blood is composed of cellular and fluid parts and due to the extremely exposed body surface of most of the birds carrying major feather genes, the fluid component might have been evaporated as a result of dehydration thus, making the concentration of the cellular part higher. This may explain why the *NaNaff, Nanaff, nanaFF*, *NaNaFF* and *NanaFf* birds had significantly higher PCV compared to the *nanaff* and *nanaFf* genotypes. The higher packed cell volume may boost growth and hence improve the productivity of these birds. Again, the higher PCV may enhance oxygen delivery to the tissues particularly at moderate temperature (El-Safty *et al*., 2006).

The higher total plasma protein may demonstrate the fact that females of oviparous species show a marked increase in total plasma protein concentration just before egg production. This oestrogen-induced hyperproteinamia is associated with an increase in vitellogenin and lipoprotein, which are necessary for yolk production (Schmidt *et al*., 2007). The total plasma protein recorded by the *NaNaff* (53.00 g/dl) is above what Ladokun *et al*. (2008) reported for indigenous *NaNa* (46.3 g/dl) birds.

The significantly higher albumin level recorded by the *NaNaff* compared to the *nanaFF* might show a greater reservoir of protein. A higher albumen level may promote the transport

of small molecules such as vitamins, minerals, hormones and fatty acids (Margaret, 2001). The high globulin level may indicate a higher level of immunity and may help to reduce the negative effect associated with malnutrition (Ladokun *et al*., 2008).

# CONCLUSION AND RECOMMENDATIONS

## CONCLUSION

The following conclusions can be drawn from the results of this study.

- The *Na_*, *F_* and *Na_F_* birds had higher fertility levels than *nanaff* ones.
- The *nanaff* reached sexual maturity significantly ($p<0.05$) earlier and recorded a higher hen day egg production (%) with heavier egg weights than all other genotypes.
- Birds carrying the *Na* and *F* genes recorded higher PCV concentrations than the *nanaff* ones.

## RECOMMENDATIONS

It is therefore recommended that:

- Further studies be conducted using these phenotypes in rainy and dry seasons of the country.
- Variation in disease resistance in chickens with major feather genes should be investigated.
- Studies involving feed consumption and conversion efficiency should be undertaken.
- Studies should also be carried out to assess the effects of the frizzle gene on feather pecking in a purely frizzled feathered flock and/or in a mixed flock with other genotypes under intensive management.

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## APPENDICES

Anova for fertility of eggs

| Source of variation | df | se | cv% |
|---|---|---|---|
| Batch | 13 | 4.378 | 4.9 |
| Batch*Units* | 351 | 19.225 | 21.4 |

Anova for hatchability of fertile eggs

| Source of variation | df | se | cv% |
|---|---|---|---|
| Batch | 13 | 7.44 | 9.2 |
| Batch*Units* | 351 | 26.12 | 32.1 |



Anova for fertility of eggs set

| Source of variation | df | se | cv% |
|---|---|---|---|
| Batch | 13 | 8.05 | 10.9 |
| Batch*Units* | 351 | 26.63 | 35.9 |

Anova for fertility as affected by genotype and storage length

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 13 | 6975.2 | 536.6 | 1.45 | |
| Genotype | 3 | 4891.8 | 1630.6 | 4.41 | 0.005 |
| Days | 6 | 5354.2 | 892.4 | 2.41 | 0.027 |
| Genotype/Days | 18 | 6271.2 | 348.4 | 0.94 | 0.0527 |
| Residual | 351 | 129730.1 | 369.6 | | |
| Total | 391 | 153222.6 | | | |

Anova for hatchability of eggs set as affected by genotype and storage length

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 13 | 23562.7 | 18125 | 2.56 | |
| Genotype | 3 | 11932.4 | 3977.5 | 5.61 | <0.001 |
| Days | 6 | 39145.6 | 6524.2 | 9.20 | <0.001 |
| Genotype/Days | 18 | 19947.5 | 1108.2 | 1.56 | 0.067 |
| Residual | 351 | 248949.2 | 709.3 | | |
| Total | 391 | 343537.5 | | | |

Anova for hatchability of fertile eggs as affected by genotype and storage length

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 13 | 20162.1 | 1550.9 | 2.27 | |
| Genotype | 3 | 4933.2 | 1644.4 | 2.41 | 0.067 |
| Days | 6 | 28782.4 | 4797.1 | 7.03 | <0.001 |
| Genotype/Days | 18 | 15607.7 | 867.1 | 1.27 | <0.204 |
| Residual | 351 | 239527 | 682.4 | | |
| Total | 391 | 309012.4 | | | |

Anova for Day-old

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 25.896 | 62.389 | 0.53 | |
| Genotype | 6 | 374.333 | 9.842 | 6.34 | <.001 |
| Residual | 114 | 1121.937 | | | |
| Total | 125 | 1522.166 | | | |

Anova for 3 weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 23206.4 | 4641.3 | 25.89 | |
| Genotype | 6 | 1952.0 | 325.3 | 1.81 | 0.102 |
| Residual | 114 | 20434.7 | 179.3 | | |
| Total | 125 | 45593.1 | | | |

Anova for 6 weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 136759 | 27352 | 15.86 | |
| Genotype | 6 | 21302 | 3550 | 2.06 | 0.064 |
| Residual | 114 | 196644 | 1725 | | |
| Total | 125 | 354705 | | | |

Anova for 9 weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 91490 | 18298 | 3.61 | |
| Genotype | 6 | 118240 | 19707 | 3.89 | 0.001 |
| Residual | 114 | 578123 | 5071 | | |
| Total | 125 | 787852 | | | |

Anova for 12 weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 168969 | 33794 | 4.25 | |
| Genotype | 6 | 205955 | 34326 | 4.32 | <0.001 |
| Residual | 114 | 905659 | 7944 | | |
| Total | 125 | 1280583 | | | |

Anova for 15 weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 96909 | 19382 | 1.98 | |
| Genotype | 6 | 474167 | 79028 | 8.07 | <0.001 |
| Residual | 114 | 1116272 | 9792 | | |
| Total | 125 | 1687352 | | | |



Anova for 18 weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 137944 | 27589 | 2.16 | |
| Genotype | 6 | 773377 | 128896 | 10.07 | <0.001 |
| Residual | 114 | 1458714 | 12796 | | |
| Total | 125 | 2370035 | | | |

Anova for Average Daily Weight

| Source of Variation | df | ss | ms | Vr. | F.pr. |
|---|---|---|---|---|---|
| Batch | 5 | 8.4858 | 1.6972 | 2.14 | |
| Genotype | 6 | 47.0669 | 7.8445 | 9.89 | <0.001 |
| Residual | 114 | 90.4270 | 0.7932 | | |
| Total | 125 | 145.9797 | | | |

Anova for Total weight

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 138148 | 27630 | 2.19 | |
| Genotype | 6 | 750072 | 125012 | 9.93 | <0.001 |
| Residual | 114 | 1435856 | 12595 | | |
| Total | 125 | 2324076 | | | |

Anova for weight gain from day old to three weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 23231.3 | 4646.3 | 30.14 | |
| Genotype | 6 | 1175.1 | 195.8 | 1.27 | 0.276 |
| Residual | 114 | 17572.3 | 154.1 | | |
| Total | 125 | 41978.7 | | | |

Anova for body weight gain between the third and sixth weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 88454 | 17691 | 13.73 | |
| Genotype | 6 | 12021 | 2003 | 1.55 | 0.167 |
| Residual | 114 | 146892 | 1289 | | |
| Total | 125 | 247367 | | | |



Anova for body weight gain between the sixth and ninth weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 340595 | 68119 | 25.31 | |
| Genotype | 6 | 45828 | 7638 | 2.84 | 0.013 |
| Residual | 114 | 306840 | 2692 | | |
| Total | 125 | 693263 | | | |

Anova for body weight gain between the ninth and twelfth weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 55372 | 11074 | 4.29 | |
| Genotype | 6 | 18009 | 3001 | 1.16 | 0.331 |
| Residual | 114 | 294251 | 2581 | | |
| Total | 125 | 367632 | | | |

Anova for body weight gain between the twelfth and fifteenth weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 203855 | 40771 | 14.34 | |
| Genotype | 6 | 68713 | 11452 | 4.03 | 0.001 |
| Residual | 114 | 324132 | 2843 | | |
| Total | 125 | 596700 | | | |

Anova for body weight gain between the fifteenth and eighteenth weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 20993 | 4183 | 2.33 | |
| Genotype | 6 | 49758 | 8293 | 4.61 | <0.001 |
| Residual | 114 | 205018 | 1798 | | |
| Total | 125 | 275689 | | | |

Anova for shank diameter at 9 weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 0.211937 | 0.042387 | 15.57 | |
| Genotype | 6 | 0.057471 | 0.009579 | 3.52 | 0.003 |
| Residual | 114 | 0.0310357 | 0.002722 | | |
| Total | 125 | 0.579766 | | | |



Anova for shank diameter at 12 weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 0.048168 | 0.009634 | 4.57 | |
| Genotype | 6 | 0.076594 | 0.012766 | 6.05 | <0.001 |
| Residual | 114 | 0.240521 | 0.002110 | | |
| Total | 125 | 0.365283 | | | |

Anova for shank diameter at 15 weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 0.040619 | 0.008124 | 4.45 | |
| Genotype | 6 | 0.053276 | 0.008879 | 4.86 | <0.001 |
| Residual | 114 | 0.208248 | 0.001827 | | |
| Total | 125 | 0.302143 | | | |

Anova for shank diameter at 18 weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 0.007848 | 0.001570 | 0.93 | |
| Genotype | 6 | 0.077460 | 0.012910 | 7.62 | <0.001 |
| Residual | 114 | 0.193263 | 0.001695 | | |
| Total | 125 | 0.278571 | | | |

Anova for shank length at 9 weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 2.8911 | 0.5782 | 4.13 | |
| Genotype | 6 | 2.8665 | 0.4777 | 3.41 | 0.004 |
| Residual | 114 | 15.9725 | 0.1401 | | |
| Total | 125 | 21.7301 | | | |

Anova for shank length at 12 weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 4.7463 | 0.9493 | 6.12 | |
| Genotype | 6 | 6.6837 | 1.1139 | 7.18 | <0.001 |
| Residual | 114 | 17.6941 | 0.1552 | | |
| Total | 125 | 29.1241 | | | |

Anova for shank length at 15 weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 0.2656 | 0.0531 | 0.51 | |
| Genotype | 6 | 6.3089 | 1.0515 | 10.16 | <0.001 |
| Residual | 114 | 11.8010 | 0.1035 | | |
| Total | 125 | 18.3756 | | | |



Anova for shank length at 18 weeks

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 0.1792 | 0.0358 | 0.32 | |
| Genotype | 6 | 5.3609 | 0.8935 | 7.96 | <0.001 |
| Residual | 114 | 12.7993 | 0.1123 | | |
| Total | 125 | 18.3393 | | | |

Anova for age at sexual maturity (days)

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 1175.21 | 235.04 | 5.18 | |
| Genotype | 3 | 799.12 | 266.37 | 5.87 | 0.001 |
| Residual | 87 | 3944.63 | 45.34 | | |
| Total | 95 | 5918.96 | | | |

Anova for rate of lay

| Source of variation | df | se | cv% |
|---|---|---|---|
| Batch | 5 | 5.158 | 9.3 |
| Batch*Units* | 363 | 13.793 | 24.9 |

Anova for egg weight

| Source of variation | df | se | cv% |
|---|---|---|---|
| Batch | 5 | 0.880 | 2.1 |
| Batch*Units* | 363 | 7.887 | 18.6 |

Anova for egg weight as affected by genotype and month of lay

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 247.64 | 49.53 | 0.80 | |
| Genotype | 3 | 1332.33 | 444.11 | 7.14 | <0.001 |
| Month of lay | 3 | 18749.74 | 6249.91 | 100.47 | <0.001 |
| Genotype/Month of lay | 9 | 1623.62 | 180.40 | 2.90 | <0.003 |
| Residual | 363 | 22580.72 | 62.21 | | |
| Total | 383 | 44534.05 | | | |

Anova for rectal temperature at 12 weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 2.64254 | 0.52851 | 17.89 | |
| Genotype | 6 | 0.21048 | 0.03508 | 1.19 | 0.318 |
| Residual | 114 | 3.36857 | 0.02955 | | |
| Total | 125 | 6.22159 | | | |

Anova for rectal temperature at 15 weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 1.65976 | 0.33195 | 5.52 | |
| Genotype | 3 | 0.71429 | 0.11905 | 1.98 | 0.074 |
| Residual | 87 | 6.85524 | 0.06013 | | |
| Total | 95 | 9.22929 | | | |

Anova for rectal temperature at 18 weeks of age

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 0.59302 | 0.11860 | 2.36 | |
| Genotype | 3 | 0.40889 | 0.06815 | 1.36 | 0.238 |
| Residual | 87 | 5.72921 | 0.05026 | | |
| Total | 95 | 6.73111 | | | |

Anova for Red blood cell

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 1.4128 | 0.2826 | 1.20 | |
| Genotype | 6 | 0.6137 | 0.1023 | 0.43 | 0.853 |
| Residual | 72 | 16.9330 | 0.2352 | | |
| Total | 83 | 18.9594 | | | |

Anova for White blood cell

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 3081.17 | 616.34 | 6.76 | |
| Genotype | 6 | 3193.97 | 532.33 | 5.84 | <.001 |
| Residual | 72 | 6568.26 | 91.23 | | |
| Total | 83 | 12843.94 | | | |

Anova for Haemoglobin

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 61.682 | 12.336 | 9.40 | |
| Genotype | 6 | 20.472 | 3.412 | 2.60 | 0.025 |
| Residual | 72 | 94.499 | 1.312 | | |
| Total | 83 | 176.654 | | | |

Anova for Packed cell volume

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 165.211 | 33.042 | 4.28 | |
| Genotype | 6 | 115.959 | 19.327 | 2.50 | 0.029 |
| Residual | 72 | 555.512 | 7.715 | | |
| Total | 83 | 836.682 | | | |



Anova for Total protein

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 652.95 | 130.59 | 2.60 | |
| Genotype | 6 | 371.33 | 61.89 | 1.23 | 0.301 |
| Residual | 72 | 3622.38 | 50.31 | | |
| Total | 83 | 4646.67 | | | |

Anova for Albumin

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 67.51 | 13.50 | 0.77 | |
| Genotype | 6 | 164.24 | 27.37 | 1.55 | 0.174 |
| Residual | 72 | 1269.42 | 17.63 | | |
| Total | 83 | 1501.18 | | | |

Anova for Globulins

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 533.37 | 106.67 | 2.50 | |
| Genotype | 6 | 375.31 | 62.55 | 1.47 | 0.202 |
| Residual | 72 | 3073.57 | 42.69 | | |
| Total | 83 | 3982.25 | | | |

Anova for Total cholesterol

| Source of Variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 6.4024 | 1.2805 | 2.45 | |
| Genotype | 6 | 3.6390 | 0.6065 | 1.16 | 0.338 |
| Residual | 72 | 37.6890 | 0.5235 | | |
| Total | 83 | 47.7304 | | | |

Anova for mortality due to Feather Pecking and internal laying

| Source of variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 0.00690 | 0.00345 | 0.13 | |
| Genotype | 6 | 4647.00932 | 774.50155 | 29346.00 | 0.001 |
| Residual | 12 | 0.31670 | 0.02639 | | |
| Total | 23 | 4647.33292 | | | |

Anova for mortality due to Coccidiosis

| Source of variation | df | ss | ms | Vr. | F. pr. |
|---|---|---|---|---|---|
| Batch | 5 | 0.009267 | 0.004633 | 1.00 | |
| Genotype | 6 | 251.856029 | 41.976005 | 9059.57 | 0.001 |
| Residual | 12 | 0.055600 | 0.004633 | | |
| Total | 23 | 251.920895 | | | |



Ambient temperature and relative humidity of study area

| Weeks | Parameters | | |
|---|---|---|---|
| | Minimum temperature (0C) | Maximum temperature (0C) | Relative humidity (%) |
| 20th | 30.3 | 21.3 | 87.0 |
| 21th | 30.5 | 21.3 | 85.8 |
| 22nd | 30.8 | 21.5 | 85.7 |
| 23rd | 31.2 | 21.6 | 84.7 |
| 24th | 31.2 | 21.6 | 84.8 |
| 25th | 31.8 | 21.8 | 80.5 |
| 26th | 32.1 | 22.0 | 84.0 |
| 27th | 32.2 | 22.1 | 84.7 |
| 28th | 32.6 | 21.9 | 78.7 |
| 29th | 32.7 | 21.3 | 80.8 |
| 30th | 32.7 | 22.2 | 82.8 |
| 31st | 32.8 | 21.7 | 83.8 |
| 32nd | 32.8 | 21.1 | 83.5 |

| | | | |
|---|---|---|---|
| 33rd | 32.8 | 21.9 | 85.7 |
| 34th | 33.0 | 21.0 | 83.7 |
| 35th | 32.8 | 20.5 | 75.0 |
| Average | 32.02 | 21.55 | 83.20 |