LOCAL DOMESTIC CHICKENS: THEIR POTENTIAL AND IMPROVEMENT

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DECLARATION

I hereby declare that this submission is my own work towards the Doctor of Philosophy (PhD) 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 acknowledgment has been made in the text.

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ABSTRACT

This study was conducted to assess the potential of indigenous chickens and improve their performance in traits of economic importance by incorporating in them the naked neck and frizzle genes, and also genes from a commercial layer (exotic breed) through crossbreeding (local naked neck/frizzle males × commercial females).

Study One

A survey was conducted to assess the current performance of local chickens in the Ashanti Region of Ghana. One-hundred and thirty five (135) local chicken keepers from Bosomtwe Atwima-Kwanwoma, Ejisu-Juaben and Asante-Akim South Districts were interviewed. All the keepers practised the extensive system of production with flock sizes averaging 22 in the ratio of 4: 6: 12 for cocks, hens and chicks respectively. A small amount of feed supplement was given either everyday or occasionally. Mortality of chicks (between day-old and six weeks) and total mortality (annual mortality for the entire flock) were 50% and 65% respectively. The average weights of cocks, hens and eggs were 1.55kg, 1.13kg and 42.80g respectively. The clutch size per bird ranged from 9-13. The major challenges faced by the keepers included diseases, predation, lack of funds to increase stock and construct structures, small sizes of birds and eggs, low numbers of eggs laid and poor fertility of eggs. Local birds provide immense benefits for keepers but their productivity is significantly hindered by genetic and management problems.

Study Two

Another survey was conducted to evaluate the potential of indigenous naked neck (*Nana*) and frizzle (*Ff*) birds within the indigenous chicken population in the Ashanti Region of Ghana. The study involved ninety (90) interviewees who were local chicken keepers in Bosomtwe Atwima-Kwanwoma, Ejisu-Juaben and Asante-Akim South Districts. Average body weight of *Nana* cocks did not differ significantly (P>0.05) from *Ff & nana/ff* (normal feathered) ones while *Nana* hens were significantly (P>0.05) heavier than *Ff* birds, but *nana/ff* birds did not differ significantly (P>0.05) from the two genotypes. *Nana* layers were significantly superior ($P<0.05$) in egg size, number of eggs per clutch and number of eggs per bird per year to *Ff* layers which were significantly better than *nana/ff* layers. However, clutches of eggs per year did not show any significant difference ($P>0.05$) among the three genotypes. Eggs from *Ff* layers had a significantly higher ($P<0.05$) hatchability compared to those from *Nana & nana/ff* layers. Eggs from *Nana* layers were significantly better ($P>0.05$) in Haugh unit and egg shell thickness compared to those from *Ff & nana/ff* layers and eggs from *Ff* layers were significantly better ($P>0.05$) in Haugh unit compared to those from *nana/ff* layers. Mortality was significantly lower ($P>0.05$) in *Nana* birds followed by *Ff & nana/ff* birds respectively. The carcass of *Nana* birds had a significantly higher ($P>0.05$) dressing percentage than that of *Ff* and *nana/ff* birds. Naked neck and frizzle genes improve the productivity of local birds but the naked neck gene appears to be more effective than the frizzle gene.

Study Three

The first mating in Experiment Three was between four indigenous naked neck males and thirty-six Lohmann commercial females in a ratio of 1: 9. This produced offspring in the proportion of 48.7% *Nana* to 51.3% *nana* in the F_1 generation. *Nana* birds were significantly better ($P<0.05$) in body weight, body weight gain, number of eggs per clutch, hen-housed and hen-day rates of lay, egg size, Haugh unit, shell thickness, survivability and carcass yield, than their *nana* counterparts. However, age at first egg and egg size to body weight ratio were significantly better in the *nana* birds compared to the *Nana* ones. In the second mating, ten males and one hundred females of F_1 *Nana* birds were selected and mated *inter se* in a ratio of 1:10. This produced 16.8% *NaNa*, 54.5% *Nana* and 28.7% *nana* offspring in the F_2 generation. It was observed that *Nana* and *NaNa* birds were significantly higher (P<0.05) in body weight, body weight gain, number of eggs per clutch, hen-housed and hen-day rates of lay, egg size, Haugh unit, shell thickness, survivability and carcass yield, compared to their *nana* counterparts. However, chick survivability was significantly better (P<0.05) in the *nana* birds compared to *Nana and NaNa* ones. Using birds that show the naked neck phenotype in local chicken production will enhance productive and reproductive performances significantly.

Study Four

Five local frizzle males were mated to forty Lohmann commercial females in a ratio of 1:8. This produced almost equal numbers of offspring, that is 50.2% *Ff* and 49.8% *ff* in the F_1 generation. The *Ff* birds were significantly superior (P<0.05) to their *ff* counterparts in terms of body weight, number of eggs per clutch, hen-housed and henday rates of lay, Haugh unit and carcass yield. However, survivability was significantly better (P<0.05) in the *ff* birds compared to the *Ff* birds. The second mating was made between ten males and one-hundred females of F_1 *Ff* birds. It was done *inter se* in a ratio of 1:10. This produced offspring in the proportion of 22.4% *FF*, 51.5% *Ff* and 26.1% *ff* in the F_2 generation. The F_2 *Ff* and *FF* birds were significantly higher (P<0.05) than their *ff* counterparts in number of eggs per clutch, hen-housed and hen-day rates of lay, Haugh unit, shell thickness, survivability and carcass yield. However, body weight, body weight gain, egg size and chick mortality did not differ significantly between the frizzles and the *ff* genotypes. Using frizzle (*FF*, *Ff*) hybrids in local chicken production will increase productivity markedly, though to a lesser extent than the naked necks (*NaNa*, *Nana*).

Study Five

In a comparative study involving all the five genotypes (*NaNa, Nana, FF, Ff and nana/ff*) reared under intensive, semi-intensive and extensive management systems, it was observed that the *NaNa* and *Nana* birds performed better (P<0.05) than their *FF* and *Ff* counterparts in body weight, body weight gain, number of eggs per clutch, henhoused and hen-day rates of lay, egg size, Haugh unit, shell thickness, carcass yield and economics of production. It was also economically most profitable to rear all the genotypes (*NaNa, Nana, FF, Ff & nana/ff*) under the semi-intensive system followed by the extensive and the intensive systems respectively. Aside genetic improvements, rearing local birds under the semi-intensive system will improve profitability significantly.

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CHAPTER ONE

1.0 INTRODUCTION

Ghana has a population of 23.8 million and 31.4% of this number survives below the poverty line. About 70% of those below the poverty line live in villages, with little or no education (UN/DESA, 2009). These eke out a living through subsistence agriculture and petty trading, however, the benefits derived from these activities are sometimes not enough to feed an entire family. Eating low-protein diets to survive becomes their best option and this leads to malnutrition among the children. Malnutrition plays a major role in the deaths of over five million children annually in Africa (WHO, 2000). In Ghana, thirty six percent (36%) of children less than five years old are stunted and fifty four percent (54%) of mortality among children below five years is caused by malnutrition (Poel *et al*., 2007).

In Ghana, the total poultry population is estimated to be over 33 million with 60-80% of this being rural scavenging chickens (LPIU, 2006; Gyening, 2006). Rural poultry production is an important agricultural activity of almost all rural communities in Africa, providing scarce animal protein in the form of meat and eggs as well as being a reliable source of petty cash. Village chickens also fulfill a number of other functions for which it is difficult to assign any monetary value. These include the fact that rural chickens play an active role in pest control and are used for traditional ceremonies and festivals. They are also used for rituals, honouring guests, and alerting owners of the presence of dangerous animals and the provision of aesthetic value (VSD, 1998).

Among small livestock, chickens are preferred for the generation of food and income.

The preference has been attributed to the shorter growing cycle of chickens (Global Plan, 1992) that makes it possible for the benefits, in the form of meat and eggs, to be reaped in less than six months. One egg weighing 55g meets 50% of the daily protein requirement of children between the ages of 1 to 5 (Ponapa, 1982). Therefore, if all the children in the villages of Ghana have access to one or two eggs daily, malnutrition among the children in these villages will be reduced markedly.

The contribution of rural poultry to the national economy of developing countries and the nutritional status and income levels of many smallholder farmers and landless communities has been very significant; contributing 1.37% of Gross Domestic Products (GDP) in Bangladesh (Creevey, 1991). This opportunity seems unexplored in Ghana since no intensive research has been done to improve the production of local chickens to the benefit of the people living in rural areas. The few studies that have been carried out on indigenous chickens in Ghana were baseline surveys (van Veluw, 1987; Awuni, 2002; Osei-Amponsah *et al*., 2007). It was only the studies of Dankwa *et al.* (2005) that looked into the effect of using live maggots as a feed supplement on the performance of scavenging indigenous layers.

In spite of the many problems involved in poultry keeping, almost all poor households in the villages keep poultry; and poultry production is therefore considered an excellent tool in poverty alleviation due to its quick turn over and low investment. Thus, if production could be improved, village poultry production would create an opportunity for the development of the poor segments of society (Quisumbing *et al*., 1995; 1998; Todd, 1998; Permin *et al.*, 2000; Gueye,).

The main objective of this study therefore, was to assess the productive potential of indigenous chickens and to determine the magnitude of improvement that can be obtained by mating them with commercial hybrid layers. The specific objectives of the study were to:

1. assess the current performance of local chickens in the Ashanti Region of Ghana.
2. determine the potentials of frizzle and naked neck birds among indigenous chickens in the Ashanti Region of Ghana.
3. produce homozygous and heterozygous naked neck birds which perform better in traits of economic importance by mating local naked neck males with commercial layers.
4. compare the productive and reproductive performance of homozygous and heterozygous naked neck birds with that of their normal feathered counterparts.
5. produce dual-purpose (meat and eggs) homozygous and heterozygous frizzle birds as a result of a mating between indigenous frizzle males and commercial layers.
6. compare the performance of homozygous and heterozygous frizzle birds with that of their normal feathered counterparts in traits of economic importance.
7. compare the productivity and profitability of rearing birds under intensive, semiintensive and extensive management systems.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 <u>LOCAL CHICKENS AND THEIR PRODUCTION</u>

2.1.1 <u>Origin</u>

The progenitor of the local fowl is generally considered to be the Red Jungle Fowl

(*Gallus ferrugineus* or *bankiva*), though there are three other wild species, all oriental. This species is a native of India, a part of China, the adjacent islands and the Philippines (FAO, 1998; Dalby, 2003; Anonymous, 2007). Its habitats are divers, as it can be found in lofty forests and in the dense thickets, as well as in bamboo jungles and on when cultivated lands. This wild species closely resembles the breed of poultry fanciers, the *Black-breasted Game*, but the crow of the wild cock is not as loud or prolonged as that of the tamed one (MacDonald and Blench, 2000). In Africa, chickens were first discovered in Egypt, where they were reared as foreign pets and game cocks. However, in the year 650BC they became common and economically important. They then spread from there to Sub-Saharan Africa during the first millennium AD (Dalby, 2003).

Characteristics such as naked neck, frizzled feathers and also single, pea, rose and walnut combs were common within flocks of local birds (Anonymous, 2007). The naked neck mutation originated in Transylvania, Romania and spread across Europe centuries ago; and the frizzle feathered chicken was first described by Western explorers in Fiji during the seventeenth century (FAO, 2000). These naked neck and frizzle birds were introduced to Africa and the rest of the world by sailors and traders.

Local chickens of today resulted from centuries of cross-breeding with exotic breeds and random breeding within flocks of local birds. As a result, it is not possible to standardize the characteristics and performance of indigenous chickens (FAO, 1998). The indigenous fowls have been variously referred to as the African chicken, local chicken, native chicken, family poultry, village chicken, bush chicken or runner chicken; however, distinct local varieties have been reported in Egypt, Cameroon, Burkina Faso, Morocco and Sudan (Guèye, 1998).

2.1.2 <u>Potential of Local Chickens</u>

More than 70% of the family poultry population in Africa is made up of the indigenous chicken types kept in low-input low-output production systems (Kitalyi, 1999). Family poultry is well integrated into most village farming systems, producing 40 to 70 percent of the national meat and egg supply in most tropical countries (Horst, 1988; FAO, 2000). Indigenous chickens possess unique adaptive traits that permit them to survive and reproduce under harsh climatic, nutritional and management conditions typically associated with low input–output production systems (Mwacharo *et al*., 2007). Local birds are kept by rural smallholders, landless farmers and industrial labourers, because of their scavenging adaptability, production ability and low maintenance cost (Kitalyi, 1998).

Local birds are adapted for survival under scavenging free-range conditions due to their evolvement from the same conditions. However, there still is a considerable and largely unexploited potential for increased production from local birds through improved management (FAO, 2000). According to Horst (1988) products from local poultry stocks are widely preferred because of pigmentation, leanness, and availability for special dishes. He observed that despite the important role played by local poultry, there is a paucity of information on its genetic make-up with respect to performance, its comparative evaluation with imported lines under similar management conditions and its adaptability and resistance to local diseases.

Local chickens are beneficial to rural people because they are available, adaptable, inexpensive to keep, and have tasty meat and eggs. Improving the genetic potential of local birds will result in faster multiplication of birds, increase in body weight, and improved egg weight and taste. It will also result in more eggs for hatching, sale and consumption, and more income (Mburu and Ondwasi, 2005). Adaptability of local chickens to unfavourable conditions is usually high (Mukherjee, 1990).

2.1.3 Feeding Management

Birds need enough feed to grow and lay eggs. They find their own feed if allowed to move freely; but extra feed should be given in the form of kitchen leftovers including fruit and vegetable waste, cereal grains and by-products, green leaves, fish meal, tubers and roots, insects, termites and worms, and brewers waste. Provision of adequate clean water and feeding of birds in a clean dry place must be ensured (Mburu and Ondwasi, 2005).

The growth potential of local chickens is not fully exploited under free-range (scavenging) conditions due to inadequate feed supply. Feeding management contributes about 30% of their growth potential (Gondwe and Wollny, 2005). They concluded that, growth of local chickens can be enhanced through improved management under free-ranging conditions.

Feed resources are a major input in poultry production systems. They are estimated to account for 60 percent of total production costs in the commercial poultry sector (Renkema, 1992). Rising poultry feed costs and particularly those of premixes have led to the use of home made rations, where concentrates of commercial feed is mixed with other ingredients (Kitalyi, 1999). Ingredients commonly used in home made rations are oyster shells, fishmeal, bone meal, blood meal and oil seed cakes. Other ingredients are cereal grains, cereal by-products and kitchen waste (Fanuel, 1997; Kitalyi, 1998).

In village chicken production systems, it is difficult to estimate the economic and/or physical value of feed input because there are no direct methods of estimating the scavenged feed resource which constitutes most of the feed input. In Sri Lanka , the village chicken feed was partitioned into household refuse, 72%; grass shoots, 13%; small metazoans, 8%; and paddy rice, 7% (Roberts and Gunaratne, 1992). Forages also form part of the scavenged feed resource (Soukossi, 1992).

The scavenging feed resource base depends on household food status (Gondwe and Wollny, 2005). The nature of the area available for scavenging influences strongly the feed intake pattern of the chickens when these have free access to both energy- and protein-rich supplements (Samnang, 1998).

2.1.4 Housing

Housing in modern poultry is an important input, accounting for a major component of the initial capital investment. In modern poultry enterprises, the structures are constructed and designed in consideration of bird welfare and efficiency of production (Bhagwat, 1996; Weaver, 1996). According to Huchzermeyer (1976), there are three types of traditional poultry houses in Africa, namely saddle roofed houses, round thatched huts, boxes and basket types. However, birds sometimes roost in the family house, kitchen or on tree branches (Kitalyi, 1999).

Housing in rural poultry is at a rudimentary stage, and field surveys have shown cases where no housing or shelter is provided (Huchzermeyer, 1973; Kuit *et al*., 1986; Atunbi and Sonaiya, 1994; Yongolo, 1996). The traditional poultry housing structures are small in size and, therefore, difficult for a person to go into most of them to clean up. Such houses would definitely not provide a healthy environment (Kitalyi, 1999).

Research on the economic efficiency of housing in rural poultry in Africa is scanty. However, published reports suggest that where housing is provided to village chickens, the houses are made with locally available materials such as wood, mud bricks, sugarcane stems, bamboo and cereal stovers (Atunbi and Sonaiya, 1994; Huchzermeyer 1973; Yongolo, 1996). In an evaluation of the economic efficiency of the local materials for housing laying hens, Atunbi and Sonaiya (1994) reported that cane cages were cheaper than wooden cages.

Free-ranging local chickens are known for their ability to survive under various types of shelter, including makeshift chicken houses, kitchens and even roosting on trees (Andrews 1990; Musharaf 1990; Yongolo 1996). According to Mwalusanya *et al*. (2004), 95.2% local chicken keepers allow their birds to scavenge during the day and are provided with simple housing at night. Proper chicken housing should keep the birds, especially young chickens, secured from wild animals and hawks, be spacious, well lit and airy, have perches, be easy to clean and maintain (Mburu and Ondwasi, 2005).

2.1.5 <u>Health and Disease Control</u>

Newcastle disease is the most devastating disease of village chickens in Africa

(Melewas, 1989; Minga *et al.*, 1989; Bell *et al.*, 1990; Bourzat and Saunders, 1990; Chaheuf, 1990; Awan *et al*., 1994; Chrysostome *et al*., 1995). Other diseases such as Gumboro, coccidiosis, fowl pox, fowl typhoid, fowl cholera, infectious coryza, chronic respiratory disease (CRD) and both internal and external parasites have also been reported (Melewas, 1989; Yongolo, 1996).

A study of ectoparasites of domestic fowls in Nigeria showed that infestation of lice, *Menacanthus straminen*, was the major problem in rural poultry (Zaria *et al.*, 1993). Studies on the incidence of worms in village chickens in some African countries revealed that worm species such as *Ascaridia galli, Prosthogonium spp., Strongyloids avium, Heterakis gallinarum, Raillietina spp, Davainea progglottina, Tetrameres americana*, and species of *Trichuridae* and *Raillietinidae* were common in village chickens (Tona, 1995). According to Mukherjee (1990), resistance of local birds to prevailing diseases such as Newcastle, fowl pox and coccidiosis is low resulting in generally high juvenile, and occasionally high adult mortality rates.

Cleaning the chicken house frequently to maintain hygiene; vaccinating chickens against Newcastle disease, fowl typhoid and fowl pox, deworming growers to control internal parasites and dusting the birds to control external parasites, help in protecting local birds against sickness (Mburu and Ondwasi, 2005).

2.1.6 Economic Importance of Keeping Local Birds

Various scholars and rural development agencies have recognized the importance of rural poultry in the economies of developing countries and its role in improving the nutritional status and incomes of many small farmers and landless communities in the last two decades (FAO, 1982, 1987; Bembridge, 1988; Mokotjo, 1990; Creevey, 1991). However, rural poultry does not rate highly in the mainstream national economies because of the lack of measurable indicators of its contribution to macroeconomic indices such as gross domestic product (GDP).

A survey conducted in northern Ghana by van Veluw (1987) revealed that the main function of village chickens from the farmer's perspective is the provision of meat and eggs for home consumption. The village chicken provides readily harvestable animal protein to rural households and, in some parts of Africa, is raised to meet the obligation of hospitality to honoured guests (Chale and Carloni, 1982). Village chickens are more widely distributed in rural areas of Ghana than the other livestock species (van Veluw, 1987) and can therefore provide a cheap source of food and easy cash to the family (Mburu and Ondwasi, 2005).

Chicken meat and eggs are reported to complement staple diets of rural Africa due to the higher nutrient concentration (Table 2.1). Resource-poor households of South Africa with small poultry production units having 12 layers each have reported an increase in the consumption of animal protein and reduced incidence of malnutrition (MacGregor and Abrams, 1996).

Table 2.1: The amount of nutrients provided by 100g (edible portions) of Chicken meat and eggs

Chicken Product/Nutrient	Energy (kcal)	Protein (g)	Calcium (mg)	Iron (mg)	Vitamin A (μg)

Egg (fresh)	158	12.1	56	2.1	156
Poultry meat	139	19.0	15	1.5	0

Source: FAO, (1997)

2.1.7 Performance of Local Chickens

According to FAO (1998), the main production characteristics of local breeds are: small body size (low nutritional maintenance requirement); lateness in maturing (up to 36 weeks of age); low performance in egg numbers (20 to 50) and egg size (25 to 45 g); small clutch sizes (two to ten eggs); long pauses between laying of clutches and a predominant inclination to broodiness. A hatchability of 80 percent from natural incubation is normal, but a range of 75 to 80 percent is considered satisfactory (FAO, 2000).

Flock size varies between 20 and 50 birds with ages between day-old to about three years and each farmer keeps about one or two adult males and three or four adult females in their flock for breeding purposes as reported in Malaysia (Ramlah, 2005). According to Mwalusanya *et al.* (2004), the mean flock size for a village chicken is 16.2, with a range of 2 to 58. However, flock sizes in local poultry production systems are highly variable; ranges of 3 to 97 and 6 to 130 have been reported in Nigeria and Malawi respectively (Sonaiya *et al*., 1999; Kitalyi 1998).

Ramlah (2005) reported that in Malaysia, local hens laid eggs in clutches of about 8-16 eggs per clutch before sitting on the eggs for hatching. He continued that chicks were normally brooded by the broody hen or brooded in a box or cage and then the brood was left to roam for food following the mother hen for about 40-60 days until they could look after themselves. It was further reported that, the survival rate of these chicks was low compared to chicks that were kept under the semi-intensive system. According to Mwalusanya *et al.* (2004), the mean clutch size, egg weight and hatchability were 11.8, 44.1 g and 83.6%, respectively whilst mean chick survival rate to 10 weeks of age was 59.7%. They continued that the mean live weights for cocks and hens were 1.95 kg and 1.35kg, respectively; and the mean growth rates to the age of 10 weeks were 4.6 g/day and 5.4 g/day, while from 10 to 14 weeks of age the rates were 8.4 g/day and 10.2 g/day for female and male birds, respectively. It was further stated that, the age at first lay ranged between 6 and 8 months, and the average hen had three laying cycles per year. Furthermore, only small amounts of supplementary feeds were occasionally given and minimal health care was provided.

Local chickens perform very well when extra feed, proper housing and disease-free environment are provided (Mburu and Ondwasi, 2005). The major constraints to the production of local chickens are outbreaks of Newcastle disease among chickens in the months of September to December every year, predators that feed on pigeons, chickens and ducks, and poor housing and prolonged weaning periods for chickens and ducks as reported in Malawi (Gondwe *et al*., 2005). The low productivity of local chickens is partly due to poor management practices, in particular the lack of proper health care, poor nutrition and poor housing (Mwalusanya *et al*., 2004).

The performance of local chickens and their price trends are associated with status of food security in rural households (Gondwe *et al*., 2005). The productivity of local chickens is low with regard to egg production, egg weight, growth rate and chick survival rate. Chicken housing, feeding, and health care are below standard (INFPD, 1999). Table 2.2 shows the variations in the performance of village chicken in some African countries.

Table 2.2: Performance of Village Chickens in Some African Countries

Reference	Country	Clutches Per year	Eggs Per Clutch	Egg Weight (g)	Hatcha-bility (%)	Matured Body Weight (kg)		Mortality	
						Cock	Hen	Chick	Mature
Shanawany and Banerjee (1991)	Ethiopia	-	-	44 - 49	39 - 42	-	-	-	1.1-1.7
Bourzat and Saunders (1990)	Burkina Faso	2.7 – 3.0	12 - 18	30 - 40	60 - 90	-	-	-	-
Minga *et al.*, (1989)	United Republic of Tanzania	-	6 - 20	41	50 - 100	1.2	2.2	>80	-
Van Veluw (1987)	Ghana	2.5	10	-	72	-	-	50	50
Wilson *et al.*, (1987)	Mali	2.1	8.8	34.4	69.1	1.6	1.02	56	-
Wilson (1979)	Sudan	4.5	10.87	40.6	90	2.1	1.31	-	-

Source : Kitalyi (1998)

In rural smallholder extensive systems, meat production cannot be separated from egg or chick production, and thus a highly broody (with consequent low egg production), low body-weight (low-feed requirement) hen is best suited under these conditions. Surplus cockerels, whatever their weight, are usually sold for meat at three to four months of age and there is little control in reproduction as they brood their own chicks for continuous regeneration of the flock (Kitalyi, 1998). The egg brooding (incubation) and chick rearing activity increase the length of the reproductive cycle from 58 days to about 74 days (Horst, 1999). Thus, most hens can produce chicks about four to five times per year.

With four to five reproductive cycles per year, only about nine replacement pullets out of 40 or 50 may be obtained (FAO, 1998). Fertility and hatchability are also high in local birds since they generally adapt well to unfavourable management conditions, and resistance to prevailing diseases is usually assumed to be high, although juvenile and sometimes adult mortality rates can be high in extensive production systems (FAO, 2000).

2.1.7.1 <u>Broodiness in Local Birds</u>

Broodiness is a common characteristic of the native chicken, and a hen incubates 4 or 5 clutches of eggs in every year (Islam, 2006). Signs of broodiness are that the hen stops laying, remains sitting on her eggs, ruffles her feathers, spreads her wings and makes a distinctive clucking sound. Brooding may be induced with dummy eggs or even stones (FAO, 2000). The hen does not start to incubate her eggs until the whole clutch is laid. The physiology of a hen changes after the whole clutch has been laid. She will remain on them, with her wings slightly spread to keep them warm, for about 21 days. She makes muttering, growling sounds if disturbed, and may even peck or otherwise try to defend her nest. She will only leave the nest once a day to eat, drink and defecate (FAO, 1998). Broodiness, caused by the effect of the hormone prolactin (Prl), is a hindrance to high egg production (Pampin and Ruiz, 1998).

Incubation behavior in chickens is not controlled by a major gene (or genes) on the Z sex chromosome, and there must, therefore, be major autosomal genes contributing to the expression of the behavior. If a broody gene does exist on the Z chromosome, it is one of at least three genes including two dominant autosomal genes, one causing and the other one inhibiting incubation behavior, with probably equal influence (Rumanov,

2001).

Zadworny *et al.* (1988) found that plasma levels of Prolactin (Prl) increased before incubation and were maintained at high levels during incubation but decreased rapidly at the onset of the hatching of the young. It was observed that during incubation, plasma levels of Prl appeared to be associated with time spent on the nest. Lea *et al*. (1981) observed that the concentration of plasma protein increased while that of LH fell successively during the days before the onset of incubation, which resulted from the increase in plasma Prl.

Broodiness does occur under low concentrations of Prl. However, elevated levels of Prl during broodiness appear to be maintained by a stimulus associated with the nest itself or some other aspect(s) of the environment (Zadworny *et al.*, 1985). Plasma Prl decreased and plasma LH increased in hens deprived of their nest: these changes were reversed when the hens re-nested. Secretion of Prl in broody hens is facilitated by the presence of chicks and increased concentration of plasma Prl maintains incubation behavior (Sharp *et al.*, 1988).

Lea *et al*. (1981) found that hens spent progressively more time in the nest during the 5 days before the onset of incubation so that by the first day of incubation they were spending more than 90% of their time in this way. Li and Lee (1995) found that 48% of birds in floor pens showed broodiness versus 3.2% of caged birds. Nixey (1973) observed that about 56% of the birds laying in the warmer environment (19.5 and 12.5^{o}C) showed signs of broodiness, while only 27% of the birds in the colder environment (7.1 ^{o} and 3.1^{o} C) showed it. The flocks in the colder environment laid on average, 86.9 vs. 77.6 % eggs per hen in flocks in the warmer environment. Most of this difference was accounted for by increased broodiness.

2.1.7.2 <u>Mortality under the Scavenging System of Producing Birds</u>

Abdelqaer *et al*. (2005) reported that in Cameroon, 40% of the flock of local birds under the local management system was lost before reaching 6 months of age, and mortality from diseases, predators, parasites, and cold stress for chicks accounted for 49 %, 31.6 %, 10 %, and 9.4% of the total loss, respectively. It was added that the most frequent outbreak of diseases, as perceived by the keepers, was in this order of occurrence: Newcastle Disease (51 %), Infectious Bronchitis (21 %), Fowl Typhoid (18 %) and other diseases (10 %); the main predators were foxes (25% of the cases), and wild cats (11.5%).

Wirsiy and Fonba (2005) observed that, under the Tanzanian local system of producing chickens, disease outbreaks were common and often erased stocks of chicken from an entire household. According to them, poultry disease epidemics were also common during the transitional periods (end of rainy season and start of dry season). Mortality for exotic birds under scavenging conditions were higher than that of local birds indicating that, exotic chickens were subjected to considerable hazard of diseases, parasites and predators under scavenging condition (Samnang, 1998; Demeke, 2003) Local chicken contributes significantly to the nutritional and economic functions in rural communities, however, mortality due to diseases and predation constrain these functions markedly. It has been estimated in Malaysia that, the mean annual financial loss per flock of sixty birds due to mortality, was 42 US dollars (Abdelqader *et al*., 2005). Experience has shown that vaccination of local fowls against major poultry diseases like Newcastle disease, infectious bronchitis and Gumboro can prevent these losses due to disease outbreaks (Wirsiy and Fonba, 2005).

2.1.8 Systems of Production of Local Birds

There are three poultry management systems: intensive, semi-intensive and extensive or scavenging (Kitalyi, 1999). Under the intensive system, birds are fully confined either in houses or cages. Capital outlay is highest and the birds are totally dependent on their owners for all their feed requirements; production however is highest. There are three types of intensive systems namely: deep litter, slatted floor and battery cage systems. In the semi-intensive or ‘run’ system the birds are confined in an enclosed area outside during the day and housed at night. Feed and water are provided in the enclosed to avoid wastage by rain, wind and wild animals (FAO, 2002). There are two types of extensive systems: free-range and backyard. Under the free-range extensive system, the birds are not confined and can scavenge for food over a wide area. Rudimentary shelters may be provided, and these may or may not be used. The birds may roost outside, usually on trees, and nest in the bush. The flock has birds of different species and varying ages. In the backyard extensive system, birds are housed at night but allowed free-range scavenging during the day. They are usually fed a handful of grains in the morning and evening to supplement scavenging. The mentioned management systems frequently overlap. Thus, free-range is sometimes coupled with feed supplementation, backyard with night confinement but without feeding, and poultry cages in confined spaces (Branckaert and Guèye, 1999).

The intensive system is normally based on specialized breeds and is found mainly in urban and peri-urban areas, constituting less than 30 % of the total poultry population in Africa. The extensive or scavenging system is based on indigenous chickens and is mostly found in the villages (Kitalyi, 1999). According to Ramlah (2005), free-range and semi-intensive systems of keeping local chicken are still the most popular and viable production systems for rural households with little inputs; rarely would one find village fowl being kept under the intensive system such as the deep litter or caged system. Thus, intensive systems of rearing indigenous chickens commercially is uncommon, a notable rare exception being in Malaysia, where the industry has developed in response to the heavy demand for indigenous chickens in urban areas
(Supramaniam, 1988).

The traditional system of keeping the village fowl has been the backyard system whereby the birds are let loose to scavenge for food, with housing provided at night, in both the semi-intensive and free-range systems (Ramlah, 2005). However, the effectiveness of the semi-intensive system is hampered by poor infrastructure (Yongolo,
1996).

2.1.9 The Way Forward in Local Chicken Production

There is tremendous potential for improving and increasing the productivity of the local poultry through small holder schemes. The success, however, depends on improving the genetic potential and management of local poultry (Mukherjee, 1990). The major constraints to production are poor housing, poor disease control, extremely high rearing mortalities, and a lack of well-organised vaccination programmes and poultry extension services (FAO, 1998).

According to Mukherjee (1990), the potential significance of local poultry for future breeding strategy is still unidentified. However, Horst (1988) noted that the genetic resource base of the indigenous chickens in the tropics is rich and should form the basis for genetic improvement and diversification to produce a breed adapted to the tropics.

The low-input and low-out production of village chicken flocks could be improved through improved management and disease control to reduce the large number of bird losses (Kitalyi, 1998). The critical management objective for scavenging free-range systems is to reduce the high mortality in both growing and adult age groups, of about 60 to 70 percent mortality. This high mortality means that a large proportion of eggs laid by the hen need to be used for reproduction to maintain flock size, instead of being used as a source of income or food. It also means that many birds that die could instead be sold or consumed as meat (FAO, 1998).

Mortality can be significantly reduced through increasing farmer awareness of health needs, through the provision of vaccine (especially for Newcastle Disease) and through improving the nutrition of growing stock (for example, by providing a local mash to supplement scavenging). These are the most important improvements to management activities that will enable the farmer to best exploit the existing potential of local breeds under scavenging free-range system (FAO, 1998).

The performance of local breeds will increase slightly under cage or deep litter management (Oluyemi *et. al.,* 1979) but, because the genetic potential for egg production (or meat production) of local breeds is lower than that of commercial hybrids, the same investment in intensive management will achieve a much higher production result by using commercial hybrids.

According to Kitalyi (1998), improved poultry housing resulted in lower chick mortality (19%) relative to that observed in Ethiopia (66%) and Tanzania (33%), where no housing improvements were made. Osei- Amponsah *et al*. (2007) found that, the productivity of local chickens in Ghana could be improved if regular feeding is done. If balanced feed, good health-care supplies, and day-old chicks of hybrid varieties were locally available, then intensive poultry management could be an option. If these were not available, raising local breeds under scavenging free-range systems was still the best choice (FAO, 1998). Kitalyi (1999) suggested that specialized high yielding breeds are necessary for improvement of local poultry but it should be preceded by improvements in housing, feeding and disease control. There seems to be a possibility for laying birds to adapt to diets with lower crude protein levels which will make possible, production based on "home grown" crops even in Northern part of Europe (Sorensen, 2003).

2.2 Crossbreeding of Local Birds

The village fowls, normally found in the rural and suburban areas of Africa, are no longer a pure breed but rather the result of crossbreeding with various exotic stocks introduced Africa (Ramlah, 2005). In village chicken production, uncontrolled mating is practised, which is often modulated by indigenous breeding practices (Gondwe and Wollny, 2005). The production performance of the first filial generation (F_1) of local birds crossed with improved breed is superior to the local ones and manifest heterosis (Oluyemi, 1979; Isika *et al.*, 2005). According to Oluyemi (1976) upgrading can transform local chicks closer to the improved breeds than the direct importation of the improved genotype. Local fowls perform lower than their crossbreds and growth rate is not positively influenced by dietary manipulations. Crossbreds benefit more from increasing dietary crude protein (200 g/kg – 240 g/kg) with age to the extent of their growth potential (Isika *et al*., 2005). Crossbreeding indigenous chickens with exotic breeds improves growth traits, which include traits like live weights, daily gains and feed intake (Omeje and Nwosu, 1988; Asiedu and Weever, 1993).

Crossbreeding of the indigenous chickens with an exotic breed tends to improve the egg size of the crossbred progeny due to the positive genetic correlation between body size and egg size. Indigenous chicken crossbreds tolerate higher environmental temperatures than broilers. According to Katule (1992), in a cross between indigenous and exotic strain of chickens, the F_1 generation had better growth rate than any of the parental breeds, indicating existence of heterosis for this trait. However, breeds that attain sexual maturity early end up laying lighter eggs than late maturers (Oni *et al*., 1991). Fayeye *et al*. (2005) reported that Fulani-ecotype, a local crossbred in Nigeria was found significantly better in shell thickness, yolk index and Haugh unit than Yaffa and ISA Brown layers (Oguike and Onykweodiri, 1999). According to Isikwenu *et al.* (1999) yolk index and haugh unit are the best indicators of internal egg quality; and the higher the yolk index (Ayorinde 1987) and haugh unit the more desirable the egg. Cheong and Chung (1985) developed two-way White Leghorn crossbreds that preformed better than both parents in hen-day and hen-housed egg production with 3.78 and 6.16 percent heterosis, respectively. They also had similar results in survival rate, age at sexual maturity, and body weight. In Egypt, the White Mamourah breed was developed by crossing Alexandria males and inbred Dokki-4 females, and then backcrossing the F_1 females to Alexandria males. The crossbred birds were superior in economic traits such as body weight, breast width, and feed conversion ratio (Abdel-Gawad *et al.*, 1980).

2.3.0 <u>Mutant Genes in Chickens</u>

According to FAO (1998), seven mutants that are common among local birds in the tropics and are found to be potentially useful are: Na - naked neck; Dw - dwarf; K - slow feathering; Fa - Fayoumi ; F - frizzle ; H - silky; and Fm - fibro-melanosis. The use of these genes to improve productivity in small holder poultry breeding programmes has been researched in various tropical countries, including Indonesia, Malaysia, Thailand, Bangladesh, Bolivia, India, Cameroon and Nigeria (Horst, 1988; Mukherjee,

1990; Barrio *et al*., 1991; Mathur, 2003; FAO, 1998; Njenga, 2005; Cahaner, 2007).

It has been found that, the use of single or combined dominant genes for feather restriction (Na) and feathering structure (F), as well as the sex-linked recessive gene for reduced body size (dw), has positive effect on productivity of birds in the tropics (Horst, 1989; Haaren-Kiso *et al.*, 1995). Research into the effects of these genes on economic factors has been undertaken in most African and Asian countries (Khadijah, 1988;
Mathur and Horst, 1989).

2.3.1 <u>The Naked Neck Gene and its Effects on the Performance of Chickens</u> The naked neck gene in chickens is caused by an autosomal gene which exhibits incomplete dominance (Davenport, 1914; Warren, 1933). The naked neck gene was assigned the symbol *Na* by Hertwig (1933). It is incompletely dominant with the heterozygous (Nana) birds showing an isolated tuft of feathers on the ventral side of the neck above the crop, while the homozygous (NaNa) birds either lack this tuft or it is reduced to just a few pinfeathers or small feathers (Crawford, 1976). The resulting bare skin becomes reddish, particularly in males as they approach sexual maturity (Hutt, 1949; Somes 1990). The apteria of birds carry scattered down and semiplume feathers but that of the naked neck birds contain no feathers. The feather tracts themselves are either absent or reduced in area so that birds have greatly reduced feather cover (Horst, 1982; 1987; Merat, 1990). Anonymous (2005) stated that naked neck birds are happy to free range or be confined in runs and are not known as being particularly good fliers; they however need protection in extremely cold temperatures because of their lack of feathers but can cope remarkably well in very hot climates; they are easy to tame, very placid and calm.

According to Bordas *et al*. (1978), the feather coverage of naked neck birds is reduced by 20 - 30% and 30 - 40% respectively in the heterozygote (*Nana*) and homozygote (*NaNa*). This reduction in feather coverage facilitates better heat dissipation and improves thermoregulation resulting in better relative heat tolerance in hot climates. At a temperature of 30ºC or higher, homozygous or heterozygous naked neck birds were heavier than their normal feathered counterparts and their feed efficiency was at least equal (Merat, 1986). In studies involving fast growing naked neck and normal feathered birds, a higher growth rate and meat yield were exhibited by the naked neck birds compared to their normally feathered counterparts when reared at high or moderate ambient temperatures (Merat, 1986; Cahaner *et al*., 1993; Eberhart and Washburn, 1993). Mahrous *et al*. (2008) reported that under moderate temperature, the naked neck (*Nanaff*) and naked neck frizzled (*NanaFf*) genotypes had significantly heavier body weight compared to their normal feathered (*nanaff*) counterparts. They added that, the presence of the *Na* gene in a single state or interacted with *F* gene, significantly improved feed conversion ratio compared to their *nanaff* sibs.

Under constant heat stress the heterozygous naked neck (Nana) layers have significantly higher egg number, egg weight, egg mass, body weight and productivity index than the normal feathered (Somes, 1988; Hareen-Kiso, 1991; Mathur, 2003). However, according to Mathur (2003) under natural conditions there were large differences in the performance of naked neck birds in terms of egg number, egg weight, egg mass, body weight and productivity index at different locations (Turkey, Egypt, Cuba, Burundi, Bolivia and Malaysia).

The reduction of plumage (20 - 40%) gives 1.5 - 3.0% more carcass yields to the naked neck genotypes than their normal feathered counterparts regardless of the temperature. Due to the higher proportion of muscle in the pectoral region of naked neck birds, there is 1.8-7.1 percent more meat in them than normal feathered birds when their carcasses are dressed (Merat 1986). Fathi *et al.* (2008) reported that the naked neck genotypes (*NaNa* or *Nana*) exhibited higher relative weight of dressed carcass, drumstick and breast muscles compared to normally feathered individuals (*nana*) and that the proportion of abdominal fat was decreased in both naked neck genotypes compared with normally feathered ones. Intramuscular and subcutaneous fat in naked neck birds is low due to the utilization of a larger fraction of energy for thermoregulation (Merat, 1990). N'Dri *et al*. (2005) observed that slow growing homozygous and heterozygous naked neck birds under fluctuating temperature, tended to reach the weight of 2 kg 3.3 days sooner than normally feathered birds and that carcass yield of *Na* birds was higher than that of normally feathered birds (81.6 % vs. 80.0 %). Singh *et al*. (1996) reported that heterozygous naked neck broilers gained about 3% more weight than their normally feathered counterparts under commercial conditions during the spring and summer months, and that this advantage was almost tripled at high ambient temperature of about 32°C.

Rauen *et al*. (1986) reported that egg numbers were not significantly affected by the naked neck gene at moderate temperatures; however, naked neck hens had a better laying rate at high temperatures. Adult body weight of naked neck hens was slightly higher than full plumage ones at temperatures above 30^{o}C, nevertheless, the situation was reversed at temperatures below 20^{o}C. They added that, although the ratio of egg weight to body weight was increased by the *Na* gene at any temperature, the increase of mean egg weight in *NaNa* and *Nana* genotypes compared with *nana* was lower at moderate temperature than at high temperature where it reaches 3 - 4g for the naked neck homozygote. In a study under temperate and subtropical conditions in Taiwan and France, Chen *et al*. (2008) reported that the naked neck genotype had a negative effect on body weight and a positive effect on feed intake, feed efficiency, clutch length and egg weight. Above 30^{o}C feed efficiency was superior for naked neck females compared to their normal feathered counterparts. Fraga and Lam (1987) found better egg shell strength for the *Na/na* genotype. Rauen *et al*. (1986) observed that the advantage of the *Na* gene at high temperature for egg production mainly involved persistency of laying, and was more marked in medium-sized than in light strains.

At temperatures of 18^{o}C and 30^{o}C, Hammade *et al.* (1987) obtained at successive ages a larger semen volume and a higher number of spermatozoa per ejaculate for *NaNa* than for *nana* males, with intermediate values for heterozygotes without any genotype – temperature interaction. Ladjali *et al*. (2005) studied the abnormalities in embryos of naked neck and normal feathered hens and found that the naked neck females showed a much lower proportion of abnormal embryos than normally feathered females whatever the temperature.

An increase of embryonic mortality (up to 10% in pure strains) was associated with the *NaNa* and *Nana* genotypes (Crawford, 1977, 1978; Horst, 1982; Rauen, 1985 and Merat, 1986). Post embryonic chick mortality was not different for naked neck and fully feathered chicks except when exposed to heat stress above 40^{o}C, in which case the mortality of fully feathered chicks was slightly higher than their naked neck counterparts (Merat, 1990). Adult mortality did not differ between the naked neck and normal feathered birds at 20^{o}C; however, at 30^{o}C or more, mortality for heterozygous naked neck layers was lower than their fully feathered counterparts (Rauen *et al*., 1986). There was less frequent cannibalism among naked neck birds and this may have a relation to survival rate (Barrio *et al.*, 1987).

Naked neck birds are superior to normal feathered birds for growth, feed efficiency, carcass traits, viability, immunocompetence, blood biochemical parameters and mortality (Barrio *et al.*, 1991). Haushi *et al.* (2002) studied the naked neck and the normal feathered phenotypes for general immunocompetence by assessing antibody response to SRBC (Sheep Red Blood Cell), haemolytic complement level in the serum, *in-vivo* cell mediated immune (CMI) response to Concanavalin-A (Con-A) and a phagocytic index at 10 - 12 weeks of age. They found that the naked neck gene did not seem to influence the antibody response to SRBC, CMI to Con-A or the phagocytic index; however, a significantly higher ($P<0.05$) haemolytic complement level in serum was observed in birds carrying a copy of the *Na* gene as compared to the normally feathered birds. Mahrous *et al*. (2008) studied the immunocompetence of naked neck and naked neck-frizzle genotypes and reported that, total antibody titer against Sheep Red Blood Cells (SRBCs) and Cutenous Basophilic Hypersensitivity (CBH) increased significantly within *Na-* and *Na-F-* genotypes compared to *nanaff* genotypes; likewise, naked neck and naked neck-frizzled birds had significantly higher carbon clearance index (lower carbon particles in their blood circulation) compared to normally feathered counterparts. They concluded that the naked neck gene in a single state or in combination with the frizzle gene significantly increased immune response of chickens under moderate temperature; therefore, introducing the naked neck (*Na*) gene in selection programs for disease-resistance must be advisable, particularly in unfavorable environments.

The naked neck gene has a higher resistance to coccidiosis-causing protozoa- *E. tanella and E. necatrix* (Barrio *et al.*, 1991; Banga Mboko, 1996). Naked neck broilers are superior to their normal feathered counterparts in both winter and summer in terms of growth rate, feed efficiency, dressing percentage and liveability, however the difference is higher in summer than in winter (Singh *et al*., 1998). According to Sharifi (2006), the use of the naked neck gene (*Na*) in the homozygous form under high temperatures results in a distinct improvement of survival ratio of hens, growth and components of reproduction like number of eggs, egg weight, shell quality, proportion of settable eggs, fertility, number of chicks hatched and chick weight as compared to their normal feathered counterparts. He added however that, due to an increase in embryonic mortality as a result of the naked neck gene, the naked necks (*NaNa*) were inferior to the normal hens (*nana*) for hatchability when the embryos were homozygous for the *Na*-gene. He noted, on the other hand that, if the embryos were heterozygous descending from a *nana* x *NaNa* mating plan, *NaNa* hens were superior to *nana* hens in hatchability. It was further stated that, under temperate conditions, the growth rate of *NaNa* hens was reduced compared to *nana* hens; but in the components of reproduction performance, differences were not significant (P>0.05) between both genotypes; an exception was found only in hatchability and consequently in the complex trait of number of chicks hatched.

The annual egg production of indigenous naked neck birds is 50 - 55 eggs per hen (Akhtar-Uz-Zaman, 2002). According to Njenga (2005), among the indigenous birds of Kenya (naked neck, frizzle, dwarf and normal feathered) the naked neck was superior in terms of body weight, egg weight, eggshell thickness, growth rate up to 5 weeks and survivabilty (low mortality). However, fertility was lowest for naked neck. Moreki and Masupu (2003) reported that under scavenging conditions the naked neck genotype was superior in egg production and hatchability. Desai *et al*. (1961) reported 106, 68 and 86 eggs per bird per year for Bare-neck (naked neck), large Baladi and Betwil (indigenous chickens in Sudan) respectively. However, Mohammed *et al.* (2005) did not find any significant difference in hen-day egg production, hen-housed egg production and egg shell thickness when they studied the three phenotypes mentioned ealier; the naked neck was only superior in live weight. Additionally, the studies of Singh *et al*. (1996) in India did not show any significant difference between the indigenous naked neck and other ecotypes in terms of age at sexual maturity, 40-week body weight, annual egg production, clutch size, fertility and hatchability except egg size, which was significantly heavier within the naked neck ecotype compared to other ecotypes.

Indigenous naked neck birds are able to protect themselves and their chicks from predators because of their alertness and fighting characteristics. They can thrive well under adverse environment, poor housing, management and nutrition with variable temperature and relative humidity. Due to their fewer feathers, they save protein that may be used for meat tissues (Horst, 1987; Merat, 1990). The reduction in their protein requirement results in a reduced incidence of feather pecking and cannibalism (Merat, 1990). Akhtar-Uz-Zaman (2002) noted that the reduction in feather coverage of naked neck birds enabled them to receive more solar radiation, which might facilitate greater vitamin D synthesis and in turn, contributes to better shell quality. It was added that, naked neck birds interact well when crossed with other stocks and this resulted in better performing progeny. The 40 percent less feather coverage in naked neck birds reduced considerably the need for dietary nutrition to supply protein input for feather production. This makes them suitable for village chicken production since protein is a limiting factor in many scavengers feed resource bases (FAO, 2002).

Báldy *et al*. (1954) conducted a study aimed at making the native Hungarian naked neck bird uniform in colour and body shape, improving egg production together with body weight and meat quality. This work resulted in a good dual-purpose (meat and egg) Hungarian naked neck chicken breed, which was propagated all over the country and abroad. Singh *et al*. (1996) noted that, the naked neck gene had positive effects on growth, feed efficiency, body composition and meat yield in broilers and also egg laying, egg quality traits, reproduction and liveability in broiler breeding and laying birds. They concluded that, the future use of this genotype at high ambient temperatures, either for meat or egg production would be very encouraging.

According to Merat (1986), there was a considerable opportunity to utilize the genetic variability that existed among random mated indigenous stock, in particular, the naked neck genotype. The naked neck gene can be used to develop stocks that are better able to survive under tropical conditions and to produce increased quantities of egg (AkhtarUz-Zaman, 2002). Among the indigenous genotypes, the naked neck is superior in egg production, egg size and body weight in an environment where the average temperature is about 30^{o}C (Yoshimura *et al.*, 1997). Mathur (2003) concluded that the naked neck genotype was more suitable for the tropical climatic conditions and their superiority was greater with increasing heat stress.

2.3.2 The Frizzling Gene and its Effects on the Performance of Chickens

The frizzling phenotype is caused by a single autosomal incompletely dominant gene, *F* (Hutt, 1930; Landauer and Dunn, 1930). The effects of the frizzle gene are greatly restricted by an autosomal recessive modifying gene, *mf*. In unmodified homozygous frizzled birds, the rachises of all feathers are extremely recurved with barbs also being extremely curled. These feathers are easily broken and therefore the birds appear quite bare. The modifying gene lessens the extreme aspects of the homozygotes so that they appear less woolly. Unmodified heterozygous have the feather shafts and barbs recurved, to a much less extent than the homozygotes, and the rectrices and remiges are much less affected. However, when the modifier gene is present heterozygous birds are almost indistinguishable from the normal feathered phenotypes (Landauer, 1933; Hutt, 1936; Somes, 1990). According to Anonymous (2005) the chicks appear to be normally feathered when they are hatched but the wing feathers soon start to grow and turn outwards. The frizzling gene is a feather structure gene (Horst, 1988) that causes a reduction in tropical heat stress by improving the bird's ability for convection, resulting in improved feed conversion and better performance (Merat, 1990). Benedict *et al*. (1932) found a considerable increase in energy metabolism for frizzled birds, implying that they will respond differently from normal feathered birds to high temperatures.

The frizzle gene has favourable effects on production traits such as egg number, egg weight, egg mass, body weight and productivity index but less pronounced than the naked neck gene (Somes, 1988; Mathur, 2003). Mahrous *et al*. (2008) reported that under moderate temperatures the frizzled (nanaFf) and the naked neck frizzled (NanaFf) genotypes had significantly heavier (P<0.05) body weights compared to their normally feathered (nanaff) counterparts. However, according to Mathur (2003) under natural conditions there are large differences in the performance of frizzle birds in terms of egg number, egg weight, egg mass, body weight and productivity index at different locations (Turkey, Egypt, Cuba, Burundi, Bolivia and Malaysia).

In a study to evaluate the general immunocompetence of the frizzle and normal feathered phenotypes by assessing antibody response to SRBC (Sheep Red Blood Cell), haemolytic complement level in the serum, *in-vivo* cell mediated immune (CMI) response to Concanavalin-A (Con-A) and a phagocytic index at 10-12 weeks of age, Haushi *et al.* (2002) found that the frizzle gene does not seem to influence the antibody response to SRBC, CMI to Con-A or the phagocytic index. However, Mahrous *et al*. (2008) studied the immunocompetence of frizzle and naked neck-frizzle genotypes and reported that total antibody titre against sheep red blood cells (SRBCs) increased significantly in *F-* and *Na-F-* genotypes compared to *nanaff* genotype; likewise, frizzled and naked neck-frizzled birds had significantly higher carbon clearance index (lower carbon particles in their blood circulation) compared to their normally feathered counterparts.

The basal metabolism of frizzle birds is accelerated leading to increased production of both thyroid and adrenal gland hormones. Food intake, oxygen consumption, heart rate and volume of circulating blood are increased, resulting in enlargement of heart, spleen, gizzard and alimentary canal in frizzled birds (Benedict *et al*., 1932; Boas and Landauer, 1933, 1934; Landauer and Aberle, 1935; Landauer and Upham, 1936). The effect of this gene on production has been shown to be favourable by an increase in egg number and egg mass, alongside a reduction in mortality under hot conditions (Horst, 1987).

Under high ambient temperatures, the frizzle gene in heterozygous form (*Ff*) has positive effect on survival rate, laying performance and fertility while under moderate temperatures the frizzle gene in heterozygous form has no significant impact on survival rate, growth and the components of reproductive performance (Sharifi, 2006). According to him, the survival ratio of hens and components of reproductive performance such as number of eggs, egg weight, shell quality, proportion of settable eggs, fertility, hatchability, number of chicks and chick weight clearly improve if the *F*gene is present in homozygous form (*FF*). Furthermore, under temperate conditions, the effect of the homozygous *F*-gene on reproductive performance is inconsistent. While survival ratio of hens, egg shell quality, fertility, egg weight and weight of chicks improve by the presence of the *F*-gene, number of eggs and number of chicks are distinctly reduced. The reason for the depressive effect of the homozygous *F*-gene on laying intensity consists in the delay in age at first egg which occurs under moderate and high temperatures. This deficiency gains a considerable dimension when the frizzle gene is combined with the dwarfism gene (*FFdw-*) especially under temperate conditions, adding up to a triple interaction (Sharifi, 2006).

Missohou *et al.* (2003) studied frizzle, sex- linked dwarfism, normal feathered and combined frizzle and sex- linked dwarfism birds under Senegalese conditions and found that, the interaction between the two genes is only positive for growth traits and egg number. They noted that, neither of the two genes significantly influenced egg quality. The frizzle phenotype has the highest chick weight within the first week of life among indigenous phenotypes such as the naked neck, dwarf and normal feathered birds (Njenga, 2005). According to Mukherjee (1990), frizzling and silky feathering structures are exceptions to the normal feather structure within indigenous fowls.

Among indigenous chickens, the frizzle is normally pecked (Njenga, 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.0.1 Introduction

Five studies were conducted. The first two were field surveys and the last three were experiments. To improve local birds, it is imperative to have a good knowledge about their current performance. Therefore the first survey (Study one) dealt the current performance of local chickens in terms of their productive and reproductive traits, profitability and the major challenges hindering their productivity. The second survey (Study two) focused on the potential of naked neck and frizzle genes within the population of local chickens. In the first of the three experiments conducted (Study Three), there were two matings. The first one was between indigenous naked neck males (*Nana*) and Lohmann commercial layers (*nana*). The second was an *inter se* mating of the first generation heterozygous naked neck birds (*Nana*). Productive and reproductive performance of the parental generations were studied. There were also comparative studies between first generation birds (heterozygous naked neck (*Nana*) birds and normal feathered (*nana*) ones), and also between second generation birds (*NaNa* (homozygous naked neck), *Nana* & *nana*). The second experiment (Study four) was conducted in a similar way as the first. The only exception was that the matings involved frizzles instead of naked necks. In the third experiment (Study five), all the five genotypes (*NaNa*, *Nana*, *FF* (homozygous frizzle), *Ff* (heterozygous frizzle) and *nana/ff* (normal feathered)) from the two previous experiments were studied under three management systems (Intensive, semi-intensive & extensive). However, comparative studies in terms of productive and reproductive performances were conducted between naked neck (*NaNa*, *Nana*) and frizzle (*FF*, *Ff*) phenotypes since all the other comparisons have already been made. The effect of a management system on the productive and reproductive performances of the birds were also looked at.

3.1 STUDY ONE: THE CURRENT PERFORMANCE OF INDIGENOUS CHICKENS IN THE ASHANTI REGION OF GHANA

3.1.1 Study Areas and Duration

The study was conducted in the Ashanti Region of Ghana. Three districts, namely: Asante–Akim South (AAS), Bosomtwe Atwima-Kwanwoma (BAK) and Ejisu-Juaben (EJ), (Fig. 3.1.1), were selected based on convienience, for the survey. Three villages/towns were convieniently selected from each district (AAS – Juaso, Yawkwei and Nkwanta; BAK – Jachie, Kuntananse and Abono; EJ – Kwamo, Ejisu and Kwaso) and fifteen chicken keepers within each village/town were randomly selected and interviewed. Therefore, a total of forty- five keepers from each district and a grand total of one- hundred and thirty five were involved in the study. The study lasted for two months: from December 20, 2005 to February 16, 2006

3.1.2 Data Collection

The study was done through formal and informal interviews. The formal interviews were aided by a structured questionnaire (Appendix 1A). The questionnaire used for the interviews was made up of both pre-coded and open-ended questions. Information ascertained included flock size, years in chicken keeping, management system, feed supplementation, weights of birds and eggs, number of eggs per clutch, clutches per year, average number of eggs per year, hatchability of eggs, survivability of chicks, total mortality, sales of eggs and birds per year, cost of production, health of birds, purpose of keeping the birds, economics of keeping the birds and various challenges faced by keepers and their suggested solutions.

3.1.2.1 **Weights of Birds**

Weights of cocks, hens, chicks and eggs were taken during the survey by the use of galvanized and electronic weighing scales. Chicks from day-old to five days of age in all the house holds visited were weighed and the average was taken. Males and females, six months of age or above were also weighed and the averages were taken as the weights of cocks and hens respectively.

3.1.2.2 **Profitability of Production**

This was simply calculated by deducting the cost of production per year from the sales of birds and eggs per year.

3.1.2.3 **Health of Birds**

To know the health status of the birds, the keepers were asked whether vaccines, antibiotics or any drugs had ever been given to the birds. Symptoms of diseases that attack the birds, mortality rate, and other causes of mortality apart from diseases were also ascertained.

3.1.2.4 <u>Mortality</u>

Survivability of chicks was measured as the average percentage of chicks hatched that survived beyond six weeks of age; while total mortality was calculated as the average percentage of the flock lost per year. These parameters were calculated with the help of the keepers.

3.1.3 <u>Analysis of Data</u>

Genstat software (2007) was used to estimate the means and their standard deviations. Microsoft excel was also used for the pictorial presentation of the data.

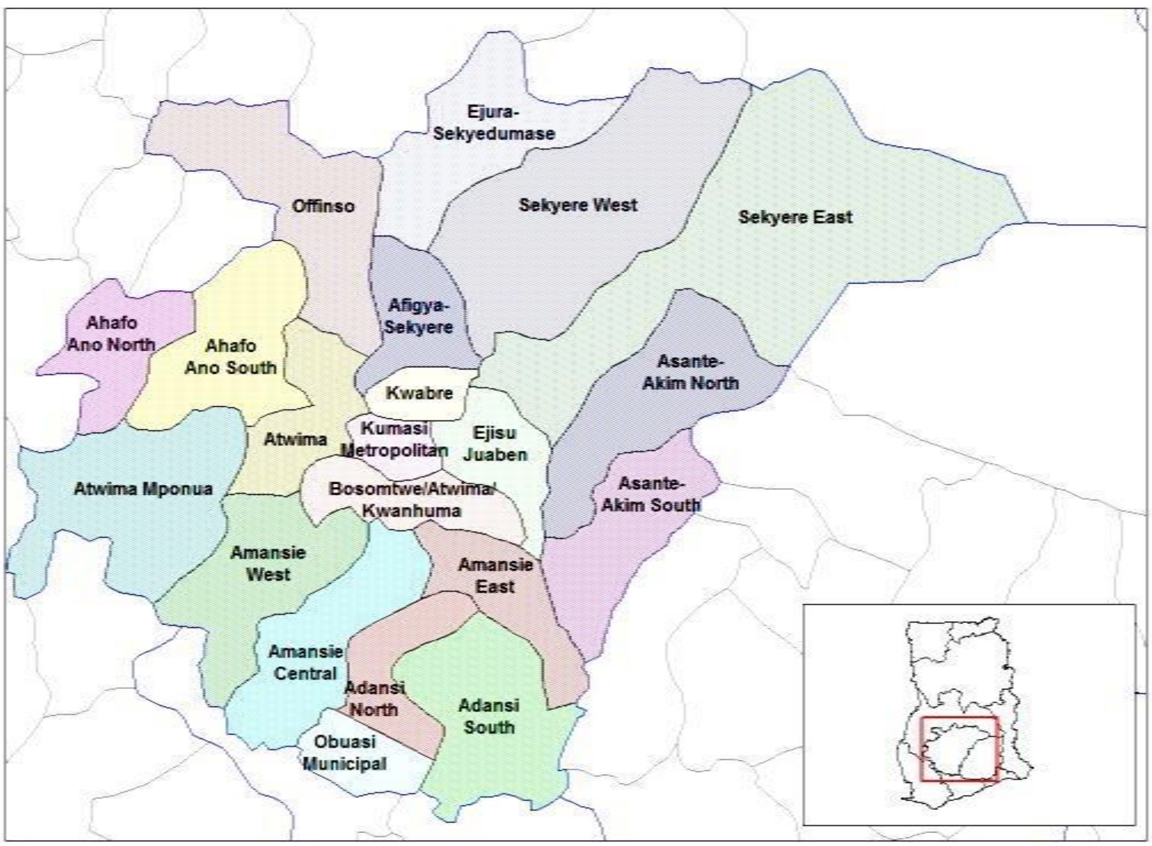


Fig. 3.1.1: **Map of Ashanti Region, Showing the Study Areas**

3.2 STUDY TWO: THE POTENTIAL OF INDIGENOUS NAKED NECK (*NaNa, Nana*) AND FRIZZLE (*FF*, *Ff*) BIRDS

3.2.1 Study Areas and Duration

The study was conducted in the Ashanti region of Ghana. Three districts, namely: Asante–Akim South (AAS), Bosomtwe Atwima-Kwanwoma (BAK) and Ejisu-Juaben (EJ), were convieniently selected for the survey. Three villages/towns were selected based on convienience from each district (AAS – Juaso, Yawkwei and Nkwanta; BAK – Jachie, Kuntananse and Abono; EJ – Kwamo, Ejisu and Kwaso) and ten chicken keepers within each village/town were randomly selected and interviewed. Therefore, a total of thirty chicken keepers from each district and a grand total of ninety chicken keepers were involved in the study. The study lasted for two months: from December 20, 2005 to February 16, 2006

3.2.2 Data Collection

The study was done through formal and informal interviews. Participatory Rural Appraisal (PRA) tools were also employed in some situations. The formal interviews were aided by a structured questionnaire (Appendix 1B), which had both pre-coded and open-ended questions. Information ascertained included percentage of frizzle (*FF*, *Ff*), naked neck (*NaNa*, *Nana*) and normal feathered birds in the flock. Weights of birds and eggs, number of eggs per clutch, clutches per year, average number of eggs per year, hatchability of eggs, egg quality parameters, carcass parameters, chick mortality and total mortality were measured for each phenotype (naked neck, frizzle and normal feathered).

3.2.2.1 Weights of Birds and Eggs

Day-old chicks of each phenotype (*Nana*, *Ff*, *nanaff*) were not available during the survey and therefore average weight of chicks within the first five days of life was used as the weight of chicks for each of the phenotypes. Average weights of males and females not less than six months of age were taken as the average age of cocks and hens respectively for each phenotype. All the eggs available for each phenotype were weighed and the averages were taken as the weight of eggs. These parameters were assessed with the assistance of the keepers.

3.2.2.2 Mortality

Chick mortality was measured as the percentage of chicks that died within the first six weeks of life for each phenotype (*Nana*, *Ff*, *nanaff*). Total mortality was calculated as the percentage of birds that did not survive to the end of their useful lives for each of the phenotypes.

3.2.2.3 Egg Quality Parameters

Egg quality parameters measured included shell thickness, albumen height, yolk height, yolk diameter, yolk colour score and Haugh unit. Fifteen eggs from each phenotype within each district were randomly selected and the various egg quality parameters were determined at the laboratory of the Department of Physics, KNUST, Kumasi. The eggs were weighed, broken and gently poured on a plastic plate so as to have the thick albumen and the yolk at their normal positions. After breaking the eggs for albumen height, the remaining liquid inside the eggshells was washed out manually, membranes were removed, and the shells were dried at room temperature (21-27°C) for one week before measuring the shell thickness. To obtain the average value of eggshell thickness, 2 points along the egg equator and 2 points at the egg poles were selected for each eggshell. Electronic digital balance was used to measure egg weight; micrometer screw-gauge was used to measure shell thickness; spherometer was used to measure albumen height and yolk height; straight rule was used to measure yolk diameter and yolk colour score fan was used to measure yolk colour score. Haugh unit was calculated from egg weight and albumen height using the formula:

HU= [100Log (HA-/G (30W $^{0.37}$-100)) +19]/100 (Panda, 1996)

Where,

HU = Haugh unit

HA = observed albumen height (mm).

G = gravitational constant, 32.2

W = observed weight of egg.

This procedure used in measuring egg quality parameters was repeated in Studies 3, 5 and 5

3.2.2.4 <u>Carcass Parameters</u>

Two cocks which were six months old from each phenotype within each district were randomly selected. The birds were starved for twelve hours, slaughtered, bled, scalded, defeathered, eviscerated and then cut into parts. The gizzard and the intestines were emptied before weighing. The following carcass parameters were measured: defeathered weight, dressed weight, breast muscle weight, thigh and drum stick weight, wing weight, intestine weight, gizzard weight and liver weight. These parameters were expressed as a percentage of live weight before slaughter. This was repeated in studies 3, 4 and 5

3.2.3 Analysis of Data

The data were analyzed using the following linear models; Egg

Production Parameters:

$Y_{ij} = \mu + G_i + D_j + E_{ij}$

Where Y_{ij} = Observation for a given variable μ =

Overall general mean common to all observations G_i

= Genetic effect due to ith genotype (i= 1, 2, 3)

D_j = Environmental effect due to jth district (j = 1, 2, 3)

E_{ij} = Random error effects peculiar to each observation.

Growth Parameters, Egg quality parameters, Carcass Parameters and Mortality:

$Y_i = \mu + G_i + E_i$

Where Yi = Observation for a given variable μ =

Overall general mean common to all observations

G_i = Genetic effect due to jth genotype (i= 1, 2, 3)

E_i = Random error effects peculiar to each observation.

Analysis of variance (ANOVA) was performed by using Genstat Software (2007).

3.3 STUDY THREE: MATING COMMERCIAL LAYERS (*nana*) WITH LOCAL NAKED NECK MALES (*Nana*), AND COMPARING THE PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF THE FIRST AND SECOND FILIAL GENERATION (F1 & F2) NAKED NECK BIRDS (*NaNa*, *Nana*) WITH THEIR NORMAL FEATHERED (*nana*) COUNTERPARTS

3.3.1 Location and Duration of Experiment

The experiment was carried out at the Animal Science Department, Kwame Nkrumah

University of Science and Technology (KNUST), Kumasi (Altitude 261.4MSL, Latitude 06° 41'N and Longitude 01° 33'W), (Meteorological Services Department, Kumasi); and three selected villages/towns within the Asante-Akim South District of Ashanti Region, namely, Yawkwei, Juaso and Nkwanta. These villages were selected based on convienience and availability of reliable chicken keepers. The average rainfall, temperature and relative humidity of the KNUST experimental station during the experimental months are presented in Appendix 3

The experiment extended from May, 2006 to December, 2007. This also applies to studies 4 and 5

3.3.2 Experimental Birds

Thirty-six (36) Lohman brown layers and four (4) indigenous heterozygous naked neck (*Nana*) males were used in the initial crossing. The Lohmann layers were received from Akate Farms Limited, Kumasi at the age of 52 weeks. The local naked neck males were bought from four different villages/towns/cities within the Asante-Akim South District and Kumasi Metropolitan Area of Ashanti Region, namely, Yawkwei, Juaso, Nkwanta and Kumasi (Central Market). The four sires varied in colour, which helped in their identification. The sires were between nine and fourteen months of age.

The indigenous naked neck males were feet-washed with disinfectant to avoid spread of infections before they were brought to the Animal Science Department, K.N.U.S.T. The naked neck males were dewormed and vaccinated against Newcastle disease (Newcavac). All birds were weighed individually. The indigenous naked neck males were then housed with the Lohman layers in a ratio of 1:9 to ensure natural mating.

3.3.2.1 Management

The birds were kept in a deep litter system for three months. They were fed layer mash *ad-libitum* (17.5% CP and 2700 kcal ME/kg) and were also provided with fresh water *ad libitum*. Each of the four pens had two laying boxes measuring 30 cm x 30 cm. Eggs were collected twice daily, labelled and stored for not more than 7 days at room temperature (21^{o} C to 27^{o} C) before incubation.

The birds were dusted with Malathion poultry dust (Kepro, Netherlands) against lice, soft ticks and mites. They were also dewormed and given Pen Strip (Kepro, Netherlands), which is a source of antibiotic and vitamins. This applies to the second parents and also studies 4 and 5.

3.3.2.2 Incubation

The eggs were selected for artificial incubation by discarding very small eggs or very large eggs, broken shells, blood stained or dirty eggs. The eggs were incubated and hatched at the hatchery of Akropong Farms, a commercial hatchery based in Kumasi. The incubation was done weekly for ten consecutive weeks. This applies the generation of the F_2 birds and also study 4.

3.3.2.3 Chick Rearing

After hatching, each batch of chicks was brooded in one unit of the brooder house. Electric bulbs (100watts) were used to provide light and the required heat for the chicks. The chicks were wing-tagged and weighed individually. Glucose was administered via the drinking water. Commercial chick mash from AGRICARE Ghana Ltd. (19.5%CP and 2800Kcal ME /Kg) and fresh drinking water were given *ad libitum*. The chicks were vaccinated against Newcastle and gumboro diseases. Coccidiostat, antibiotics and vitamins were also given through their drinking water during the first month. The growth rates of chicks were recorded weekly up to the sixth-week. This apply to the F_2 birds and also in study 4.

3.3.2.4 Parents for the Second Generation Birds

At the end of the sixth week, twenty (20) heterozygous naked neck males and onehundred and twenty (120) heterozygous naked neck females were selected to be mated *inter se* to produce the second generation. The males were kept separately from the females. The birds were fed commercial grower mash from AGRICARE Ghana Ltd.
(15% CP and 2650 kcal ME/Kg) at six weeks of age and layer mash (from AGRICARE Ghana Ltd) at seventeen weeks of age (17.5% CP and 2700 kcal ME/kg). Feed and fresh water were given *ad libitum.* They were vaccinated against fowl pox and
Newcastle (Newcavac) diseases. Deworming and vitamin supplementation was done after every three months via their drinking water. Four weeks after the first egg has been laid, the males were introduced to the females in a ratio of 1:10; and collection of eggs for incubation took place two weeks thereafter. Chicks were reared up to six weeks. After the sixth week, these second filial generation (F_2) birds were transferred to the three villages mentioned in section 3.1. This is also applicable to study 4.

3.3.2.5 Matings Involving Indigenous Naked Neck and Commercial Layers

There were two crosses. The first cross was between 36 normal feathered Lohmann layers (*nana*) and 4 indigenous heterozygous naked neck males (*Nana*), producing offspring that were 48.7% heterozygous naked neck (*Nana*) and 51.3% normal feathered birds (*nana*) in the first filial generation (F_1). The second cross was an *inter se* mating of the heterozygous naked necks (*Nana*) from the F_1 generation. The second cross produced offspring that were 16.8% homozygous naked neck (*NaNa*), 54.5% heterozygous naked neck (*Nana*) and 28.7% normal feathered (*nana/ff*) birds. Both F1 and F2 birds were made up full-sib and half-sib sire families but due to the difficult of separating these, they were reared together as sire families. The two crosses are diagrammatically shown below:

First Mating	**Second Mating**
First Parents (P_1): Male Female	Second Parents (P_2): Male Female
(Indigenous) *Nana* × *nana* (Lohmann)	*Nana* × *Nana* (*inter se*)
↓	↓
(48.7%) *Nana* (51.3%) *nana* (F_1)	(16.8%) *NaNa* (54.5%) 2*Nana* (28.7%) *nana* (F_2)

3.3.2.6 <u>Selection and Training of Chicken Keepers</u>

The chicken keepers used for the study were selected prior to the study. The selection was done during an earlier survey to assess the performance of local chickens in Ghana. Six keepers were selected from each of the three villages/town (Yawkwei, Juaso and Nkwanta). The selection was based on the ability to read and write, reliability and also interest in keeping local birds. Each keeper made a hen-coop or prepared a place for the birds and these were inspected prior to the transfer of the birds.

A top-loader weighing scale was given to each keeper. They were trained on simple poultry management practices such as feeding and giving water under sanitary conditions, culling, litter changing, maintaining clean coop, recording age at first egg and counting of the number of eggs per clutch. To quantify the amount of feed given daily, each keeper was made to use a single container filled to the brim for giving feed all the time. This section applies also to studies 4 and 5

3.3.2.7 Chick Transfer and Rearing at the Villages

At the end of the sixth week, the chicks were transferred to the villages for rearing under, semi-intensive system. Each keeper was first given 48 F_1 birds, 12 from each of the four males, and these twelve birds, from each male, were made up of three males and three females each of heterozygous naked neck and normal feathered birds. For the second generation birds (F_2) each keeper was given the same number of birds (48), 16 from each of the three genotypes (homozygous naked neck, heterozygous naked neck and normal feathered). There were eight males (8) and eight females (8) for each phenotype.

The keepers kept the birds either in a locally designed hen-coop or in an uncompleted building that is roofed, in which case the cemented floor was covered with wood shavings. Each keeper was guided to prepare his own mash to supplement scavenging feeds. The mash was prepared mainly from milled-maize or milling waste mixed with smoked fish waste, palm kernel cake and wheat bran. The mash was given to the birds thrice daily. Fresh water was provided *ad libitum* either in a plastic bowl or an earthen ware pot. All the keepers put "prekese" (*Tetrapleura tetraptera*), which is considered to have medicinal properties in the water. The section applies to study 4.

3.3.3 Data Collection

3.3.3.1 Performance of the First Parents (P_1)

Ages of the indigenous heterozygous naked neck males used as the First Parents (P_1) were estimated with the help of the keepers; and their initial body weights were taken prior to the mating. Other records taken on them included biweekly body weight, fertility and hatchability. Records taken on the Lohmann layers used as the First Female Parents (P_1) included initial body weight, biweekly body weight, rate of lay, egg weight and hatchability. Record on their age was obtained from Akate Farms and Trading Company Limited. This is repeated for the second parents and also in study 4.

3.3.1.1 Fertility and Hatchability

The incubated eggs were candled on the eighteenth day, and fertility was calculated as a percentage of the number of fertile eggs divided by the number of eggs set. The hatch was pulled on the twenty-first day and the hatchability calculated as the total number of chicks hatched divided by total fertile eggs set multiplied by hundred. This is applicable to the F_2 parents and also in study 4.

3.3.3.2 First Filial Generation (F_1) Birds

Records on the F_1 birds were taken up to sixth week at the Department of Animal Science, K.N.U.S.T., Kumasi and continued in the villages when the birds were transferred except those used as parents (P_2) in the second mating which remained at the Department of Animal Science. The records taken included weight of day-old chicks, weekly body weight and weight gain (this was done up to sexual maturity), shank length, body length, body width, chick mortality, total mortality, age at first egg, rate of lay (hen-housed and hen-day), egg weight, clutch size, bi-weekly body weight of layers, egg and body weight ratio, carcass parameters and egg quality parameters. This applies also to F_2 birds and studies 4 and 5.

3.3.3.2.1 Weights of Birds and Eggs, and Body Weight Gain

An electronic digital balance (Shenyang Longteng Electronic Co. Ltd., Taiwan) was used in weighing chicks and eggs. Chicks were weighed individually. Ten eggs from heterozygous naked neck layers and normal feathered ones in each sire group from each village were weighed individually and averages taken. Pullets, cockerels and matured birds were weighed with a top-loader scale. The body weight gain for each week was calculated by subtracting the previous week's weight from the current week's weight. The weight gain from day-old to sexual maturity was used to study the growth pattern of each phenotype. The same methodology was appliede in F_2 birds and also studies 4 and 5.

3.3.3.2.2 Body Length, Body Width and Shank Length

These were measured when the birds were 20 weeks of age. A measuring tape was used for the measurements. The shank length (SL) was taken as the length of the *tarsometatarsus* from the *hock* joint to the *metatarsal* pad, and the body length (BL) was between the tip of the *Rostrum maxillare* (beak) and that of the *Cauda* (tail, without feathers). Body width (BW) was measured as the distance between the two shoulders. Ten birds from each phenotype within each male line from each village, were measured and the total value obtained was divided by ten to get the average value per bird. This is applicable to F_2 birds and studies 4 and 5.

3.3.3.2.3 Egg Production

The average age at first egg was measured as the ages at which pullets from each phenotype laid their first eggs. The number of eggs per clutch was estimated by counting the number of consecutive eggs laid by individual layers before a pause in laying. All the eggs laid were recorded daily for six months period. Egg production was calculated in terms of rate of lay i.e. percentage of the total number of eggs produced divided by the total number of hens alive per day (hen-day), or divided by the total number of hens housed (hen-housed). These methods were applied in F_2 birds and studies 4 and 5.

3.3.3.2.4 Egg and Body Weight Ratio

This was determined as the ratio of egg weight to the body weight of the layer. Three eggs each collected from three layers selected from each phenotype within each sire group from each village were used in calculating the ratio. This was repeated in the F_2 generation and also studies 4 and 5.

3.3.3.2.5 Mortality

Chick mortality and total mortality were estimated. Chick mortality was estimated as the percentage of chicks that died from day-old till the end of the sixth week. Total mortality was calculated as the percentage of birds that died between day-old and the end of the experiment. It was repeated in the F_2 and also studies 4 and 5.

3.3.3.2.6 Egg Quality Analysis

The egg quality analysis was done twice. In each village, five eggs from each phenotype within each sire family were selected at random and used for the analysis. This was repeated in the F_2 and in studies 4 and 5.

3.3.3.2.7 Carcass Analysis

The carass parameters were taken only on six-months old males. In each village, two cocks from each phenotype (*Nana* and *nana*) within each sire family (N1-N4) were selected at random and used for the carcass analysis. This was repeated in the F_2 and in studies 4 and 5.

3.3.3.4 Performance of Second Filial Generation (F_2) Birds

There were three phenotypic groups in the F_2 generation, namely, homozygous naked neck, heterozygous naked neck and the normal feathered birds.

3.3.4 Statistical Analysis

Genstat software (2007) was used to estimate the means and standard deviations of the performance data on the first and second parental generations.

The data on F_1 birds for the comparative studies (between *Nana* & *nana*) was analyzed using the following linear models; Egg Production Parameters:

$Y_{ijkl} = \mu + B_i + V_j + G_k + L_l + E_{ijkl}$ Where

Y_{ijkl} = Observation for a given variable μ = Overall general mean common to all observations

B_i = The environmental effect of ith hatch (I = 1, 2, 3, 4, 5)

V_j = Environmental effect due to ith village (j=1, 2, 3)

G_k = Genetic effect due to jth phenotype (k=1, 2)

L_l = Genetic effect due to kth sire (l= 1, 2, 3, 4)

E_{ijkl} = random error effects peculiar to each observation.

Growth Parameters, Body Measurements, Egg Quality Parameters, Carcass Parameters and Mortality:

$Y_{ijk} = \mu + B_i + S_j^* + G_k + E_{ijk}$

Where Y_{ijk} = Observation for a given variable μ = Overall general mean common to all observations

B_i = Environmental effect due to ith hatch (I = 1, 2, 3, 4, 5)

S_j = Genetic effect due jth sex (j = 1, 2)

G_k = Genetic effect due to jth genotype (k=1, 2)

E_{ijk} = random error effects peculiar to each observation.

S_j^* - Not applicable to egg quality and carcass parameters

The data on F_2 birds for the comparative studies (between *NaNa, Nana* & *nana*) was analyzed using the following linear models:

Egg Production Parameters:

$Y_{ijk} = \mu + B_i + V_j + G_k + E_{ijk}$

Where Y_{ijk} = Observation for a given variable μ =

Overall general mean common to all observations

B_i = Environmental effect due ith hatch (i = 1, 2, 3, 4, 5)

V_j = Environmental effect due to ith village (j=1, 2, 3)

G_k = Genetic effect due to jth genotype (k=1, 2, 3)

E_{ijk}= random error effects peculiar to each observation.

Growth Parameters, Body Measurements, Egg Quality Parameters, Carcass Parameters and Mortality:

$$Y_{ijk} = \mu + B_i + S_j + G_k + E_{ijk}$$

Where Y_{ijk} = Observation for a given variable μ =

Overall general mean common to all observations

B_i = Environmental effect due to ith hatch (I = 1, 2, 3, 4, 5)

S_j = Genetic effect due jth sex (j = 1, 2)

G_k = Genetic effect due to jth genotype (k=1, 2)

E_{ijk} = random error effects peculiar to each observation.

S_j^* - Not applicable to egg quality and carcass parameters

Analysis of variance (ANOVA) was performed using Genstat Software (2007).

3.4 STUDY FOUR: CROSSBREEDING BETWEEN INDIGENOUS FRIZZLE MALES (Ff) AND COMMERCIAL LAYERS (ff), AND COMPARING THE FIRST AND SECOND FILIAL GENERATION BIRDS IN SOME TRAITS OF ECONOMIC IMPORTANCE

3.4.1 Experimental Birds

Five (5) indigenous frizzle males and forty (40) Lohmann layers were used for the initial mating. The layers were received from Akate Farms and Trading Company Limited, Kumasi; and the indigenous frizzle males were bought from three different villages/towns within the Asante-Akim South District of Ashanti, namely, Yawkwei, Juaso and Nkwanta.

The indigenous frizzle males were feet-washed with disinfectant before they were brought to the Department of Animal Science, K.N.U.S.T. to avoid spread of infection in case there any. They were housed separately for two-weeks during which they were dewormed and then vaccinated with Newcastle Disease Vaccine (Newcavac). All birds were weighed individually. The indigenous frizzle males were then crossed with the Lohman layers in a ratio of 1:8.

3.4.2 Second Parental Generation (P_2)

These parents were selected heterozygous frizzle birds from the F_1 generation. They were reared and mated *inter se*.

3.4.3 Mating

P_1: (Indigenous) *Ff* × *ff* (Lohmann) **P_2:** *Ff* × *Ff* (*inter se*)

This mating involved indigenous heterozygous frizzle and commercial layers, and also F_1 heterozygous frizzles in the first and second mating respectively. The offspring in both F1 and F2 were made of full-sib and half-sib sire families but due to the difficult in separating these, they were reared together as sire families.The two crosses are described below:

Mating 1 **Mating 2**

Male Female Male Female

(50.2%) *Ff* (49.8%) *ff* (F_1) (22.4%) *FF* (51.5%) 2*Ff* (26.1%) *ff* (F_2)

3.4.4 Transfer of Chicks and Rearing at the Villages

In the F1 generation heterozygous frizzle and normal feathered birds were involved in the first transfer to the villages. And in the second transfer, F_2 homozygous frizzle, heterozygous frizzle and normal feathered birds were involved.

3.4.5 Egg Quality Analysis

The egg quality analysis was done twice for F_1 heterozygous frizzle and normal feathered birds within each of the five sire families from each of the three villages. In each village, five eggs from each phenotype within each sire group were selected at random and used for the analysis.

3.4.6 Carcass Analysis

The carcass parameters were taken only on the males when they were six months old. In each village, two cocks from each phenotype (*Ff* and *ff*) within each sire group (F1-F5) were selected at random and used for the carcass analysis.

3.4.7 Second Filial Generation (F_2) Birds

In the F_2 generation, data was taken on homozygous frizzle (*FF*), heterozygous frizzle (*Ff*) and normal feathered (*ff*) birds in each village.

3.4.8 Statistical Analysis

Genstat software (2007) was used to estimate the means and standard deviations of the performance data on the first and second generation parents.

The data on F_1 birds for the comparative studies (between *Nana* & *nana*) was analyzed using the following linear models; Egg Production Parameters:

$$Y_{ijkl} = \mu + B_i + V_j + G_k + L_l + E_{ijkl}$$ Where

Y_{ijkl} = Observation for a given variable μ = Overall general mean common to all observations

B_i = The environmental effect of ith hatch (I = 1, 2, 3, 4, 5)

V_j = Environmental effect due to ith village (j=1, 2, 3)

G_k = Genetic effect due to jth phenotype (k=1, 2)

L_l = Genetic effect due to kth sire (l= 1, 2, 3, 4)

E_{ijkl} = random error effects peculiar to each observation.

Growth Parameters, Body Measurements, Egg Quality Parameters, Carcass Parameters and Mortality:

$$Y_{ijk} = \mu + B_i + S_j^* + G_k + E_{ijk}$$

Where Y_{ijk} = Observation for a given variable μ = Overall general mean common to all observations

B_i = Environmental effect due to ith hatch (I = 1, 2, 3, 4, 5)

S_j = Genetic effect due jth sex (j = 1, 2)

G_k = Genetic effect due to jth genotype (k=1, 2)

E_{ijk} = random error effects peculiar to each observation.

S_j^* - Not applicable to egg quality and carcass parameters

The data on F_2 birds for the comparative studies (between *NaNa, Nana* & *nana*) was analyzed using the following linear models:

Egg Production Parameters:

$Y_{ijk} = \mu + B_i + V_j + G_k + E_{ijk}$

Where Y_{ijk} = Observation for a given variable μ = Overall general mean common to all observations

B_i = Environmental effect due ith hatch (i = 1, 2, 3, 4, 5)

V_j = Environmental effect due to ith village (j=1, 2, 3)

G_k = Genetic effect due to jth genotype (k=1, 2, 3)

E_{ijk}= random error effects peculiar to each observation.

Growth Parameters, Body Measurements, Egg Quality Parameters, Carcass Parameters and Mortality:

$$Y_{ijk} = \mu + B_i + S_j + G_k + E_{ijk}$$

Where Y_{ijk} = Observation for a given variable μ = Overall general mean common to all observations

B_i = Environmental effect due to ith hatch (I = 1, 2, 3, 4, 5)

S_j = Genetic effect due jth sex (j = 1, 2)

G_k = Genetic effect due to jth genotype (k=1, 2)

E_{ijk} = random error effects peculiar to each observation.

S_j^* - Not applicable to egg quality and carcass parameters

Analysis of variance (ANOVA) was performed using Genstat Software (2007).

3.5 STUDY FIVE: COMPARING THE PRODUCTIVE AND REPRODUCTIVE PERFORMANCE AND PROFIT MARGIN OF REARING NAKED NECK (NaNa, Nana), FRIZZLE (FF, Ff) AND NORMAL FEATHERED (nanaff) BIRDS UNDER INTENSIVE, SEMI-INTENSIVE AND EXTENSIVE MANAGEMENT SYSTEMS

3.5.1 Location and Duration of Experiment

Nine keepers were selected in each of the three villages (Yawkwei, Juaso and Nkwanta). These selected keepers were grouped into three with each group consisting of three keepers. The first, second and third groups reared their birds under intensive, semi-intensive and extensive systems respectively.

The experiment started in July, 2006 and ended in December, 2007.

3.5.2 Experimental Birds

The second filial generation birds from experiments three and four were used for this experiment. The chicks were reared at the Animal Science Department, K.N.U.S.T for six weeks and then transferred to the various villages to be reared under the various management systems. There were nine keepers in each of the three villages. Three of these keepers in each of the three villages reared their birds under one of the three management systems (Extensive, Semi-intensive & Intensive). Each keeper was given eighty (80) birds, 16 from each of the five genotypes (*NaNa*, *Nana*, *FF*, *Ff* & *nana/ff*). There were eight males (8) and eight females (8) for each phenotype.

3.5.3 Rearing of Birds under the Various Management Systems

3.5.3.1 Intensive System

Almost all the keepers who rear their birds under this system used an uncompleted building that is roofed to house the birds. The floors were cemented and covered with wood shavings. Commercial poultry mash for growers (15% CP and 2650 kcal ME/kg) and layers (17.5% CP and 2700 kcal ME/kg) from AGRICARE Ghana Limited were used. Feed and water were provided *ad libitum.* Dewormers and vitamins were given intermittently.

3.5.3.2 Semi-intensive System

The keepers who reared their birds under this system had a coop outside or inside the house. Some of the houses were compound houses with gates and others were without fence and gates. Feed was given to the birds three or four times daily either in the coop or at the courtyard of the house. The feed was supplemented with green leaves such as 'kontomire'. Fresh water was given *ad libitum* via a plastic bowl or earthen ware pot either in the coop or at the courtyard of the fenced- house. The feed given was a local mash prepared with available ingredients (see Table 3.1 for the composition of the Local Mash). An antibiotic was given when the birds were sick. The birds were opened once or twice a day to scavenge in and around the house with the supervision of the keeper or any member of the family.

Table 3.1: Composition of the Local Mash

Ingredients	Quantity Used (%)

Maize	63
Wheat bran	13.5
Palm Kernel Cake	13
Dried Fish Waste	10
Salt	0.5
Calculated: CP=13.7%, ME= 2726.8 kcal/kg and CF= 4.75%	

Fig. 3.5.6 shows the shed used for confining birds under this system and the locally prepared mash.

Fig. 3.5.1: Structures used under this system, the locally prepared Mash and birds being fed

3.5.3.3 <u>Extensive System</u>

Birds reared under this system scavenged for their own feed. A little feed (30g per bird per day), which was either milled corn or milling waste or a mixture of milled corn and dried fish waste, was given in the morning before the birds went out for scavenging. Water was provided *ad libitum* in the courtyard. In the evening, the birds roosted either in a coop outside the house or in the family kitchen. Anti-biotic was given in case of sickness.

3.5.4 Data Collection

In addition to productive and reproductive data, the profit margin for rearing the birds under each of the management systems was also determined.

3.5.4.1 Profit Margin

The profit margins for rearing the birds under each of the management systems were calculated by computing the cost of rearing under each management system and subtracting it from the total receipts of meat and eggs sales. The total cost involved the cost of purchasing feed and drugs.

3.5.5 Statistical Analysis

All data were analyzed using the following linear model:

$Y_{ijkl} = \mu + B_i + S_{j*} + G_k + M_l + E_{ijkl}$

Where Y_{ijkl} = Observation for a given variable μ = Overall general mean common to all observations B_i = Environmental effect due to ith hatch (I = 1, 2, 3, 4, 5)

S_j = Genetic effect due jth sex (j = 1, 2)

G_k = Genetic effect due to ith genotype (k=1, 2, 3, 4, 5)

M_l = Environmental effect due to jth management system (l= 1, 2, 3,) E_{ijkl} = random error effects peculiar to each observation.

S_j^* - Not applicable to egg quality and carcass parameters

ANOVA was performed using Genstat Software (2007).

CHAPTER FOUR

4.0 RESULTS

4.1 STUDY ONE

4.1.1 Number of Years in Local Chicken Production

On the averagely, the 135 local chicken keepers within Bosomtwe Atwima-Kwanwoma, Ashanti-Akim South and Ejisu-Juaben districts in the Ashanti Region of Ghana have been rearing local birds for 24 years (Table 4.1.1). However, 68% of the chicken keepers interviewed said they were given local birds to own by their grandparents or parents when they were in basic schools. They would sell their surplus eggs and cocks and either use the money for schooling or save it for clothes during Christmas.

4.1.2 Management

4.1.2.1 Flock Sizes

The average flock size kept by the chicken keepers was 22.0, in the ratio of 4: 6: 12 for cocks, hens, and chicks respectively. However, the flock sizes of individual keepers among the respondents varied greatly (Table 4.1.1).

4.1.2.2 Management System

All the respondents were practicing the extensive system of management where the birds scavenge throughout the day. A supplementary feed was given to the chicks or to the whole flock either in the morning or in the evening and it was given everyday or occasionally. The feed was normally provided in an improvised feeder, or in a small coop, or on a piece of old roofing sheet or on the kitchen floor.

Table 4.1.1: Performance of Local Chickens in the Ashanti Region of Ghana

PARAMETERS	AVERAGE VALUE	RANGE	STANDARD ERROR
Years in chicken production	24.00	4 - 50	6.5720
Flock size	22.00	6 - 60	6.8804
Weight of Birds and Egg			
Cock# (kg)	1.55	1.2 - 2.3	1.5212
Hen# (kg)	1.13	0.9 - 1.6	1.848
Chick (g)	35.0	30 - 38.5	2.8692
Egg (g)	42.8	38 - 49	2.9578
Layers and their performance			
No. of layers	8.0	2 - 20	3.7937
Clutches/year	2.5	2 - 3	
Eggs/Clutch		9 - 13	
Eggs/bird/year		20 - 40	
Hatchability (%)	77	65 - 100	
Health of Birds			
Chick Survivability (%)	50	30-90	
General Mortality (%)	65	50-100	
Economics of Production			
Cost of Prod./yr (GH¢)	20*	2-350	
Price of Cock# (GH¢)		2.5-5.0	
Price of Hen# (GH¢)		1.5-4.0	
Price of an Egg (GHp)		7.0-10.0	
No. of Birds sold/year	8.05	2-20	5.4132
Profit/year (GH¢)		8.0-30.0	

These are matured ones (>5months of age). * Most of the villagers used maize from their own farms as supplementary feed, so, the quantity and cost was estimated by using market price

In the evening, the birds were either kept in a part of the kitchen or in a coop or they roosted on trees. The coops were wooden or bamboo structures.

4.1.2.3 Types of Feed Supplements

Among the 135 respondents, 90 (66.67%) provided feed supplement while 45 (33.33%) did not. Among those who provided supplement 54 (60%) offered whole maize as feed supplement, 22 (24.44%) gave maize bran and 14 (15.56%) supplied milled maize and waste of dried herrings.

4.1.2.4 Health of Birds

4.1.2.4.1 Survivability of Chicks and Total Mortality

Among the indigenous local fowls, 50% of the chicks hatched died before they reached cockerel or pullet stage and annually 65% of the entire flock die before the keeper could reap any benefits in terms of meat or eggs.

4.1.2.4.2 Disease Control

Keepers of local chickens in the Ashanti Region of Ghana have various methods of preventing or controlling diseases. These methods can be ranked in a descending order of preference as shown in the Table 4.1.2.

Table 4.1.2: Rankings of Various Methods Used for Preventing/Controlling Diseases

Method	Number	%	Rank
Using tetracycline and B- complex	122	90.37	1

Use of Ethno-veterinary medication such as ‘prekese’, pawpaw leaves, and back and leaves of mango tree	94	69.63	2
Slaughter the sick one if matured (culling)	68	50.37	3
Doing nothing about it	43	31.85	4
Using veterinary drugs prescribed by the district’s veterinary officer	3	2.22	5

The local chicken keeper will make use of one of these alternatives in an attempt to prevent/control diseases. Ninety percent (90%) of those interviewed had given tetracycline or B- complex to their sick birds before. Another alternative was ethnoveterinary medicines; some put either ‘prekese’ or the bark of mango trees in water for the birds, and others will rub mango or pawpaw leaves between their palms in water and give this to them in drinking water. On some occasions, people choose to slaughter their matured sick birds, or just leave the bird without treatment to either die or survive by itself. Two percent (2%) of the respondents said they contacted the veterinary officer for treatment of their sick birds.

4.1.3 Performance

4.1.3.1 Weight of Birds and Eggs

The average weights of local cocks, hens, chicks and eggs were 1.55 kg, 1.13 kg, 35 g and 42.8 g respectively. The average weights of birds and eggs are shown in Fig. 4.1.2.

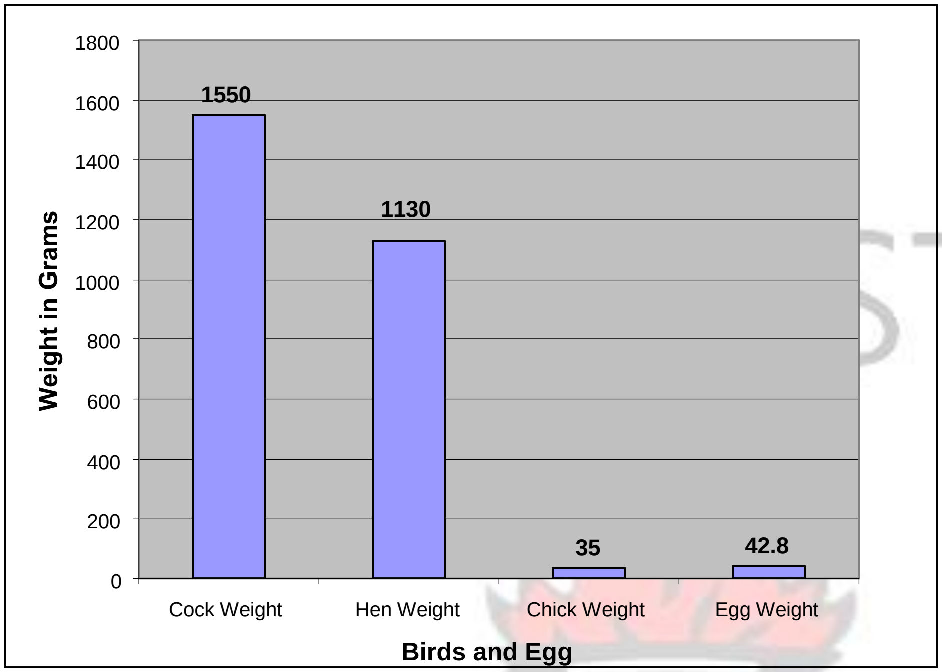


Fig. 4.1.1: A Bar Chart Showing the Body and Egg Weights of Local Birds

4.1.3.2 Number of Layers and their Performance

The number of laying hens kept per chicken keeper in the three districts averaged eight (8) with a range of 2 to 20 (Table 4.1.1). The number of clutches per year ranged from two to three. The number of eggs per hen per clutch ranged from 9 to 13, and the number of eggs per hen per year was between 20 and 40. Percentage of eggs hatched averaged 77%.

4.1.3.3 Economics of Production

The price of a cock ranged between two Ghana cedis and fifty pesewas, and five Ghana cedis (GH¢2.50 - GH¢5.00); while that of a hen ranged between one and half, and four Ghana cedis (GH¢1.50 - GH¢4.00). An egg was sold between seven and ten Ghana pesewas (GHp7.00 - GHp10.00). Anually, each chicken keeper spends between two and thirty five Ghana cedis (GH¢2.00 - GH¢35.00) on production and sells an average of eight birds. Profit received per year ranged between eight and thirty Ghana cedis (GH¢8.00-GH¢30.00).

4.1.4 Reasons for Keeping Local Birds

The various reasons why local birds were kept by keepers can be ranked in a descending order of preference from 1 to 6 as shown in Table 4.1.3:

Table 4.1.3 Ranking of Reasons for Keeping Local Birds

Reason	Number	Percentage, %	Rank
Home Consumption	135	100.00	1
Sell for money	118	87.41	2
Honour Guest	98	72.59	3
Use for rituals	65	48.15	4
Aesthetic value	16	11.85	5
Announce the presence of dangerous animals such as snakes	2	1.48	6

4.1.6 Challenges in Local Chicken Production and Suggested Solutions

4.1.6.1 Challenges

Local chicken production in Ghana is faced with various challenges and these have been ranked from 1 to 4 in descending order of intensity and seriousness, in Table 4.1.4.

Table 4.1.4: Rankings of Various Challenges Facing Local Chicken Production in Ghana

Problem	Number	%	Rank
Diseases, Predators and Theft	130	96.30	1

Lack of Funds for increasing stock and putting up structures	122	90.37	2
Small sizes of birds and eggs, and smaller numbers of eggs laid	87	64.44	3
Low fertility of eggs	11	8.15	4

Diseases such as Newcastle disease, coccidiosis and fowl pox; predators such as hawks, crows, snakes, foxes and dogs, and theft were pertinent problems for all the respondents. Other problems mentioned were lack of funds to purchase new stock, feed supplement, and to build bigger coops; small sizes of birds and eggs and low numbers of eggs laid per bird per year were also mentioned. Eight percent (8%) had problems with fertility of eggs, however, 3% of the respondents did not have any problems at all.

4.1.6.2 Solutions

The suggested solutions by the respondents to the problems outlined have been ranked below (Table 4.1.5) in descending order of urgency from 1 to 5:

Table 4.1.5: Ranking of Suggested Solutions to the Challenges Faced by Local Chicken Keepers

Solutions	Number	%	Rank
Confining birds to protect them from predators	132	97.78	1
Produce disease resistant breeds	128	94.81	2
Provision of funds to increase production	115	85.19	3
Develop breeds with improved meat and eggs production	98	72.59	4
Availability of a low-cost local concentrate	62	45.93	5

4.2 STUDY TWO

4.2.1 Percentage of Naked Neck (*Nana*), Frizzle (*Ff*) and Normal Feathered

(*nana/ff*) Birds within the Population of Indigenous Birds in the Asante Akim South, Ejisu Juabeng and Bosomtwe Atwima KwanwomaDistricts

The normal feathered birds formed a significantly higher ($P<0.05$) percentage of the population of indigenous chickens in the Bosomtwe Atwima-Kwanwoma, Asante-Akim South and Ejisu-Juaben Districts (Table 4.2.1). However, the percentages of the naked neck (*Nana*) and the frizzle (*Ff*) birds did not vary significantly ($P>0.05$) from each other. Only heterozygous forms of the two genes (*Nana* & *Ff*) were encountered. The total incidence of both naked neck (*Nana*) and frizzle (*Ff*) birds within the population of indigenous chickens in the areas surveyed was only 21.6% (Table 4.2.1and Appendix 2).

Table 4.2.1: Percentages of Naked Neck (*Nana*), Frizzle (*Ff*) and Normal Feathered (*nana/ff*) Birds and their Body Weights

Parameters/Phenotypes	**Naked neck (*Nana*)**	**Frizzle (*Ff*)**	**Normal (*nana/ff*)**	**LSD**	**SEM**
% Phenotype In Flock	13.3^{a}	8.3^{a}	78.4^{b}	1.617	0.7700
Average Weight of Cock (Kg)	1.590	1.520	1.537	0.0739	0.0352
Average Weight of Hen (Kg)	1.300^{a}	1.033^{b}	1.180^{ab}	0.124	0.0589
Average Weight of Chick (g)	33.85^{a}	35.90^{b}	35.12^{b}	0.0353	0.01678

^{a,b} Means different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean

4.2.2 Average Weights of Cocks, Hens and Chicks

The average weight of cocks did not differ significantly ($P>0.05$) between the naked neck (*Nana*), frizzle (*Ff*) and normal feathered (*nana/ff*) birds (Table 4.2.1 and Appendix 2). The differences in the average weights of hens was significant ($P<0.05$) with the naked neck (*Nana*) hens being heavier than the frizzles (*Ff*). There was no significant difference

(P>0.05) between the naked neck (*Nana*) and normal feathered (*nana/ff*) birds nor the frizzle (*Ff*) and the normal feathered (*nana/ff*) birds. The average weight of naked neck (*Nana*) chicks was significantly lower (P<0.05) than that of the frizzle (*Ff*) and the normal feathered (*nana/ff*) chicks (Table 4.2.1 and Appendix 2).

4.2.3 Laying Performance

The naked neck (*Nana*) layers were significantly superior (P<0.05) in egg size, number of eggs per clutch and number of eggs per bird per year followed by the frizzle and the normal feathered birds, respectively (Table 4.2.2a and Appendix 2). However, the number of clutches per year was not significantly different (P>0.05) among the three phenotypes. Eggs from frizzle hens had a significantly higher hatchability than those from naked neck and the normal feathered hens (Table 4.2.2a and Appendix 2).

Table 4.2.2a: Egg Laying Performance of Indigenous Naked neck (*Nana*), Frizzle (*Ff*) and Normal feathered (*nana/ff*) Birds

Parameters/ Phenotypes	Naked neck (*Nana*)	Frizzle (*Ff*)	Normal (*nana/ff*)	LSD	SEM
Av.Egg Weight (g)	42.89^{a}	41.49^{b}	39.34^{c}	0.330	0.15720
Av.Clutches/ year	2.567	2.667	2.633	0.114	0.05440
Av.Eggs/ clutch	16.33^{a}	13.67^{b}	10.33^{c}	0.990	0.47100
Av.Egg/Bird/year	55.67^{a}	44.33^{b}	36.67^{c}	0.990	0.47100
Av.Hatchability (%)	76.33^{a}	80.33^{b}	78.00^{ab}	2.215	1.05400

$^{a-c}$ Means with different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.2.3.1 Effect of Environment on Laying Performance

The birds in Ejisu-Juaben District produced the heaviest (P<0.05) eggs followed by those in Asante-Akim and Bosomtwe Atwima-Kwanwoma Districts respectively (Table 4.2.2b and Appendix 2). The number of clutches per year was significantly higher

(P<0.05) for the birds in Bosomtwe Atwima-Kwanwoma District as compared to those in the Ejisu-Juabeng District but the difference between the number of clutches per year of birds in Bosomtwe Atwima-Kwanwoma and Asante-Akim South districts was not significant (P>0.05) neither was there any difference (P>0.05) between those from Ejisu-Juabeng and Asante-Akim South Districts. The number of eggs per clutch and the number of eggs per bird per year did not differ significantly (P>0.05) among birds from the three Districts. Hatchability was significantly lower (P<0.05) for eggs laid by layers from Asante-Akim South district as compared to eggs laid by those from Bosomtwe Atwima-Kwanwoma and Ejisu-Juabeng Districts (Table 4.2.2b and Appendix 2).

Table 4.2.2b: The Effect of Environment on Egg Laying Performance of Indigenous Naked neck, Frizzle and Normal Feathered Birds.

Parameters/Districts	Asante-Akim South	Bosomtwe Atwima-Kwanwoma	Ejisu-Juabeng	LSD	SEM
Av.Egg Weight (g)	41.07^{b}	40.27^{c}	42.38^{a}	0.330	0.1572
Av.Clutches/ year	2.600^{ab}	2.733^{a}	2.533^{b}	0.114	0.0544
Av.Eggs/ clutch	13.00	13.67	13.67	0.990	0.4710
Av.Egg/Bird/year	45.33	45.00	46.33	0.990	0.4710
Av.Hatchability (%)	76.67^{a}	81.00^{b}	77.00^{a}	2.215	1.0540

$^{a-c}$ Means different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.2.4 Egg Quality

The eggs laid by naked neck birds were significantly superior (P<0.05) in albumen height, Haugh Unit and egg shell thickness as compared to those of the frizzle and normal feathered birds; eggs of the frizzle birds were also significantly superior (P<0.05) to the normal feathered ones in Haugh unit (Table 4.2.3 and Appendix 2). Yolk height and yolk diameter were significantly lower (P<0.05) in eggs of normal feathered birds as compared to that of naked neck and frizzle birds. Yolk colour score was not significantly different (P>0.05) among eggs laid by birds from the three phenotypes (Table 4.2.3 and Appendix 2).

Table 4.2.3: Egg Quality and Survivability Performances of Indigenous Naked neck (*Nana*), Frizzle (*Ff*) and Normal feathered (*nana/ff*) Birds

Parameters/Phenotypes	Naked neck (*Nana*)	Frizzle (*Ff*)	Normal (*nana/ff*)	LSD	SEM
Av.Albumin Height (mm)	6.150^{a}	5.840^{b}	5.813^{b}	0.0099	0.00471
Av.Haugh Unit (%)	81.33^{a}	78.00^{b}	73.33^{c}	0.990	0.47100
Av.Shell Thickness (mm)	0.3200^{a}	0.3000^{b}	0.3033^{b}	0.0114	0.00544
Av.Yolk height (mm)	16.10^{a}	16.09^{a}	15.40^{b}	0.222	0.10580
Av.Yolk Diameter (mm)	41.00^{a}	39.33^{a}	36.00^{b}	1.144	0.54400
Av.Yolk Colour Score	8.33	7.67	8.33	1.095	0.52100
Av.Chick Mortality (%)	53.67^{a}	50.00^{b}	52.33^{a}	1.144	0.54400
Av.Total Mortality (%)	40.00^{a}	49.33^{b}	52.67^{c}	0.990	0.47100

$^{a-c}$ Means different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.2.5 <u>Mortality and Carcass Parameters</u>

Frizzle (*Ff*) chicks (day-old to 6 weeks) had significantly lower (P<0.05) mortality as compared to naked neck (*Nana*) and normal feathered (nana/ff) chicks (Table 4.2.3 and Appendix 2). However, total mortality was significantly lower (P<0.05) in naked neck birds followed by the frizzles which survived significantly (P<0.05) better than the normal feathered birds (Table 4.2.3 and Appendix 2).

The carcasses of naked neck (*Nana*) birds were significantly (P<0.05) superior in percentage of defeathered weight, dressing percentage and percentage of breast muscle weight to those of frizzles (*Ff*) which were significantly (P<0.05) better than those of normal feathered (*nana/ff*) birds; however, the differences were not significant (P>0.05) for breast muscle percentage between the frizzle (*Ff*) and the normal feathered (*nana/ff*) birds (Table 4.2.4 and Appendix 2). Thigh and drumstick percentage and wings percentage were not significantly different (P>0.05) betweeen the three phenotypes (*Nana, Ff and nana/ff*).

Table 4.2.4: Carcass Parameters of Indigenous *Nana* (Naked neck), *Ff* (Frizzle) and *nana/ff* (Normal feathered) Birds

Parameters/Genotypes	*Nana*	*Ff*	*nana/ff*	LSD	SEM
Live Weight	1.48^{a}	1.36^{b}	1.37^{b}	0.0798	0.0380
Av.Defeathered % (Weight in kg)	93.22^{a} (1.38)	90.72^{b} (1.24)	88.09^{c} (1.21)	0.0140	0.00667
Av.Dressing % (Weight in kg)	70.87^{a} (1.05)	67.80^{b} (0.92)	66.68^{c} (0.91)	0.0128	0.00609
Av.Breast Muscle % (Weight in kg)	16.37^{a} (0.24)	13.20^{b} (0.18)	12.86^{b} (0.18)	0.0128	0.00609
Av.Thigh and Drumstick % (Weight in kg)	23.40 (0.35)	23.41 (0.32)	23.35 (0.32)	0.0128	0.00609
Av.Wings % (Weight in kg)	9.93 (0.15)	9.76 (0.13)	9.98 (0.14)	0.738	0.351
Av.Gizzard % (Weight in kg)	3.207^{b} (0.047)	3.523^{a} (0.048)	3.057^{b} (0.042)	0.0475	0.002261
Av.Intestines % (Weight in kg)	3.190 (0.047)	3.403 (0.046)	3.303 (0.042)	0.0475	0.002261
Av.Heart % (Weight in kg)	1.570^{b} (0.023)	1.690^{a} (0.023)	1.557^{b} (0.021)	0.0099	0.00471
Av.Liver % (Weight in kg)	1.591^{b} (0.024)	1.693^{a} (0.023)	1.557^{b} (0.021)	0.0106	0.00505

$^{a-c}$ Means with different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

The *Ff* (frizzle) birds were significantly higher in the percentages of gizzard, intestine, heart and liver compared to the *Nana* (Naked neck) and the *nana/ff* (Normal feathered) ones (Table 4.2.4 and Appendix 2).

4.3.0 STUDY THREE: MATINGS INVOLVING NAKED NECK BIRDS

4.3.2 First Parental Generation (P_1)

Body weight of the indigenous heterozygous naked neck (*Nana*) males ranged from 1,300 to 1,700g with sire N2 being the heaviest and sire N1 the lightest. Fertility of eggs from mating involving the four sires ranged between 86.45% (sire N3) and 98.00% (sire N2) while hatchability ranged from 52.80% (sire N4) to 80.65% (sire N2), (Table 4.3.1a).

Table 4.3.1a: Some Characteristics of the Four Indigenous *Nana* (Naked neck) Males used in the First Mating

Sire Number	Sire Colour	Age (Months)	Av.Weight ±SE (g)	Av.Fertility ±SE (%)	Av.Hatcha bility ±SE (%)
N1	Red	14	1300 ± 1.49	96.55 ± 1.54	63.90 ± 2.33
N2	Multi	9	1700 ± 1.87	98.00 ± 1.78	80.65 ± 1.92
N3	Barred	12	1500 ± 1.62	86.45 ± 2.46	66.15 ± 2.08
N4	Black	12	1600 ± 1.95	95.00 ± 2.11	52.80 ± 2.53

SD = Standard Error; Av=Average

The Lohmann commercial females used in the first mating were a year old. The average body weight, average egg size, average egg size to body weight ratio, average fertility and average hatchability of the eggs from the Lohmann commercial females used in the first mating are presented in Table 4.3.1b.

Table 4.3.1b: Characteristics of the Commercial Lohmann Females used in the First Mating

Trait	Performance	Standard Error
Colour	Brown	-
Age (wks)	52.00	-
Average Weight (g)	1600.00	2.06
Average Egg Size (g)	62.00	1.68
Average Egg Size to Body Wt Ratio	1 : 25.81	2.22
Rate of Lay – Hen day (%)	66.67	2.91
Average Fertility of eggs (%)	94.00	2.14
Average Hatchabiltity of eggs (%)	65.88	2.26

Egg quality characteristics such as albumen height, Haugh unit, shell thickness, yolk height, and yolk diameter and yolk colour score of the eggs from the Lohmann commercial females used in the first mating are presented in Table 4.3.1c

Table 4.3.1c: Egg Quality Characteristics of the Commercial Lohmann Females used in the First Mating

Trait	Performance	Standard Error
Av.Albumen Height (mm)	7.11	3.02
Av.Haugh Unit (%)	77.00	2.41
Av.Shell Thickness (mm)	0.32	1.75
Av.Yolk Height (mm)	15.00	1.96
Av.Yolk Diameter (mm)	40.00	2.06
Av.Yolk Colour Score	5.00	1.93

Av=Average

4.3.2 First Filial Generation (F_1) Naked Necks (*Nana*) and Normals (*nana*)

4.3.2.1 Plumage Colour

The F1 birds (Naked necks and Normals) had varying plumage colours; some were multi-coloured while others had single colours (Fig. 4.3.2.1).

Fig. 4.3.1: F_1 Heterozygous Naked neck (*Nana*) and Normal Feathered (*nana*) Birds

The colours included white, black, barred, red, and brown; however, majority of the females were brown in colour.

4.3.2.2 Body Weight and Body Weight Gain (Day-old to 20th Week)

Body weight and body weight gain from day-old to the sixth week were significantly (P<0.05) higher in the naked neck (*Nana*) chicks as compared to their normal feathered (*nana*) counterparts (Table 4.3.2.2a, Fig. 4.3.2.2a and Appendix 2).

Table 4.3.2.2a: Body Weight and Body Weight Gain of F_1 *Nana* (Naked neck) and *nana* (Normal feathered) Chicks (Day-old to week 6)

P'TERS/G'TYPE	*Nana*	*nana*	LSD	SEM
Av. Body Wt at Day-old	43.15^b	41.64^a	0.3061	0.1444
Av. Body Wt at WK1	60.61^b	58.41^a	0.0442	0.0209
Av. Body Wt Gain b/n WK0&1	17.47^a	16.77^b	0.03209	0.01514
Av. Body Wt at WK2	117.02^a	111.90^b	0.0439	0.0207
Av. Body Wt Gain b/n WK1&2	56.41^a	53.49^b	0.02935	0.01384
Av. Body Wt at WK3	177.49^b	170.69^a	0.03165	0.01493
Av. Body Wt Gain b/n WK2&3	60.46^b	58.79^a	0.3065	0.1446
Av. Body Wt at WK4	249.35^a	220.18^b	0.00865	0.00408
Av.Body Wt Gain b/n WK3&4	71.86^a	49.49^b	0.0439	0.0207
Av. Body Wt at WK5	345.57^a	312.98^b	0.00865	0.00408
Av. Body Wt Gain b/n WK4&5	96.23^b	92.82^a	0.03296	0.01555
Av. Body Wt at WK6	449.04^b	409.67^a	0.00865	0.00408
Av.Body Wt Gain b/n WK5&6	103.47^b	96.67^a	0.01467	0.00692

$^{a, b}$ Means with different superscripts are significantly different at 5% level of significance; P'TERS=PARAMETERS; G'TYPES= GENOTYPES; LSD=Least Significant Difference; and SEM= Standard Error of the Mean; Av=Average; Wt=Weight; WK=Week; b/n = between

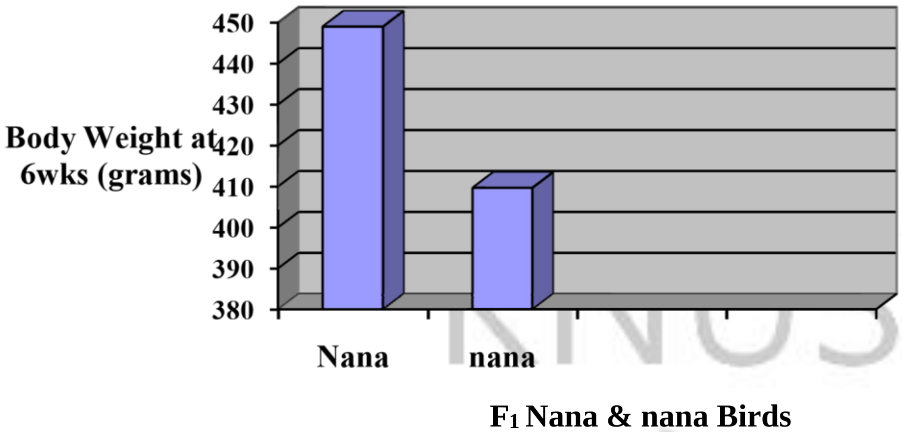


Figure 4.3.2a: A Bar Chart Showing Six-week Body Weight of Heterozygous Naked neck and Normal feathered Birds

From weeks 7 to 20, body weight and body weight-gain of F_1 *Nana* birds were significantly higher than that of F_1 *nana* ones (Tables 4.3.2.2b & c, Figs. 4.3.2.2b & c and Appendix 2).

Table 4.3.2.2b: Body Weight and Body Weight Gain (Week 7 to Week 13) of F_1 *Nana* (Naked neck) and *nana* (Normal feathered) Birds

P'TERS/P'TYPE	Naked neck(*Nana*)	Normal feathered (*nana*)	LSD	SEM
Av.Wt at Wk7	457.40^b	421.70^a	4.680	2.3800
Av.Wt at Wk8	519.50^b	473.60^a	5.570	2.8400
Av.Wt Gain b/n Wk7&8	63.82b	52.15^a	1.302	0.6630
Av.Wt at Wk9	601.00^a	537.20^b	5.840	2.9400
Av.Wt Gain b/n Wk8&9	79.89^a	64.03^b	1.840	0.9370
Av.Wt at Wk10	693.80^a	609.90^b	7.210	3.6700
Av.Wt Gain b/n Wk9&10	91.83^b	73.44^a	2.264	1.1530
Av.Wt at Wk11	793.50^b	686.30^a	9.060	4.6100
Av.Wt Gain b/n Wk10&11	99.83^b	76.22^a	2.413	1.2290
Av.Wt at Wk12	900.20^b	765.60^a	11.490	5.8500
Av.Wt Gain b/n Wk11&12	106.96^b	82.62^a	2.627	1.3380
Av.Wt at Wk13	1013.30^b	853.80^a	14.070	7.1600
Av.Wt Gain b/n Wk12&13	117.50^b	91.18^a	2.894	1.4740

$^{a, b}$ Means with different superscripts are significantly different at 5% level of significance;

P'TERS=PARAMETERS; P'TYPE=PHENOTYPE; LSD=Least Significant Difference; and SEM= Standard Error of the Mean; Av=Average; b/n=between

Table 4.3.2.2c: Body Weight and Body Weight Gain (Week 14 to week 20) of F_1 *Nana* and *nana* Birds

P'TERS/G'TYPE	*Nana*	*nana*	LSD	SEM
Av.Wt at Wk14	1134.50^{a}	949.70^{b}	16.800	8.5600
Av.Wt Gain b/n Wk13&14	121.05^{a}	95.16^{b}	2.896	1.4750
Av.Wt at Wk15	1260.50^{a}	1051.20^{b}	19.220	9.7900
Av.Wt Gain b/n Wk14&15	128.03^{a}	100.38^{b}	3.092	1.575
Av.Wt at Wk16	1394.70^{a}	1154.10^{b}	22.230	11.3200
Av.Wt Gain b/n Wk15&16	134.24^{a}	102.92^{b}	3.350	1.7060
Av.Wt at Wk17	1525.50^{b}	1246.10^{a}	25.000	12.7300
Av.Wt Gain b/n Wk16&17	130.35^{b}	97.69^{a}	3.391	1.7270
Av.Wt at Wk18	1652.00^{a}	1342.30	27.730	141200
Av.Wt Gain b/n Wk17&18	127.00^{a}	94.71	3.452	1.7580
Av.Wt at Wk19	1768.70^{b}	1436.80^{a}	35.550	18.1100
Av.Wt Gain b/n Wk18&19	120.89^{b}	93.85^{a}	3.553	1.8100
Av.Wt at Wk20	1895.80^{a}	1565.40^{b}	31.550	16.0700
Av.Wt Gain b/n Wk19&20	117.76^{a}	94.63^{b}	3.176	1.6170

$^{a,\ b}$ Means with different superscripts are significantly different at 5% level of significance; P'TERS=PARAMETERS; G'TYPE=GENOTYPE; LSD=Least Significant Difference; and SEM= Standard Error of the Mean; Av=Average; b/n = between

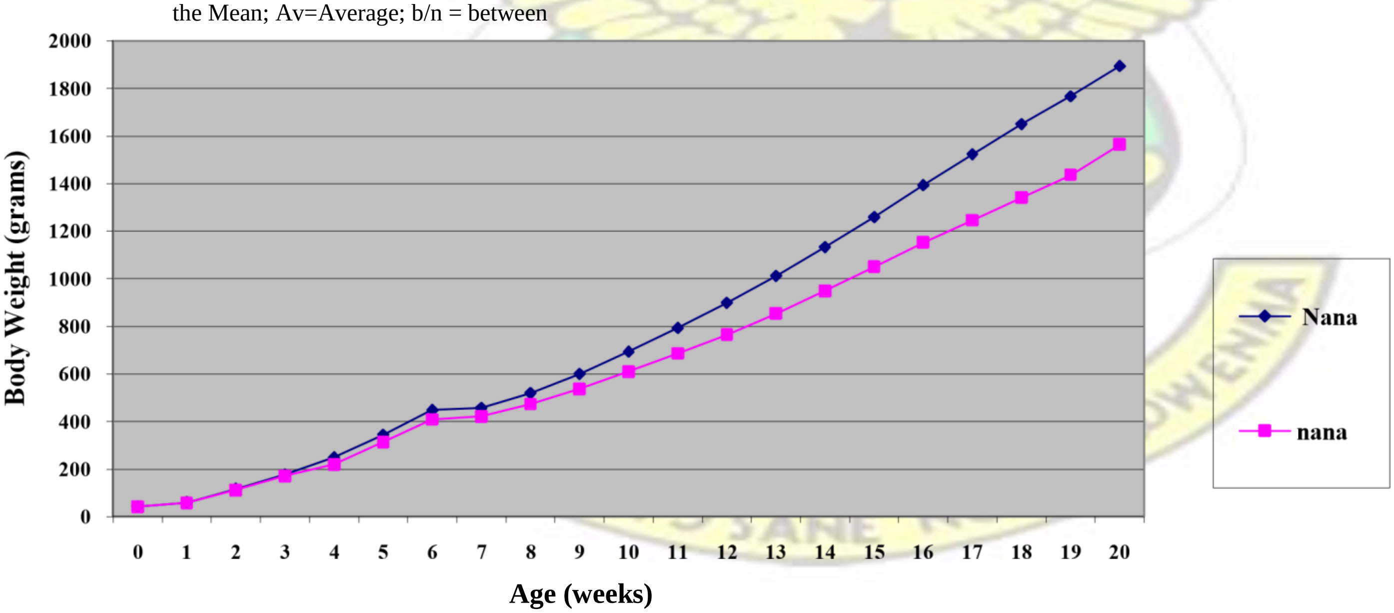


Fig.4.3.2b: Comparative Growth Curves of F_1 Nana and nana Birds

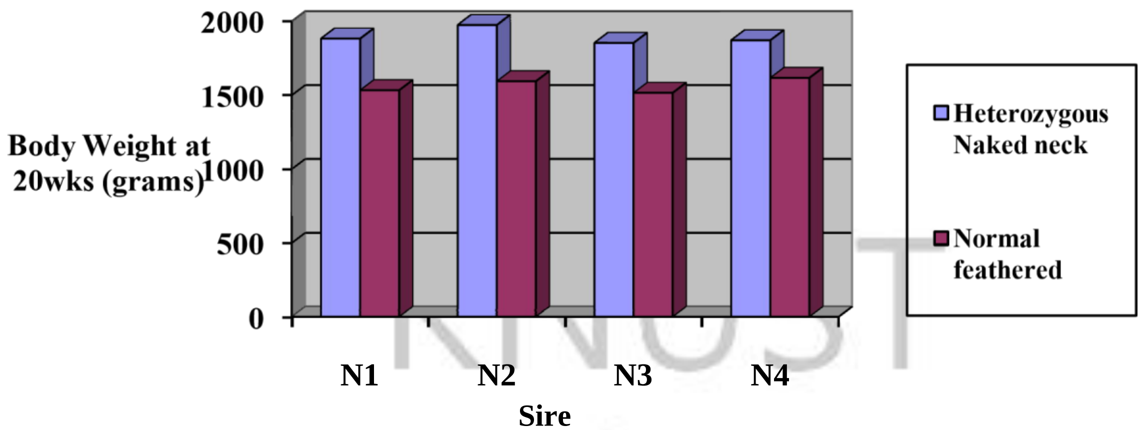


Fig. 4.3.2c: Comparison of the 20wk Body Weights of Nana & nana Offspring of Four Naked neck Sires

4.3.2.3 Body Measurements

Body length and body width values were significantly higher (P<0.05) in the naked neck birds compared to the normal feathered birds. However, shank length did not show any significant difference (P>0.05) between the two phenotypes (Table 4.3.2.3 and Appendix 2).

Table 4.3.2.3: Body Measurements of F_1 *Nana & nana* Birds

Parameters/Genotype	*Nana*	*nana*	LSD	SEM
Av.Body Length (cm)	36.04[a]	34.83[b]	0.226	0.1153
Av.Body Width (cm)	13.93[a]	13.42[b]	0.153	0.07790
Av.Shank Length (cm)	8.38	8.34	0.110	0.05600

[a, b] Means different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; and SEM= Standard Error of the Mean; Av=Average

4.3.2.4 Laying Performance

Number of eggs per clutch, egg size, hen-housed and hen-day egg production rates were significantly (P<0.05) better in the *Nana* layers compared to the *nana* ones (Table 4.3.2.5a). However, age at first egg and egg size to body weight ratio were significantly (P<0.05) superior in *nana* layers than *Nana* ones (Table 4.3.2.4a and Appendix 2).

Table 4.3.2.4a: The Effect of the Naked Neck Gene on Laying Performance

Parameters/ F_1 Birds	*Nana*	*nana*	LSD	SEM
Av.Age at first Egg	149.72^a	146.61^b	0.654	0.3330
Av.Eggs per Clutch	17.66^a	15.89^b	0.297	0.1510
Av.Egg Size (g)	50.20^a	47.11^b	0.569	0.2890
Av.Egg Size-Body Wt Ratio	32.30^a	30.03^b	0.663	0.3370
Rate of Lay (Hen-housed)	59.67^b	56.51^a	0.483	0.2450
Rate of Lay (Hen-day)	61.27^b	58.09^a	0.461	0.2350

$^{a,\ b}$ Means different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; and SEM= Standard Error of the Mean; Av=Average

4.3.2.4.1 The Effect of Environment (Village) on Laying Performance

Eggs per clutch and egg size values were significantly higher (P<0.05) in birds from Juaso followed by those from Nkwanta and Yawkwei respectively (Table 4.3.2.5b). Hen-housed and hen-day egg production rates were significantly higher (P<0.05) in birds that were kept at Yawkwei than in those kept at Nkwanta which were significantly (P<0.05) better than those reared at Juaso, however, the difference between the henhoused rate of lay of birds reared at Nkwanta and Juaso was not significant (P>0.05). Age at first egg and egg size to body weight ratio did not differ significantly (P>0.05) between birds kept in the three towns/villages (Table 4.3.2.4b and Appendix 2).

Table 4.3.2.4b: The Effect of Environmental (Village) on Laying Performance

Parameters/Village	Yawkwei	Juaso	Nkwanta	LSD	SEM
Av. Age at first Egg	147.98	148.34	148.17	0.801	0.4070
Av. Eggs per Clutch	16.43^a	17.01^b	16.89^c	0.364	0.1849
Av. Egg Size (g)	46.92^a	49.90^b	49.13^c	0.697	0.3540
Av. Egg Size-Body Wt Ratio	31.43	30.92	31.14	0.812	0.4130
Rate of Lay (Hen-housed)	58.96^a	57.48^b	57.83^b	0.591	0.3010
Rate of Lay (Hen-day)	60.68^a	58.98^b	59.37^c	0.565	0.2870

$^{a-c}$ Means different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; and SEM= Standard Error of the Mean; Av=Average

4.3.2.4.2 Sire Effects on Laying Performance

Age at first egg delayed significantly (P<0.05) in offspring of sires N1 and N3 compared to offspring of sire N4 but the differences between the values recorded for offspring of sires N1 and N2, N2 and N3, and N2 and N4 were not significant (P>0.05), (Table 4.3.2.4c). Number of eggs per clutch was significantly higher in offspring of sire N2 followed by that of N4, N1 and N3 respectively. Significantly (P<0.05) higher egg size values were recorded for offspring of sire N4 followed by that of sires N2 and N3, and those from the offspring of sire N1 were the lightest. Offspring of sires N3 and N4 had a significantly (P<0.05) better egg size to body weight ratio than those of sires N1 and N2. Hen-housed egg production and hen-day egg production rates were significantly higher in the offspring of sire N4 than those of N2 which was better than those of N1 and N3, however the difference between the hen-day egg production rates of the offspring of sires N1 and N3 was not significant (P>0.05) (Table 4.3.2.4c and Appendix 2).

Table 4.3.2.4c: The Effect of Sire on Laying Performance

Parameters/ Sires	N1	N2	N3	N4	LSD	SEM
Av.Age at first Egg	148.54^{a}	148.02^{ab}	148.76^{a}	147.33^{b}	0.925	0.4700
Av.Eggs per Clutch	16.53^{a}	17.48^{b}	16.11^{c}	16.98^{d}	0.420	0.2135
Av.Egg Size (g)	47.12^{a}	48.90^{b}	48.53^{b}	50.06^{c}	0.804	0.4090
Av.Egg Size-Body Wt Ratio	31.55^{a}	31.81^{a}	30.57^{b}	30.73^{b}	0.937	0.4760
Rate of Lay (Hen-housed)	57.73^{a}	58.62^{b}	56.96^{c}	59.06^{d}	0.683	0.3470
Rate of Lay (Hen-day)	59.09^{a}	60.01^{b}	58.58^{a}	61.03^{c}	0.652	0.3320

$^{a-c}$ Means different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; and SEM= Standard Error of the Mean; Av=Average

4.3.2.5 Egg Quality Parameters

Values for albumen height, Haugh unit, shell thickness, yolk height and yolk diameter were significantly higher (P<0.05) in the eggs from naked neck layers compared to those from their normal feathered counterparts; however, yolk colour score did not show any significant (P>0.05) differences (Table 4.3.2.5 and Appendix 2).

Table 4.3.2.5: The Effect of Naked Neck (*Nana*) Gene on Egg Quality Parameters

Parameters/ Genotype	***Nana***	***nana***	**LSD**	**SEM**
Av.Albumen Height (mm)	6.69[a]	6.35[b]	0.108	0.0551
Av.Haugh Unit (%)	81.62[a]	78.69[b]	0.719	0.3660
Av.Shell Thickness (mm)	0.33[a]	0.31[b]	0.00581	0.002950
Av.Yolk Height (mm)	15.04[a]	14.77[b]	0.154	0.07820
Av.Yolk Diameter (mm)	39.89[a]	39.25[b]	0.320	0.1628
Yolk Colour Score	8.41	8.26	0.269	0.1366

[a, b] Means different superscripts are significantly different at 5% level of significance; P;TERS=PARAMETERS; LSD=Least Significant Difference; and SEM= Standard Error of the Mean; Av=Average

4.3.2.6 Some Carcass Parameters

The heterozygous naked neck (*Nana*) birds had a significantly higher (P<0.05) defeathered weight, dressed weight, thigh and drumstick weight, breast muscle weight, weight of wings and gizzards than the normal feathered birds (Table 4.3.2.6 and Appendix 2). However, weights of intestines, heart and liver were not significantly affected by the phenotypes of the birds (Table 4.3.2.6 and Appendix 2)

Table 4.3.2.6: The Effect of the Naked Neck Gene on Some Carcass Parameters

Parameters/Genotype	***Nana***	***nana***	**LSD**	**SEM**
Av. Defeathered %	91.40[a]	86.01[b]	0.706	0.03590
Av. Dressed Weight %	74.70[a]	66.88[b]	0.917	0.04660
Av. Thigh and Drumstick %	23.24[a]	23.11[b]	0.117	0.0596
Av. Breast Muscle %	19.01[a]	16.08[b]	0.628	0.3190
Av. Weight of Wings %	10.36[a]	10.22[b]	0.108	0.05490

Av. Gizzard %	3.77^a	3.66^b	0.0731	0.03720
Av. Weight of Intestines %	3.71	3.69	0.0369	0.01875
Av. Heart Weight %	1.47	1.48	0.0257	0.01306
Av. Liver Weight %	1.84	1.83	0.0360	0.01832

$^{a, b}$ Means different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; and SEM= Standard Error of the Mean; Av=Average

4.3.2.7 Mortality

Mortality in *Nana* chicks was not significantly (P>0.05) different from that of *nana* ones; however, total mortality (chick & adult) was significantly (P<0.05) lower in the *Nana* birds compared to their *nana* counterparts (Table 4.3.2.7 and Appendix 2). **Table 4.3.2.7: The Effect of Naked Neck Gene on Survivability of F_1 Birds**

Parameters/ F1 Birds	***Nana***	***nana***	**LSD**	**SEM**
Chick Mortality (%)	1.45	1.38	0.220	0.1037
Total Mortality (%)	7.79^a	9.13^b	0.392	0.1992

$^{a, b}$ Means different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; and SEM= Standard Error of the Mean

4.3.3.0 Matings Involving Naked Necks (*Nana* × *Nana*)

4.3.3.1 The Second Generation Parents (P_2)

The male and female birds selected as parents of the second generation were heterozygous naked neck birds from the first filial generation of birds (Fig. 4.3.3.1). The males were 400 g heavier than the females (2000 g vs 1600 g) at 20weeks of age.

Mortality from the growing to the laying period was only 2%, and this resulted in a narrow difference (3%) between hen-day and hen-housed rates of lay. Reproductive performance in terms of fertility (91.78%) and hatchabilty (72.10%) were satisfactory.

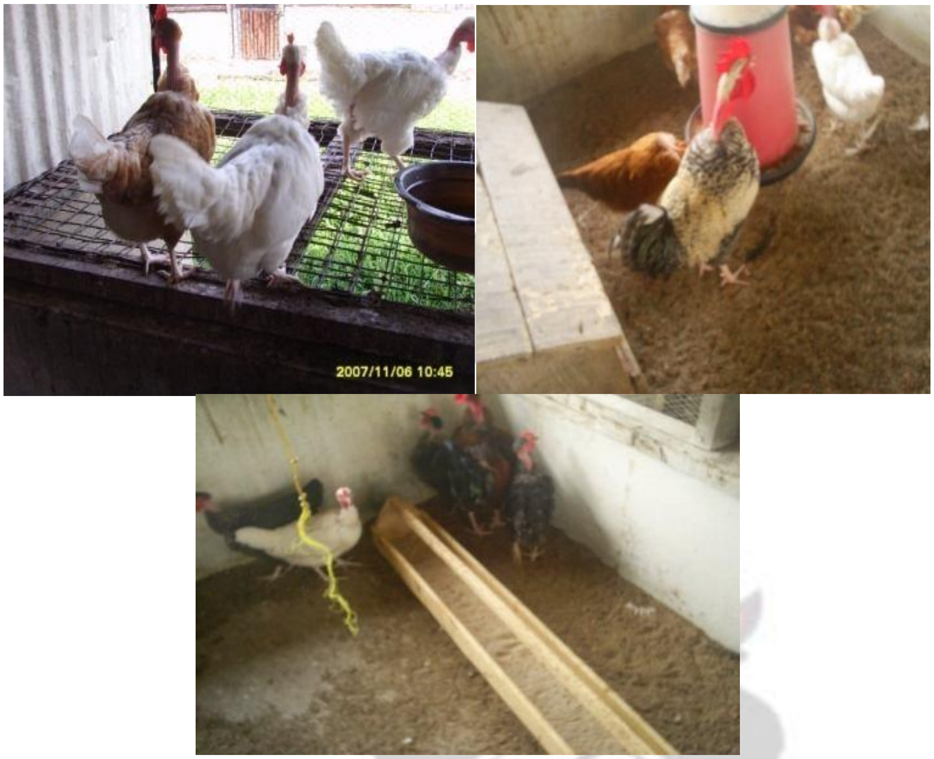


Fig. 4.3.3: Heterozygous Naked neck Males and Females Used in the Second Mating

Productive and reproductive characteristics of the second generation of parents such as average body weight at 20 weeks, average age at first egg, average rate of lay (henhoused and hen-day), average egg size to body weight ratio, fertility, hatchability and mortality, and their standard deviation are shown in Table 4.3.3a**.**

Table 4.3.3.1a: Productive and Reproductive Characteristics of the Second Parental Generation (P_2)

Trait		**Standard Error**
Av. Body Weight at 20wks-Males	2000.00g	2.65
Av. Body Weight at 20wks-Females	1600.00g	2.09
Av. Age at First Egg	148.00days	1.86
Hen-Housed Rate of Lay	65.00%	1.91
Hen-Day Rate of Lay	68.00%	2.02
Av. Egg Size to Body Weight Ratio	1: 29.31	2.31
Av. Fertility	91.78%	1.84
Av. Hatchability	72.10%	3.02

Mortality	2.00%	0.00

The eggs of the second parental generation dams were moderate in size (58g) and high in quality (Haugh unit = 78%). The egg shells were also thick (0.37mm). The egg quality characteristics of the second parental generation in terms of egg size, albumen height, Haugh unit, shell thickness, yolk height, yolk diameter and yolk colour score are presented in Table 4.3.3.1b

Table 4.3.3.1b: Egg Quality Characteristics of the Second Parental Generation

Trait		**Standard Error**
Av. Egg Size	58.00g	2.49
Av. Albumen Height	7.35mm	2.05
Av. Haugh Unit	78.00%	1.91
Av. Shell Thickness	0.37mm	1.88
Av. Yolk Height	17.00mm	2.09
Av. Yolk Diameter	40.00mm	1.98
Av. Yolk Colour Score	5.00	2.41

Av=Average

4.3.4.0 Second Filial Generation (F_2) Birds – Naked Necks (*NaNa, Nana*) and Normals (*nana*)

4.3.4.1 Plumage Colour

The second filial generation (F_2) birds (homozygous naked neck-*NaNa*, heterozygous naked neck-*Nana* & normal feathered-*nana*) had different plumage colours which were either multi or single. The colours included white, black, barred and brown; however, the majority of the females had brown plumage colour.

Fig.4.3.4: F_2 Homozygous Naked Necks

4.3.4.2 <u>Body Weight and Body Weight Gain (Day-old to Week 20)</u>

Chick weight and weekly weight gain from day-old to the end of week 2 were significantly higher in *nana* chicks than *NaNa* and *Nana* ones, except at the end of week 2 where the body weight of *nana* chicks were not significantly different from those of *NaNa* ones (Table 4.3.4.2a). *NaNa* and *Nana* chicks had a significantly higher average body weight and body weight gain from week three to the end of week six compared to the *nana* chicks (Table 4.3.4.2a, Fig. 4.3.4.2a and Appendix 2).

Table 4.3.4.2a: A Comparison of the Body Weight and Body Weight Gain of *NaNa*, *Nana* and *nana* F_2 Chicks (Day-old to Week 6)

Parameters/ F2 Chicks	***NaNa***	***Nana***	***nana***	**LSD**	**SEM**
Av.Body Weight-WK0 (g)	39.71^{b}	38.66^{b}	42.29^{a}	1.997	0.9860
Av.Body Weight-WK1 (g)	96.89^{b}	95.33^{b}	103.11^{a}	3.672	1.8140
Av.Body Weight-Gain b/n WK0&1 (g)	32.18^{b}	31.67^{b}	35.83^{a}	1.931	0.9540
Av.Body Weight-Wk2 (g)	137.40^{ab}	136.39^{a}	138.14^{b}	1.405	0.6940
Av.Body Weight-Gain b/n Wk1&2 (g)	40.45^{b}	41.06^{b}	34.97^{a}	2.571	1.2700
Av.Body Weight-WK3 (g)	183.02^{b}	182.98^{b}	181.74^{a}	0.520	0.2570
Av.Body Weight-Gain b/n WK2&3 (g)	45.69^{b}	46.59^{b}	43.66^{a}	1.639	0.8090
Av.Body Weight-WK4 (g)	232.62^{b}	233.09^{b}	230.16^{a}	1.313	0.6480
Av.Body Weight-Gain b/n WK3&4 (g)	49.59^{b}	50.11^{b}	48.42^{a}	0.936	0.4620
Av.Body Weight-WK5 (g)	300.13^{b}	301.04^{b}	295.17^{a}	2.609	1.2890
Av.Body Weight-Gain b/n WK4&5 (g)	67.52^{b}	67.95^{b}	65.00^{a}	1.296	0.6400

Av.Body Weight-WK6 (g)	383.96[b]	384.97[b]	373.30[a]	4.885	2.4130
Av.Body Weight Gain b/n WK5&6 (g)	83.83[b]	83.93[b]	78.13[a]	2.388	1.1800

[a, b] Means with different superscripts are significantly (P<0.05) different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average; b/n = between

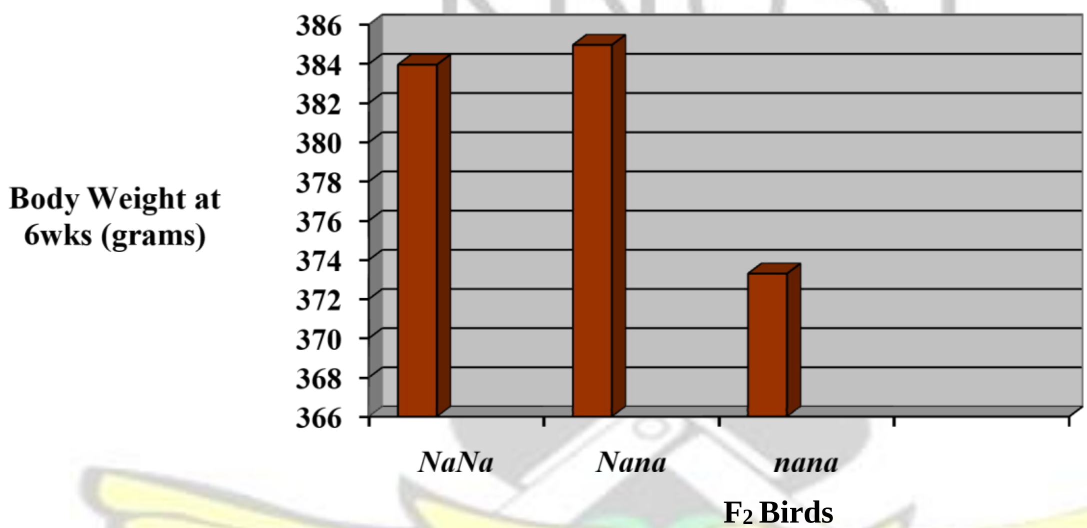


Fig. 4.3.5a: A Bar Chart Showing Six-week Body Weights of Homozygous Naked neck, Heterozygous Naked neck and Normal …

Body weights of *NaNa*, *Nana* and *nana* chickens did not show any significant (P>0.05) differences from weeks seven to twelve (Table 4.3.4.2b and Appendix 2).

Table 4.3.4.2b: Body Weight and Body Weight Gain of *NaNa, Nana & nana* F$_2$ Birds (Weeks 7 to 14)

Parameter/ F$_2$ Birds	NaNa	Nana	nana	LSD	SEM
Av.Body Weight-WK7 (g)	386.78	384.44	385.78	3.339	1.696
Av.Body Weight-WK8 (g)	427.11	425.22	427.67	4.179	2.1220
Av.Body Weight-Gain b/n WK7&8 (g)	39.56	39.56	42.01	2.350	1.1930
Av.Body Weight-Wk9 (g)	489.10	485.60	491.40	5.430	2.7600
Av.Body Weight-Gain b/n Wk8&9 (g)	61.12	60.17	62.17	2.191	1.1130

Av.Body Weight-WK10 (g)	583.30	581.10	580.00	6.830	3.4700
Av.Body Weight-Gain b/n WK9&10 (g)	92.68^{b}	94.44^{b}	87.99^{a}	3.337	1.6950
Av.Body Weight-WK11 (g)	685.90	686.20	677.20	8.710	4.4200
Av.Body Weight-Gain b/n WK10&11 (g)	102.44^{b}	105.11^{b}	97.22^{a}	3.587	1.822
Av.Body Weight-Wk12 (g)	801.10	803.20	786.00	11.130	5.6500
Av.Body Weight-Gain b/n Wk11&12 (g)	114.67^{b}	117.89^{b}	108.56^{a}	3.909	1.9850
Av.Body Weight-WK13 (g)	934.10^{b}	939.30^{b}	912.30^{a}	14.190	7.2100
Av.Body Weight-Gain b/n WK12&13 (g)	133.33^{b}	136.33^{b}	126.11^{a}	4.400	2.2340
Av.Body Weight-WK14 (g)	1077.90^{b}	1087.70^{b}	1050.30^{a}	18.330	9.3100
Av.Body Weight-Gain b/n WK13&14 (g)	143.89^{a}	148.33^{b}	138.00^{c}	4.196	2.1310

$^{a-c}$ Means with different superscripts are significantly (P<0.05) different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average; b/n = between

The average body weights at weeks 13 and 14 of the *nana* birds were significantly (P<0.05) lower than those of both *NaNa* and *Nana* birds. However, there were no significant differences in the body weights of *NaNa* and *Nana* birds during the same periods. From the 10th week to the 14th week the weights gained by the *nana* birds were significantly lower than the weight gained by the *NaNa* and *Nana* birds. A significant difference in weight gain between the *NaNa* and *Nana* birds was observed in week 14 (Table 4.3.4.2b and Appendix 2).

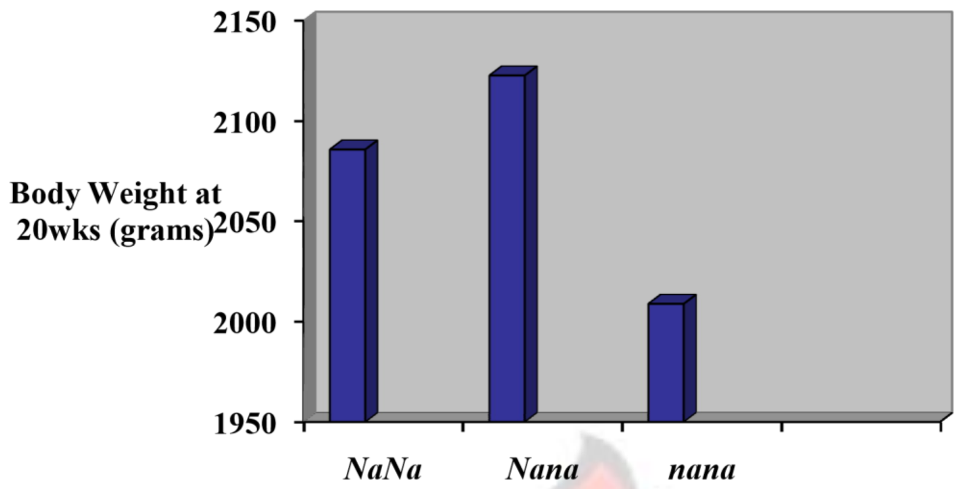
Body weight and body weight gain of *NaNa* and *Nana* birds from weeks fifteen to twenty were significantly higher compared to those of *nana* birds (Table 4.3.4.2c, Fig. 4.3.4.2b and Appendix 2).

Table 4.3.4.2c: Body Weight and Body Weight Gain of *NaNa*, *Nana* & *nana* F$_2$

Birds (Weeks 15 to 20)

Parameter/ F_2 Birds	***NaNa***	***Nana***	***nana***	**LSD**	**SEM**
Av.Body Weight-Wk15 (g)	1231.30^{b}	1247.40^{b}	1197.20^{a}	21.320	10.8300
Av.Body Weight-Gain b/n Wk14&15 (g)	153.89^{a}	158.11^{b}	148.00^{c}	4.177	2.1210
Av.Body Weight-WK16 (g)	1396.10^{b}	1413.90^{b}	1356.10^{a}	23.680	12.0300
Av.Body Weight-Gain b/n WK15&16 (g)	164.11^{b}	168.11^{b}	158.00^{a}	4.185	2.1250
Av.Body Weight-WK17 (g)	1552.10^{b}	1577.60^{b}	1502.90^{a}	28.900	14.6700
Av.Body Weight-Gain b/n WK16&17 (g)	156.30^{a}	163.20^{b}	146.60^{c}	5.630	2.8600
Av.Body Weight-WK18 (g)	1738.80^{b}	1761.20^{b}	1683.90^{a}	32.750	16.6300
Av.Body Weight-Gain b/n WK17&18 (g)	176.80^{a}	183.70^{b}	166.00^{c}	5.640	2.8700
Av.Body Weight-WK19 (g)	1911.90^{b}	1938.90^{b}	1844.60^{a}	37.680	19.1300
Av.Body Weight-Gain b/n WK18&19 (g)	173.40^{b}	179.20^{b}	162.20^{a}	5.880	2.9800
Av.Body Weight-WK20 (g)	2085.90^{b}	2122.80^{b}	2008.90^{a}	43.870	22.2700
Av.Body Weight-Gain b/n WK19&20 (g)	175.30^{a}	183.90^{b}	163.10^{c}	7.010	3.5600

$^{a-c}$ Means with followed by different superscripts are significantly ($P<0.05$) different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average; b/n = between



F_2 Birds

Fig.4.3.5b: Comparative Body Weight at Twenty Weeks of Age of F_2 NaNa, Nana and nana

The *NaNa* and *Nana* birds did not show any significant difference in body weight from week fifteen to twenty. In body weight gain *Nana* F_2 birds gained significantly more weight than *NaNa* F_2 birds in weeks 15, 17, 18 and 20 (Tables 4.3.4.2c, Fig. 4.3.4.2b and Appendix 2).

4.3.4.3 Body Measurements

Average body length of the *Nana* F_2 birds was significantly higher ($P<0.05$) than that of the *NaNa* F_2 birds whose average body length was also significantly higher than that of the *nana* F_2 birds. Body widths of *NaNa* and *Nana* F_2 birds were significantly higher ($P<0.05$) than that of the *nana* F_2 birds. However, shank length did not show any significant difference ($P>0.05$) between the F_2 birds (*NaNa*, *Nana* & *nana*), (Table 4.3.4.3 and Appendix 2).

Table 4.3.4.3: Body Measurements of *NaNa, Nana and nana* F_2 Birds

Parameters/Phenotype	*NaNa*	*Nana*	*nana*	LSD	SEM

Av.Body Length (cm)	38.17^a	38.50^b	36.50^c	0.285	0.1445
Av.Body Width (cm)	14.00^b	14.00^b	13.50^a	0.260	0.1320
Av.Shank Length (cm)	8.50	8.42	8.33	0.158	0.0803

$^{a-c}$ Means different superscripts are significantly (P<0.05) different at 5% level of significance; P'TERS=PARAMETRS; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.3.4.4 Laying Performance

Number of eggs per clutch, egg size, egg size to body weight ratio, hen-housed rate of lay and hen-day rate of lay were significantly (P<0.05) lower in the F_2 *nana* layers compared to those of *NaNa* and *Nana* F_2 birds. F_2 *nana* layers laid their first eggs significantly (P<0.05) earlier than *NaNa* and *Nana* F_2 layers. Age at first egg was significantly (P<0.05) better in *Nana* F_2 layers than *NaNa* ones whilst the value for henday rate of lay was significantly (P<0.05) higher in *NaNa* F_2 layers than *Nana* ones (Table 4.3.4.4a and Appendix 2).

Table 4.3.4.4a: Laying Performance of *NaNa, Nana and nana* F_2 Birds

Parameter/ Phenotype	***NaNa***	***Nana***	***nana***	**LSD**	**SEM**
Av.Age at First Egg (days)	135.87^a	135.20^b	129.47^c	0.665	0.3360
Av.Eggs per Clutch	18.93^b	19.27^b	16.27^a	0.472	0.2386
Av.Egg Size (g)	58.32^b	58.10^b	52.62^a	0.491	0.2480
Av.Egg Size to Body Wt Ratio	31.21^b	31.09^b	30.14^a	0.275	0.1319
Rate of Lay-Hen-housed (%)	63.27^b	63.00^b	55.93^a	0.640	0.3230
Rate of Lay-Hen-day (%)	66.00^a	65.00^b	59.20^c	0.550	0.2780

$^{a-c}$ Means with different superscripts are significantly (P<0.05) different at 5% level of significance; P'TERS=PARAMETRS; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.3.4.4.1 Effect of Environment (Village) on Laying Performance

Age at first egg, egg size to body weight ratio, hen-housed rate of lay and hen-day rate of lay were not significantly different (P>0.05) between birds from Yawkwei, Juaso and

Nkwanta. However, values for number of eggs per clutch and egg size were significantly higher ($P<0.05$) in birds kept at Nkwanta compared to those from Yawkwei and Juaso (Table 4.3.4.4b and Appendix 2).

Table 4.3.4.4b: Effect of Environment (Village) on Laying Performance

Parameters/ Villages	Yawkwei	Juaso	Nkwanta	LSD	SEM
Av.Age at First Egg (days)	133.60	133.60	133.33	0.665	0.3360
Av.Eggs per Clutch	17.93^{b}	17.93^{b}	18.60^{a}	0.472	0.2386
Av.Egg Size (g)	56.13^{b}	56.13^{b}	56.79^{a}	0.491	0.2480
Av.Egg Size to Body Wt Ratio	30.80	30.80	30.85	0.275	0.1391
Rate of Lay-Hen-housed (%)	60.87	60.87	60.47	0.640	03230
Rate of Lay-Hen-day (%)	63.40	63.40	63.40	0.550	0.2780

$^{a, b}$ Means with different at 5% level of significance; P'TERS=PARAMETRS; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.3.4.5 Egg Quality Parameters

Eggs from the layers of normal feathered birds (*nana*) had significantly lower average values for albumen height, Haugh unit, shell thickness, yolk height, yolk diameter and yolk colour score compared to those from the layers of homozygous (*NaNa*) and heterozygous (*Nana*) naked neck F_2 birds. With regard to yolk colour score the difference between eggs laid by *NaNa* and *nana* layers was not significant ($P>0.05$). Albumen height and yolk diameter were significantly superior in eggs from F_2 *NaNa* layers compared to those from F_2 *Nana* layers (Table 4.3.4.5 and Appendix 2).

Table 4.3.4.5: Egg Quality Parameters of *NaNa, Nana and nana* F_2 Birds

Parameters/ Phenotypes	*NaNa*	*Nana*	*nana*	LSD	SEM
Av.Albumen Height (mm)	7.70^{a}	7.38^{b}	6.99^{c}	0.0568	0.02870
Av.Haugh Unit (%)	82.87^{a}	82.73^{a}	76.07^{b}	1.098	0.5540
Av.Shell Thickness (mm)	0.36^{a}	0.36^{a}	0.31^{b}	0.00623	0.00315
Av.Yolk Height (mm)	18.22^{a}	18.09^{a}	17.41^{b}	0.174	0.0878
Av.Yolk Diameter (mm)	41.73^{a}	40.93^{b}	40.27^{c}	0.449	0.2268
Av.Yolk Colour Score	8.00^{ab}	8.40^{a}	7.73^{b}	0.410	0.2070

$^{a-c}$ Means different superscripts are significantly (P<0.05) different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.3.4.6: Some Carcass Parameters

Percent defeathered weight, dressed weight, thigh and drumstick weight, breast muscle weight, gizzard weight and liver weight were significantly (P<0.05) higher in the carcasses of *NaNa* and *Nana* F_2 birds compared to those of *nana* F_2 birds. However, relative weight of intestines was significantly higher (P<0.05) in *nana* F_2 birds compared to that of *NaNa* and *Nana* F_2 birds. Percent defeathered weight, dressed weight and breast muscle weight were significantly higher (P<0.05) in *NaNa* F_2 birds than *Nana* ones whilst relative weight of intestines was significantly higher (P<0.05) in *Nana* than *NaNa* F_2 birds (Table 4.3.4.6 and Appendix 2).

Table 4.3.4.6: Some Carcass Parameters of *NaNa*, *Nana* and *nana* F_2 Birds

Parameter/ Phenotype	*NaNa*	*Nana*	*nana*	LSD	SEM
Av.Defeathered Weight (%)	95.97^a	93.76^b	88.54^c	0.415	0.2095
Av.Dressed Weight (%)	74.48^a	73.09^b	69.29^c	0.978	0.4940
Av.Thigh and Drumstick Wt (%)	23.62^b	23.42^b	22.71a	0.342	0.1727
Av.Chest Muscle Weight (%)	17.79^a	17.36^b	13.37^c	0.145	0.07310
Av.Wings Weight (%)	10.00	10.26	10.09	0.298	0.1503
Av.Gizzard Weight (%)	4.13^b	4.19^b	3.59^a	0.0810	0.0409
Av.Intestines Weight (%)	4.26^a	4.41^b	4.96^c	0.160	0.0810
Av.Heart Weight (%)	1.58	1.60	1.64	0.0517	0.02610
Av.Liver Weight (%)	2.00^b	2.10^b	2.31^a	0.101	0.0508

$^{a-c}$ Means with different superscripts are significantly (P<0.05) different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.3.4.7 Mortality

Chick mortality was significantly lower (P<0.05) in *nana* F_2 chicks compared to those of *NaNa* and *Nana* F_2 birds. However, total mortality (chick & adult) was significantly

(P<0.05) higher in *nana* F_2 birds than *NaNa* and *Nana* ones (Table 4.3.4.7). **Table 4.3.4.7: Mortality of *NaNa, Nana and nana* F_2 Birds**

Parameters/ Phenotypes	***NaNa***	***Nana***	***nana***	**LSD**	**SEM**
Chick Mortality (%)	1.33^b	1.26^b	1.14^a	0.0928	0.04580
Total Mortality (%)	7.91^b	8.16^b	13.82^a	0.662	0.3350

a, b Means with different superscripts are significantly (P<0.05) different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean

4.4 STUDY FOUR: MATINGS INVOLVING FRIZZLES (*Ff* × *ff*)

4.4.1 First Parental Generation (P_1)

Body weights of the sires ranged from 1,200 g to1,650 g, with sire F_1 being the heaviest and sire F3, the lightest. Fertility of eggs from matings involving the sires ranged from 88.20% (Sire F3) to 99.20% (Sire F4). Hatchabilty of eggs from matings involving the five sires was moderate, ranging from 66.70% (Sire F3) to 89.6% (Sire F5), (Table 4.4.1a).

Table 4.4.1a: Characteristics of the Indigenous Heterozygous Frizzle (*Ff*) Males used in the First Matings

Sire Number	**Sire Colour**	**Age (Months)**	**Av.Weight ±SE (g)**	**Av.Fertility ±SE (%)**	**Av.Hatchability ±SE (%)**
F1	Brown and White	14.00	1650 ± 1.38	96.90 ± 1.24	69.65 ± 2.15
F2	Brown	8.00	1500 ± 1.61	94.30 ± 1.55	70.95 ± 2.04
F3	White	10.00	1200 ± 1.66	88.20 ± 1.36	66.70 ± 2.25
F4	Multi	18.00	1350 ± 1.22	99.2 ± 1.32	70.85 ± 1.98
F5	Ash	16.00	1400 ± 1.88	89.65 ± 2.01	89.65 ± 2.32

SD = Standard Error; Av = Average

The forty Lohmann commercial females used in the first mating were fifty two weeks old. Their average body weight, average egg size, average egg size to body weight ratio, average fertility and average hatchability are presented in Table 4.4.1b.

Table 4.4.1b: Characteristics of the Lohmann Commercial Lohmann Females used in the First Matings with Frizzles

Parameters		**SE**

Colour	Brown	-
Age	52.00weeks	-
Average Weight	1,650.00g	1.96
Average Egg Size	62.36g	1.77
Average Egg Size to Body Wt Ratio	26.46	2.02
Rate of Lay – Hen day	62.55%	2.24
Average Fertility	93.65%	2.46
Average Hatchabiltity	73.56%	2.08

SD= Standard Error

Egg quality characteristics such as albumen height, Haugh unit, shell thickness, yolk height, yolk diameter and yolk colour score of the eggs from the Lohmann commercial females used in the first matings are presented in Table 4.4.1c

Table 4.4.1c: Egg Quality Characteristics of the Eggs from the Commercial Lohmann Females used in the First Mating

Parameters		**Standard Error**
Av.Albumen Height	7.21mm	2.62
Av.Haugh Unit	76.60%	2.51
Av.Shell Thickness	0.31mm	1.46
Av.Yolk Height	15.50mm	1.96
Av.Yolk Diameter	40.00mm	2.17
Av.Yolk Colour Score	5.00	1.23

Av=Average

4.4.2 First Filial Generation (F_1) Frizzles (*Ff*) and Normals (*ff*)

4.4.2.1 Plumage Colour

Fig. 4.4.1: Heterozygous Frizzle and Normal Feathered F_1 Birds

The heterozygous frizzle and normal feathered birds produced in the first filial generation had varying plumage colours (Fig. 4.4.2.1); some of the birds were multicoloured while others had single colours. The colours included white, black and brown; however, the majority of the females were brown in colour.

4.4.2.2 <u>Body Weight and Body Weight Gain (Day-old to 20th Week)</u>

The F_1 heterozygous frizzle (*Ff*) birds were significantly (P<0.05) heavier than their normal feathered (*ff*) counterparts and higher (P<0.05) in body weight gain from dayold to the sixth week (Table 4.4.2.2a and Appendix 2).

Table 4.4.2.2a: Body Weight and Body Weight Gain of F1 *Ff* & *ff* Chicks (0-6 wks)

Parameters/ F_1 Birds	***Ff***	***ff***	**LSD**	**SEM**
Av.Weight at Day-old (g)	39.66^{a}	39.00^{b}	0.2410	0.1155
Av.Weight at Week 1 (g)	63.45^{b}	59.45^{a}	0.00762	0.00365
Av.Weight-Gain b/n Week 0& 1 (g)	23.79^{a}	20.44^{b}	0.00762	0.00365
Av.Weight at Week 2 (g)	111.39^{b}	101.56^{a}	0.418	0.2000

Av.Weight-Gain b/n Week 1&2 (g)	47.93^{a}	42.12^{b}	0.00762	0.00365
Av.Weight at Week 3 (g)	166.94^{b}	155.12^{a}	0.00762	0.00365
Av.Weight-Gain b/n Week 2&3 (g)	55.55b	53.55^{a}	0.2422	0.1161
Av.Weight at Week 4 (g)	230.18^{b}	212.37^{a}	0.00762	0.00365
Av.Weight-Gain b/n Week 3&4 (g)	61.64^{a}	57.25^{b}	0.03474	0.01665
Av.Weight at Week 5 (g)	333.01^{b}	306.52^{a}	0.00762	0.00365
Av.Weight-Gain b/n Week 4&5 (g)	102.80^{a}	94.20^{b}	0.3415	0.1637
Av.Weight at Week 6 (g)	435.10^{a}	403.48^{b}	0.00762	0.00365
Av.Weight-Gain b/n Week 5&6 (g)	102.10^{b}	97.00^{a}	0.2422	0.1161

[a, b] Means with different superscripts are significantly different (P<0.05); LSD=Least Significance Difference; SEM= Standard Error of the Mean; Av =Average; b/n = between

The heterozygous frizzle (*Ff*) F_1 birds were significantly heavier (P<0.05) than their normal feathered (*ff*) counterparts from week 7 to week 13. However, weekly weight gained values within the same period did not differ significantly (P>0.05) between the two phenotypes (Table 4.4.2.2b and Appendix 2).

Table 4.4.2.2b: Body Weight and Body Weight Gain (Week 7 to Week 13) of F_1 *Ff* & *ff* Birds

Parameters/ F1 Birds	***Ff***	***ff***	**LSD**	**SEM**
Av. Wt at Wk7	421.33^{b}	408.33^{a}	3.796	5.2610
Av. Wt at Wk8	473.00^{b}	457.30^{a}	4.240	2.1500
Av. Wt Gain b/n Wk7&8	49.33	47.67	2.260	1.1440
Av. Wt at Wk9	532.70^{b}	507.30^{a}	4.420	2.2400
Av. Wt Gain at Wk8&9	54.67	53.67	2.503	1.2670
Av. Wt at Wk10	604.00^{b}	568.60^{a}	4.680	2.3700
Av. Wt Gain at Wk9&10	67.67	65.00	3.276	1.6580
Av. Wt at Wk11	688.70^{b}	645.30^{a}	5.780	2.9300
Av. Wt Gain at Wk10&11	80.00	79.33	3.300	1.6700
Av. Wt at Wk12	781.00^{b}	729.00^{a}	6.550	3.3100
Av. Wt Gain at Wk11&12	87.30	88.70	3.990	2.0200
Av. Wt at Wk13	876.00^{b}	817.70^{a}	7.040	3.5600
Av. Wt Gain at Wk12&13	89.70	90.00	3.990	2.0200

[a, b]

Means different superscripts are significantly different (P<0.05); LSD=Least Significant Difference; SEM= Standard Error of the Mean; Av=Average; b/n = between

Table 4.4.2.2c: Comparing the Body Weight and Body Weight Gain (Week 14 to week 20) of F_1 *Ff* and *ff* Birds

Parameters/ F_1 Birds	*Ff*	*ff*	LSD	SEM
Av. Wt at Wk14	971.70[b]	903.00[a]	8.700	4.4100
Av. Wt Gain b/n Wk13&14	90.33	90.67	3.834	1.9400
Av. Wt at Wk15	1073.70[b]	992.30[a]	12.380	6.2600
Av. Wt Gain b/n Wk14&15	95.67	95.67	3.709	1.8770
Av. Wt at Wk16	1177.30[b]	1086.00[a]	10.180	5.1500
Av. Wt Gain b/n Wk15&16	98.67	98.22	3.665	1.8550
Av. Wt at Wk17	1241.70[b]	1141.30[a]	9.680	4.9000
Av. Wt Gain b/n Wk16&17	106.70	103.90	3.980	2.0100
Av. Wt at Wk18	1356.90[b]	1247.00[a]	11.030	5.5800
Av. Wt Gain b/n Wk17&18	111.7	108.3	4.160	2.1100
Av. Wt at Wk19	1474.00[b]	1357.00[a]	12.160	6.1600
Av. Wt Gain b/n Wk18 &19	113.7	113.2	4.110	2.0800
Av. Wt at Wk20	1582.60[b]	1467.00[a]	14.530	7.3500
Av. Wt Gain b/n Wk19&20	110.67	109.33	3.571	1.8070

[a, b] Means with different superscripts are significantly different (P<0.05); LSD=Least Significant Difference; SEM= Standard Error of the Mean; Av=Average; b/n = between

The F_1 *Ff* birds were significantly (P<0.05) higher in body weight compared to their *ff* counterparts from week 14 to week 20 whilst the differences in weekly weight gained values between the two phenotypes within the same period were not significant (P>0.05), (Table 4.4.2.2c and Appendix 2).

4.4.2.3 Body Measurements

Body length, body width and shank length of *Ff* and *ff* F_1 birds were not significantly (P>0.05) different (Table 4.4.2.4 and Appendix 2)

Table 4.4.2.3: Body Measurements of *Ff* & *ff* F_1 Birds

Parameters/ F1 Birds	*Ff*	*ff*	LSD	SEM
Av.Body Length (cm)	35.18	34.99	0.629	0.3210
Av.Body Width (cm)	14.13	14.14	0.0912	0.0465
Av.Shank Length (cm)	8.25	8.21	0.0680	0.0346

Means with different superscripts are significantly different (P<0.05); LSD= Least Significant Difference; SEM= Standard Error of the Mean; Av=Average

4.4.2.4 Egg Laying Performance

The F_1 *Ff* layers were significantly superior (P<0.05) to their *ff* counterparts in terms of number of eggs per clutch, egg size to body size ratio and rate of lay (hen-housed and hen-day). However, age at first egg was significantly better (P<0.05) in F_1 *ff* layers compared to the F_1 *Ff* ones whilst egg size was not significantly different (P>0.05) between the two phenotypes (Table 4.4.2.4a and Appendix 2).

Table 4.4.2.4a: Laying Performance of F_1 *Ff* & *ff* Birds

Parameters/ F_1 Birds	*Ff*	*ff*	LSD	SEM
Av.Age at First Egg (days)	147.32^a	144.48^b	0.828	0.4210
Av.Egg per Clutch	16.76^a	15.20^b	0.622	0.3160
Av.Egg Size (g)	48.32	48.44	0.718	0.3650
Av.Egg Size to Body Size Ratio	28.57^b	26.26^a	0.650	0.3310
Rate of Lay-Hen-housed (%)	54.83^b	51.49^a	0.693	0.3520
Rate of Lay- Hen-day (%)	60.31^b	57.88^a	0.797	0.4060

$^{a,\ b}$ Means with different superscripts are significantly different (P<0.05); P'TYPE= Phenotypes; LSD= Least Significant Difference; SEM= Standard Error of the Mean; Av=Average

4.4.2.4.1 The Effect of Environment (Village) on Laying Performance

Age at first egg, eggs per clutch, egg size, egg size to body size ratio and hen-day rate of lay were not significantly different (P>0.05) among layers that were reared in the three villages; hen-housed rate of lay was significantly lower in layers that were reared at Yawkwei as compared to those reared at Juaso and Nkwanta (Table 4.4.2.4b and Appendix 2).

Table 4.4.2.4b: The Effect of Environment on Laying Performance of F_1 Birds

Parameters/Villages	Yawkwei	Juaso	Nkwanta	LSD	SEM

Av.Age at First Egg (days)	145.66	145.98	146.06	1.014	0.5160
Av.Eggs per Clutch	15.94	15.94	16.06	0.762	0.3870
Av.Egg Size (g)	48.55	48.36	48.23	0.880	0.4470
Av.Egg Size to Body Size Ratio	27.49	27.33	27.42	0.796	0.4050
Rate of Lay-Hen-housed (%)	52.24^{a}	53.69^{b}	53.55^{b}	0.848	0.4320
Rate of Lay- Hen-day (%)	58.07	59.53	59.68	0.976	0.4970

$^{a,\ b}$ Means with different superscripts are significantly different (P<0.05); LSD= Least Significant Difference; SEM= Standard Error of the Mean; Av=Average

4.4.2.4.2 <u>The Effect of Sire on Laying Performance</u>

Age at first egg was significantly (P<0.05) better in the offspring of sires F2, F4 and F5 followed by those of sires F3, and F1 respectively (Table 4.4.2.4c). Egg size was significantly higher in the offspring of sire F1 than those of sires F2, F4 and F5 which were significantly better than those of F3. Egg size to body size ratio was significantly (P<0.05) better in the offspring of sires F3 and F4 compared to those of sires F1 and F5, and those of sire F2 performed least; however, among the offspring of sires F1 & F3 and also F3 & F5 the differences were not significant (P>0.05). Hen-housed rate of lay was significantly higher (P<0.05) in the offspring of sire F2 than those of sires F1 & F5 which were significantly better (P<0.05) compared to the offspring of sires F3 & F4.

However, the difference was not significant (P>0.05) neither between the offspring of sires F2 and F5 nor those of sires F1 and F3. Number of eggs per clutch and hen-day rate of lay did not differ significantly (P>0.05) between offspring of the five sires (Table 4.4.2.4c and Appendix 2).

Table 4.4.2.4c: The Effect of Sire on Laying Performance of F_1 Birds

P'ters/ Sires	F1	F2	F3	F4	F5	LSD	SEM
Av.Age at First Egg (days)	148.20^{a}	145.10^{b}	146.50^{c}	144.60^{b}	145.10^{b}	1.309	0.6660
Av.No. of Eggs per Clutch	15.80	15.90	16.60	15.60	16.00	0.983	0.5000
Av.Egg Size (g)	50.82^{a}	$49.11b^{e}$	45.95^{c}	$47.62d^{e}$	48.39^{e}	1.135	0.5780

Av.Egg Size to Body Size Ratio	27.31[a]	28.83[b]	26.72[ac]	26.22[c]	27.99[a]	1.027	0.5230
Rate of Lay-Henhoused (%)	53.20[ac]	54.50[b]	52.33[cd]	51.87[d]	53.90[ab]	1.095	0.5570
Rate of Lay-Henday (%)	58.60	59.40	58.27	59.40	59.80	1.261	0.6410

[a, b] Means with different superscripts are significantly different (P<0.05); Av=Average; P'TERS= Parameters; LSD= Least Significant Difference; SEM= Standard Error of the Mean;

4.4.2.5 <u>Egg Quality Parameters</u>

The eggs of the F_1 heterozygous frizzle (*Ff*) layers had significantly (P<0.05) higher values for albumen height, Haugh unit and yolk height as compared to eggs from their normal feathered counterparts. However, shell thickness, yolk diameter and yolk colour score values were not significantly different (P>0.05) between eggs from layers of the two phenotypes (Table 4.4.2.5 and Appendix 2).

Table 4.4.2.5: Egg Quality Measurements of F_1 *Ff* and *ff* Birds

Parameters/ F_1 Birds	***Ff***	***ff***	**LSD**	**SEM**
Av.Albumen Height (mm)	6.60[a]	5.91[b]	0.394	0.2000
Av.Haugh Unit (%)	80.32[a]	77.24[b]	1.222	0.9830
Av.Shell Thickness (mm)	0.31	0.31	0.00287	0.001459
Av.Yolk Height (mm)	15.50[a]	14.96[b]	0.437	0.2220
Av.Yolk Diammeter (mm)	39.59	39.40	0.998	0.5080
Av.Yolk Colour Score	8.24	8.09	0.185	0.0940

[a, b] Means with followed by different superscripts are significantly different (P<0.05); P'TERS= Parameters; LSD= Least Signiificant Difference; SEM= Standard Error of the Mean; Av=Average

4.4.2.6 <u>Carcass Parameters</u>

The carcasses of the F_1 birds with the frizzle (*Ff*) phenotype did not differ significantly (P>0.05) from those of their normal feathered counterparts in terms of defeathered weight, thigh and drumstick weight, breast muscle weight, weight of wings, gizzard weight, heart weight and liver weight (Table 4.4.2.6 and Appendix 2). Values for dressed weight and weight of intestines of the *Ff* birds were significantly (P<0.05) higher than those of the *ff* birds (Table 4.4.2.6 and Appendix 2).

Table 4.4.2.6: Some Carcass Parameters of F_1 *Ff* and *ff* Birds

Parameters/ F_1 Birds	*Ff*	*ff*	LSD	SEM
Av. Defeathered Weight (%)	90.52	90.41	0.241	0.1224
Av. Dressed Weight (%)	68.50[a]	68.24[b]	0.238	0.1212
Av. Thigh and Drumstick Wt (%)	23.18	23.09	0.153	0.0779
Av. Chest Muscle Weight (%)	14.62	14.61	0.0544	0.0277
Av. Wing Weight (%)	9.63	9.58	0.0553	0.0281
Av. Weight of Intestines (%)	4.08[a]	3.85[b]	0.0801	0.0408
Av. Gizzard Weight (%)	3.56	3.58	0.0474	0.0241
Av. Heart Weight (%)	1.56	1.56	0.0279	0.01419
Av. Liver Weight (%)	1.99	1.99	0.0242	0.01229

[a, b] Means with different superscripts are significantly different (P<0.05); LSD= Least Significant Difference; SEM= Standard Error of the Mean; Av=Average

4.4.2.7 Mortality

The *Ff* birds were significantly higher (P<0.05) in chick (day-old to 6wks) and total (day-old to end of lay) mortalities compared to their *ff* counterparts (Table 4.4.2.7 and Appendix 2).

Table 4.4.2.7: Mortality of F_1 *Ff* and *ff* Birds

Parameters/ F1 Birds	*Ff*	*ff*	LSD	SEM
Chick Mortality (%)	1.34[a]	1.24[b]	0.0762	0.0365
Total Mortality (%)	11.30[a]	10.96[b]	0.211	0.1074

[a, b] Means with different superscripts are significantly (P<0.05) different; LSD= Least Significant Difference; SEM= Standard Error of the Mean

4.4.3 Matings Involving Frizzles (*Ff* × *Ff*)

4.4.3.1 Second Parental Generation (P_2)

The male and female parents of the second generation were selected from the heterozygous frizzles produced in the first filial generation. The males were 400g heavier than the females at 20 weeks of age. Mortality from the growing to the laying period was only 3%. Fertility was 92.67% whilst hatchability was 77.70%. Productive characteristics of the second generation of parents (P_2) namely average body weight at 20 weeks, average age at first egg, average rate of lay (hen-housed and hen-day), average egg size to body weight ratio and mortality and their measures of dispersion are shown in Table 4.4.3a. Reproductive characteristics of the second parental generation such as fertility and hatchability, and their measures of dispersion are also shown in Table 4.4.3a.

Table 4.4.3a: Productive and Reproductive Characteristics of P_2 Birds

Parameters	**Mean**	**SE**
Av. Body Weight at 20wks-Males	1,900.00g	2.44
Av. Body Weight at 20wks-Females	1,500.00g	2.25
Av. Age at First Egg	138.00days	1.88
Hen-Housed Rate of Lay	60.00%	1.76
Hen-Day Rate of Lay	64.00%	2.22
Av. Egg Size to Body Weight Ratio	27.27	2.04
Av. Fertility	92.67%	1.92
Av. Hatchability	77.70%	2.85
Mortality	3.00%	0.00

SD=Standard Error; Av=Average

The eggs of the females of second generation of parents had an average weight of 55g with a Haugh unit of 75.20%. The egg quality characteristics of the P_2 female parents in terms of egg size, albumen height, Haugh unit, shell thickness, yolk height, yolk diameter and yolk colour score are presented in Table 4.4.3b.

Table 4.4.3b: Egg Quality Characteristics of the Second Generation Parents (P_2)

Parameters	**Mean**	**SE**
Av.Egg Size	55.00g	2.14
Av.Albumen Height	7.12mm	1.54
Av.Haugh Unit	75.20%	1.84
Av.Shell Thickness	0.34mm	1.28

Av.Yolk Height	16.00mm	1.82
Av.Yolk Diameter	40.00mm	1.70
AvYolk Colour Score	6.00	1.65

SD- Standard Error; Av=Average

4.4.4.0 Second Filial Generation Birds – Frizzles (*FF*, *Ff*) and Normals (*ff*)

4.4.4.1 Plumage Colour

The second filial generation (F_2) birds (homozygous frizzles-*FF*, heterozygous frizzle*Ff* and normal feathered-*ff)* had varying feather colours (Fig. 4.4.4.1); some had multicolours while others had single colours. The colours included white, black, reddish brown and brown; however, majority of the females were brown in colour.

Fig.4.4.2: The F_2 Generation Homozygous Frizzles (*FF*)

4.4.4.2 Body Weight and Body Weight Gain (Day-old to Week 20)

Body weight and body weight gain from day-old to six weeks of age of homozygous frizzle (*FF*), heterozygous frizzle (*Ff*) and normal feathered (*ff*) F_2 birds did not differ significantly (P>0.05), (Table 4.4.4.2a and Appendix 2).

Table 4.4.4.2a: Body Weight and Body Weight Gain (Day-old to Week 6) of *FF*, *Ff* & *ff* F_2 Birds

PARAMETERS/ F2 BIRDS	*FF*	*Ff*	*ff*	LSD	SEM
Av.Body Wt at Day-old	35.90	36.76	38.00	3.309	1.6350
Av.Body Weight at Week 1	70.77	71.69	71.99	2.566	1.2670
Av.Body Weight-Gain b/n Week0&1	34.27	33.50	32.64	2.418	1.1950
Av.Body Weight at Week 2	122.13	121.03	122.10	2.616	1.292
Av.Body Weight-Gain b/n Week1&2	51.56	51.27	51.84	3.210	1.5860
Av.Body Weight at Week 3	180.27	179.51	179.71	2.294	1.1330
Av.Body Weight-Gain b/n Week2&3	58.60	58.25	57.84	3.603	1.7800
Av.Body Weight at Week 4	243.58	243.68	242.64	4.857	2.3990
Av.Body Weight-Gain b/n Week3&4	62.84	62.70	61.66	2.709	1.3380
Av.Body Weight at Week 5	307.70	306.90	307.20	6.130	30300
Av.Body Weight-Gain b/n Week4&5	64.90	65.06	64.52	3.300	1.6300
Av.Body Weight at Week 6	388.10	378.40	376.90	10.740	5.3000
Av.Body Weight-Gain b/n Week5&6	80.20	72.40	72.80	8.950	4.4200

Means with different superscripts are significantly different at 5% level of significance; LSD= Least Significant Difference; SEM=Standard Error of the Mean; Av=Average; b/n = between

At the end of weeks 7 and 13 the normal feathered F_2 birds were significantly (P<0.05) higher in body weight than the homozygous and heterozygous F_2 frizzles (Table 4.4.4.2b). During weeks 8, 12 and 14 to 18, the heterozygous F_2 frizzles and the normal feathered F_2 birds were significantly heavier (P<0.05) than the homozygous F_2 frizzles. Body weight at the end of week 9 was significantly higher (P<0.05) for the heterozygous F_2 frizzles compared to the homozygous F_2 frizzles and normal feathered F_2 birds (Table 4.4.4.2b and Appendix 2).

Table 4.4.4.2b: Body Weight and Body Weight Gain (Week 7 to Week 14) of Homozygous Frizzle (*FF*), Heterozygous Frizzle (*Ff*) and the Normal Feathered (*ff*) F_2 Birds

Parameters/ F2 Birds	*FF*	*Ff*	*ff*	LSD	SEM
Av. Body Wt at Week 7 (g)	387.78^{b}	387.22^{b}	393.56^{a}	4.561	2.3160
Av. Body Weight at Week 8 (g)	425.56^{a}	431.67^{b}	434.44^{b}	4.698	2.3850
Av. Body Weight-Gain b/n Week7& 8 (g)	46.67^{b}	52.22^{a}	48.67^{b}	2.850	1.4470
Av. Body Weight at Week 9 (g)	487.22^{b}	496.11^{a}	491.22^{b}	4.568	2.3200
Av. Body Weight-Gain b/n Week8& 9 (g)	66.11	65.00	64.33	2.778	1.4110
Av. Body Weight at Week 10(g)	573.30	573.30	567.90	5.230	2.6500
Av. Body Weight-Gain b/n Week 9&10 (g)	83.33^{b}	83.33^{b}	79.00^{a}	3.209	1.6290
Av. Body Weight at Week 11 (g)	661.10	656.70	659.10	5.370	2.7300
Av. Body Weight-Gain b/n Week 10&11 (g)	91.67	91.67	92.00	3.226	1.6380
Av. Body Weight at Week 12 (g)	738.00^{a}	773.00^{b}	771.00^{b}	31.860	16.1800
Av. Body Weight-Gain b/n Week 11&12 (g)	111.67^{b}	114.44^{b}	120.33^{a}	4.072	2.0680
Av. Body Weight at Week 13 (g)	906.10^{b}	905.00^{b}	911.90^{a}	5.790	2.9400
Av. Body Weight-Gain b/n Week 12&13 (g)	133.33	137.22	135.11	4.457	2.2630
Av. Body Weight at Week 14 (g)	1038.30^{a}	1051.10^{b}	1051.90^{b}	10.470	5.3200
Av. Body Weight-Gain b/n Week 13&14 (g)	138.33	138.33	140.11	3.530	1.7930

$^{a,\,b}$ Means with different superscripts are significantly (P<0.05); LSD= Least Significant Difference; SEM=Standard Error of the Mean; Av=Average; b/n = between

Body weight gain at week 8 was significantly higher (P<0.05) for *Ff* birds as compared to the *FF* and *ff* ones (Table 4.4.4.2b and Appendix 2). During weeks 10, 12 and 18, body weight gain was significantly higher (P<0.05) for ff birds than *FF* and *Ff* birds. Body weight gain at weeks 17 and 19 was significantly higher (P<0.05) for *Ff* and *ff* birds compared to *FF* ones (Table 4.4.4.2b & c and Appendix 2). However, body weight at the end of weeks 10, 11, 19 and 20, and also body weight gain during weeks 9, 11, 13 to 16 and 20 were not significantly different (P>0.05) between *FF*, *Ff*, *ff* birds (Table 4.4.4.2b & c, Fig. 4.4.4.2 and Appendix 2).

Table 4.4.4.2c: Effect of Genotype on the Weekly Body Weight and Weekly Weight Gain of F_2 *FF*, *Ff* & *ff* Birds (Week 15 to Week 20).

Parameter/ F_2 Birds	***FF***	***Ff***	***ff***	**LSD**	**SEM**
Av.Body Weight at Week 15 (g)	1161.70[a]	1173.90[b]	1176.30[b]	6.180	3.1400
Av.Body Weight-Gain b/n Week14& 15 (g)	141.67	145.00	145.78	4.054	2.0580
Av.Body Weight at Week 16 (g)	1302.80[a]	1316.70[b]	1315.30[b]	7.710	3.9200
Av.Body Weight-Gain b/n Week 15&16 (g)	143.33	144.44	144.11	3.833	1.9460
Av.Body Weight at Week 17 (g)	1428.90[a]	1448.90[b]	1445.90[b]	10.980	5.5700
Av.Body Weight-Gain b/n Week 16&17 (g)	133.33[a]	142.22[b]	139.11[b]	4.072	2.0680
Av.Body Weight at Week 18 (g)	1540.60[a]	1555.60[b]	1552.20[b]	10.130	5.1400
Av.Body Weight-Gain b/n Week 17&18 (g)	128.30[b]	133.90[b]	141.30[a]	4.920	2.5000
Av.Body Weight at Week 19 (g) (g)	1667.20	1673.30	1664.80	12.120	6.1500
Av.Body Weight-Gain b/n Week18& 19	118.90[a]	126.70[b]	123.40[b]	5.110	2.6000
Av.Body Weight at Week 20 (g)	1760.60	1776.10	1768.00	30.890	15.6800
Av.Body Weight-Gain b/n Week 19&20 (g)	121.10	118.90	124.00	5.230	2.6500

[a, b] Means with different superscripts are significantly different at 5% level of significance; LSD= Least Significant Difference; SEM=Standard Error of the Mean; Av=Average; b/n = between

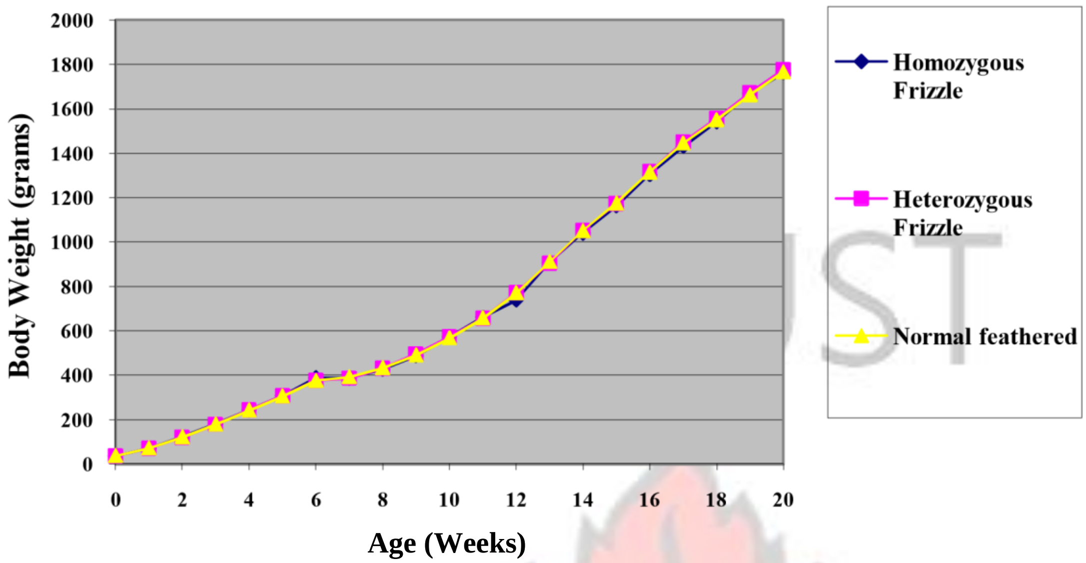


Fig.4.4.3: A Graph Showing the Growth Patterns of Homozygous Frizzle, Heterozygous Frizzle and Normal Feathered F_2 Birds

4.4.4.3 Body Measurements

Ff birds had significantly (P<0.05) higher values in average body length compared to their *FF* and *ff* counterparts. However, average body width and shank length did not differ significantly (P>0.05) among *FF*, *Ff* and *ff* F_2 birds (Table 4.4.4.3 and Appendix 2).

Table 4.4.4.3: Body Measurements of Homozygous Frizzle, Heterozygous Frizzle and Normal Feathered F_2 Birds

Parameters/F_2 Birds	*FF*	*Ff*	*ff*	LSD	SEM
Av.Body Length (cm)	37.40^b	38.07^a	37.06^b	0.517	0.2630
Av.Body Width (cm)	13.93	14.13	13.89	0.357	0.1812
Av.Shank Length (cm)	8.52	8.32	8.51	0.262	0.1328

$^{a,\ b}$ Means with different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; SEM= Standard Error of the Mean; Av=Average

4.4.4.4 Egg Laying Performance

Normal feathered (*ff*) F_2 birds had a significantly ($P<0.05$) better value for age at first egg than the frizzles (*FF* and *Ff*). Number of eggs per clutch was significantly ($P<0.05$) higher for *Ff* birds followed by *FF* ones and the *ff* birds had the lowest. Hen-housed and hen-day rate of lay were significantly ($P<0.05$) higher for the birds showing the homozygous and heterozygous frizzle phenotypes as compared to those with the normal feathered phenotype. Egg size and egg size to body weight ratio did not differ significantly ($P>0.05$) between layers from the three phenotypes (Table 4.4.4.4a and Appendix 2).

Table 4.4.4.4a: Laying Performance of F_2 *FF, Ff & ff* Birds

Parameters/ F_2 Birds	***FF***	***Ff***	***ff***	**LSD**	**SEM**
Av.Age at First Egg (days)	133.07^b	133.47^b	130.00^a	2.820	1.4250
Av.Eggs per Clutch	16.80^a	17.53^b	15.53^c	0.584	0.2950
Av.Egg Size (g)	53.95	54.23	52.84	1.204	0.6080
Av. Egg Size to Body Size Ratio	1 : 28.31	1 : 27.98	1 : 27.71	0.491	0.2480
Rate of Lay-Hen-housed (%)	59.07^b	59.93^b	55.73^a	2.447	1.2360
Rate of Lay- Hen-day (%)	63.87^b	64.27^b	60.80^a	1.651	0.8340

$^{a-c}$ Means with different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.4.4.4.1 <u>The Effect of Environment (Village) on Laying Performance</u>

Age at first egg, egg size, egg size to body weight ratio, hen-housed rate of lay and henday rate of lay of *FF, Ff* and *ff* F_2 birds were not significantly different ($P>0.05$) between layers from the three villages (Table 4.4.4.4b and Appendix 2). However, values for number of eggs per clutch were significantly higher ($P<0.05$) in layers from Nkwanta compared to those from Yawkwei and Juaso (Table 4.4.4.4b and Appendix 2).

Table 4.3.4.4b: Effect of Environment on Laying Performance of F_2 Birds (*FF, Ff & ff*)

Parameters/ Villages	**Yawkwei**	**Juaso**	**Nkwanta**	**LSD**	**SEM**
Av.Age at First Egg (days)	133.60	133.60	133.33	0.665	0.3360

Av.Number of Eggs per Clutch	17.93^{b}	17.93^{b}	18.60^{a}	0.472	0.2386
Av.Egg Size (g)	53.64	53.66	53.65	0.203	0.1428
Av.Egg Size to Body Wt Ratio	30.80	30.80	30.85	0.275	0.1391
Rate of Lay-Hen-housed (%)	60.87	60.87	60.47	0.640	03230
Rate of Lay-Hen-day (%)	63.40	63.40	63.40	0.550	0.2780

$^{a,\ b}$ Means with different superscripts are significantly different at 5% level of significance; P'TERS=PARAMETRS; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.4.4.5 <u>Egg Quality Parameters</u>

Eggs from the layers of homozygous frizzle, heterozygous frizzle and normal feathered F_2 birds did not differ significantly ($P>0.05$) in values for albumen height, yolk height, yolk diameter and yolk colour score (Table 4.4.4.5 and Appendix 2). Haugh unit value was significantly higher ($P<0.05$) in eggs from the layers of homozygous and heterozygous frizzles compared to those from the layers of normal feathered ones. Eggs from the layers with homozygous frizzle phenotype had a significantly higher ($P<0.05$) shell thickness values than the heterozygotes which also had significantly thicker ($P<0.05$) shells than the normal feathered ones (Table 4.4.4.5 and Appendix 2). **Table 4.4.4.5: Egg Quality Performance of F_2 *FF*, *Ff* & *ff* Birds**

Parameters/ F_2 Birds	***FF***	***Ff***	***ff***	**LSD**	**SEM**
Av.Albumen Height (mm)	7.39	7.23	7.11	0.364	0.1840
Av.Haugh Unit (%)	79.40^{b}	79.20^{b}	76.87^{a}	2.251	1.1370
Av.Shell Thickness (mm)	0.35^{a}	0.34^{b}	0.32^{c}	0.00484	0.002445
Av.Yolk Height (mm)	16.59	16.58	16.24	0.414	0.2093
Av.Yolk Diammeter (mm)	40.47	40.27	40.00	1.650	0.8330
Av.Yolk Colour Score	8.27	8.00	7.80	0.417	0.2108

$^{a-c}$ Means with different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.4.4.6 Some Carcass Parameters

Defeathered weight, thigh and drumstick weight, breast muscle weight, weight of wings, weight of intestines, gizzard weight and heart weight were not significantly (P>0.05) affected by the phenotypes of the birds (Table 4.4.4.6 and Appendix 2). Normal feathered F_2 birds had significantly lower (P<0.05) values for dressed and liver weights than the frizzles (*FF*, *Ff*), (Table 4.4.4.6 and Appendix 2).

Table 4.4.4.6: Comparison of Some Carcass Parameters of Homozygous Frizzle (*FF*), Heterozygous Frizzle (*Ff*) and the Normal Feathered (*ff*) F_2 Birds

Parameter/ F_2 Birds	*FF*	*Ff*	*ff*	LSD	SEM
Av.Defeathered Weight (%)	92.31	91.00	90.17	2.592	1.310
Av.Dressed Weight (%)	72.70^b	71.61^b	70.46^a	1.114	0.5630
Av.Thigh and Drumstick Wt (%)	24.50	24.24	23.97	0.950	0.4800
Av.Chest Muscle Weight (%)	15.63	15.16	15.21	0.818	0.4130
Av.Wings Weight (%)	9.49	9.46	9.80	0.615	0.3110
Av.Gizzard Weight (%)	3.72	3.64	3.47	0.852	0.430
Av.Intestines Weight (%)	4.51	4.37	4.63	0.731	0.3690
Av.Heart Weight (%)	1.55	1.55	1.58	0.0431	0.02178
Av.Liver Weight (%)	2.09^b	2.11^b	1.96^a	0.126	0.0636

$^{a, b}$ Means with different superscripts are significantly different at 5% level of significance; LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.4.4.7 Mortality

Chick mortality of homozygous frizzle, heterozygous frizzle and normal feathered F_2 birds were not affected significantly (P>0.05) by the phenotypes of the birds; while total mortality (from day-old to the end of lay) was significantly higher (P<0.05) in the normal feathered birds as compared to the homozygous and heterozygous frizzles (Table 4.4.4.7 and Appendix 2).

Table 4.4.4.7: The Effect of Genotype on the Mortality of the F_2 Birds

Parameters/ F_2 Birds	***FF***	***Ff***	***ff***	**LSD**	**SEM**
Chick Mortality (%)	1.52	1.39	1.40	0.2413	0.119
Total Mortality (%)	9.27[b]	8.80[b]	11.27[a]	0.666	0.3360

[a, b] Means with different superscripts are significantly different (P<0.05); LSD=Least Significant Difference; SEM= Standard Error of the Mean

4.5 STUDY FIVE: F_2 NAKED NECKS (*NaNa*, *Nana*), FRIZZLES (*FF*, *Ff*) AND NORMALS (*nana/ff*) REARED UNDER THREE DIFFERENT MANAGEMENT SYSTEMS (INTENSIVE, SEMI-INTENSIVE & EXTENSIVE)

4.5.1 Introduction

Comparisons in traits of economic importantance between *Nana* & *nana*; *NaNa*, *Nana* & *nana*; *Ff* & *ff*; and *FF*, *Ff* & *ff* birds have already been done in the two previous experiments. Therefore, the results of this experiment will focus on comparison between naked neck (*NaNa*, *Nana*) and frizzle (*FF*, *Ff*) phenotypes in reproductive and productive traits. However, since the economics of producing these birds have not been considered in any of the experiments, comparison between the three phenotypes (naked neck, frizzle and normal feathered) have been done on these parameters in this experiment. Additionally, results on the effects of management system (intensive, semiintensive and extensive) on all the traits measured would also be presented.

4.5.2 Body Weight and Weight Gain

Body weights from week 7 to week 20 were significantly (P<0.05) higher in F_2 birds showing the naked neck phenotypes (*NaNa* & *Nana*) compared to the frizzles (*FF* & *Ff*), (Tables 4.5.2a1 & 2). *NaNa* and *Nana* F_2 birds gained significantly (P<0.05) more weight from week 8 to week 20 than *FF & Ff* ones (Tables 4.5.2a1 & 2, Fig. 4.5.2 and Appendix 2).

Table 4.5.2a1: Body Weight and Body Weight Gain (Week 7 to week 14) F_2 Naked necks (*NaNa, Nana*) and Frizzles (*FF, Ff*)

Parameters/Genotype	*NaNa*	*Nana*	*FF*	*Ff*	LSD	SEM
Av.Wt at Wk7	509.7^{a}	508.63^{a}	440.44^{c}	448.44^{b}	3.876	1.9760
Av.Wt at Wk8	562.30^{a}	561.85^{a}	478.22^{c}	484.67^{b}	4.555	2.3220
Av.Wt Gain b/n Wk7&8	51.67^{a}	52.00^{a}	37.89^{b}	37.22^{b}	0.900	1.7650
Av.Wt at Wk9	620.74^{a}	624.07^{a}	521.11^{b}	525.67^{b}	5.535	2.8210
Av.Wt Gain b/n Wk8&9	60.00^{a}	56.00^{b}	42.78^{c}	41.11^{d}	1.651	0.8420
Av.Wt at Wk10	697.63^{a}	688.44^{b}	578.67^{c}	583.44^{c}	5.446	2.7760
Av.Wt Gain b/n Wk9&10	75.11^{a}	72.11^{b}	57.67^{c}	57.78^{c}	1.758	0.8960
Av.Wt at Wk11	786.33^{a}	777.33^{b}	653.44^{c}	652.33^{c}	5.588	2.8480
Av.Wt Gain b/n Wk10&11	90.33^{a}	88.00^{b}	74.67^{c}	68.89^{d}	1.868	0.9520
Av.Wt at Wk12	886.80^{a}	872.60^{b}	743.70^{c}	732.50^{d}	7.290	2.8800
Av.Wt Gain b/n Wk11&12	99.78^{a}	94.89^{b}	83.56^{c}	78.00^{d}	1.821	0.9280
Av.Wt at Wk13	998.90^{a}	981.80^{b}	830.00^{c}	819.30^{d}	6.590	3.3600
Av.Wt Gain b/n Wk12&13	110.44^{a}	108.56^{a}	96.11^{b}	90.67^{c}	2.225	1.1340
Av.Wt at Wk14	1121.40^{a}	1101.80^{b}	932.70^{c}	918.80^{d}	7.160	3.6500
Av.Wt Gain b/n Wk13&14	124.33^{a}	121.00^{b}	102.56^{c}	99.56^{d}	1.498	0.7640

$^{a-d}$ Means with different superscripts are significantly different (P<0.05); LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average; b/n = between

Table 4.5.2a2: Body Weight and Body Weight Gain (Week 15 to week 20) of *NaNa,Nana, FF & Ff* Birds

Parameters/Genotype	*NaNa*	*Nana*	*FF*	*Ff*	LSD	SEM
Av.Wt at Wk15	1258.80^{a}	1234.20^{b}	1052.50^{c}	1034.30^{d}	8.230	4.2000

Av.Wt Gain b/n Wk14&15	123.44^{a}	127.67^{b}	125.67^{ab}	118.67^{c}	3.091	1.5760
Av.Wt at Wk16	1413.10^{a}	1384.20^{b}	1177.70^{c}	1155.90^{d}	8.940	4.5600
Av.Wt Gain b/n Wk15&16	155.00^{a}	149.89^{a}	130.00^{c}	125.89^{d}	2.300	1.1730
Av.Wt at Wk17	1579.70^{a}	1543.90^{b}	1314.90^{c}	1283.00^{d}	9.890	5.0400
Av.Wt Gain b/n Wk16&17	163.78^{a}	158.44^{b}	133.44^{c}	126.11^{d}	2.065	1.0520
Av.Wt at Wk18	1763.80^{a}	1721.30^{b}	1463.80^{c}	1426.40^{d}	10.890	5.5500
Av.Wt Gain b/n Wk17&18	175.70^{a}	179.22^{b}	158.56^{c}	146.11^{d}	2.788	1.4210
Av.Wt at Wk19	1810.10^{a}	1925.30^{b}	1746.40^{c}	1569.60^{d}	30.420	15.5100
Av.Wt Gain b/n Wk18&19	192.56^{a}	185.89^{b}	155.89^{c}	150.67^{d}	2.275	1.1600
Av.Wt at Wk20	2159.50^{a}	2102.30^{b}	1795.80^{c}	1734.90^{d}	14.400	7.3400
Av.Wt Gain b/n Wk19&20	203.44^{a}	197.78^{b}	169.37^{c}	164.44^{d}	2.347	1.1960

$^{a-d}$ Means with different superscripts are significantly different (P<0.05); LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average; b/n = between

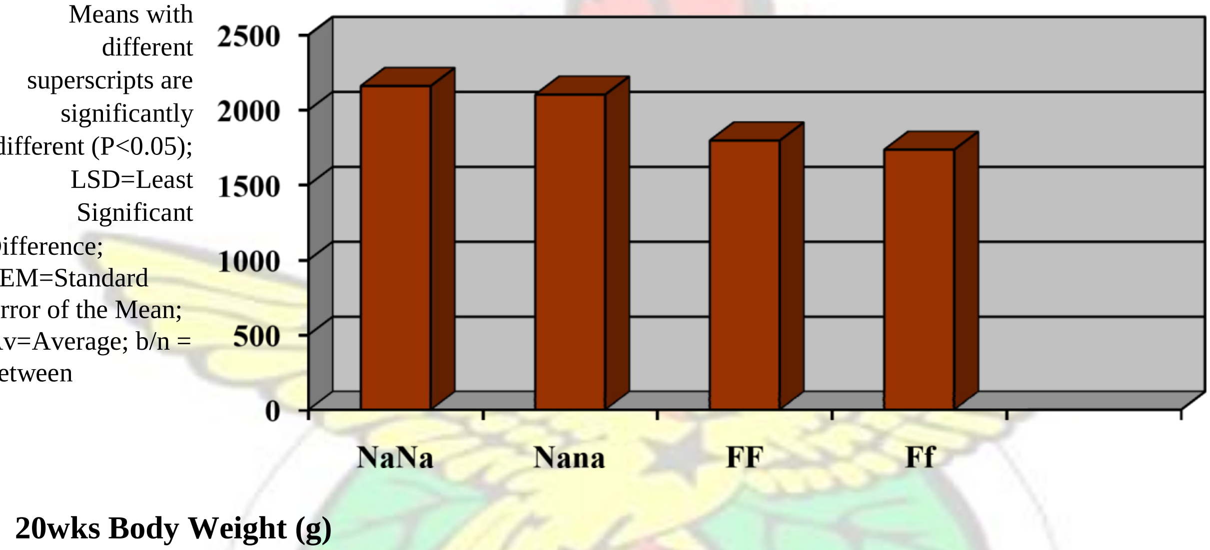


Fig.4.5.1: A Bar Chart Showing the 20wks Body Weight of Homozygous Naked neck, Heterozygous Naked neck, Homozygous Frizzle and Heterozygous Frizzle F$_2$ Birds

Fig.4.5.2: Various F_2 Phenotypes reared Under the three Management Systems

4.5.2.1 <u>The Effect of Management System on Body Weight and Body Weight Gain</u>

Body weight and body weight gain during weeks 7 to 20 were significantly higher ($P<0.05$) in birds reared under the intensive system compared to those reared under the semi-intensive system which was better ($P<0.05$) than those reared under the extensive system (Tables 4.5.2b1 & 2 and Appendix 2).

Table 4.5.2b1: The Effect of Management System on Body Weight and Body Weight Gain (Week 7 to week 14) of F_2 Birds

Parameters/ M. System	Int	Sem. Int	Ext	LSD	SEM
Av.Wt at Wk7	550.69^a	476.67^b	382.27^c	3.003	1.5310
Av.Wt at Wk8	611.40^a	522.76^b	405.40^c	3.528	1.7980
Av.Wt Gain at Wk8	61.53^a	43.93^b	23.63^c	1.368	0.6970
Av.Wt at Wk9	683.98^a	573.18^b	429.07^c	4.288	2.1860
Av.Wt Gain at Wk9	68.20^a	52.53^b	23.73^c	1.279	0.6520
Av.Wt at Wk10	761.20^a	643.93^b	468.58^c	4.219	2.1500
Av.Wt Gain at Wk10	81.53^a	71.00^b	38.33^c	1.362	0.6940
Av.Wt at Wk11	861.67^a	731.00^b	515.93^c	4.328	2.2060
Av.Wt Gain at Wk11	100.53^a	87.00^b	47.80^c	1.447	0.7380
Av.Wt at Wk12	971.90^a	822.20^b	578.90^c	5.640	2.8800

Av.Wt Gain at Wk12	110.20[a]	91.07[b]	57.20[c]	1.411	0.7190
Av.Wt at Wk13	1092.30[a]	926.70[b]	644.70[c]	5.110	2.6000
Av.Wt Gain at Wk13	118.13[a]	105.47[b]	73.87[c]	1.724	0.8790
Av.Wt at Wk14	1221.80[a]	1037.70[b]	729.50[c]	5.540	2.8300
Av.Wt Gain at Wk14	130.47[a]	110.80[b]	85.73[c]	1.160	0.5910

[a – c] Means different superscripts are significantly different (P<0.05); LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

Table

4.5.2b2: The Effect of Management System on the Growth (Week 15 to week 20) of F_2 Birds

Parameters/Sire Line	Int	Sem. Int	Ext	LSD	SEM
Av.Wt at Wk15	1365.00^a	1164.60^b	829.00^c	6.380	3.2500
Av.Wt Gain at Wk15	136.47^a	121.60^b	109.53^c	2.395	1.2210
Av.Wt at Wk16	1520.00^a	1298.20^b	947.00^c	6.920	3.5300
Av.Wt Gain at Wk16	154.67^a	139.27^b	117.87^c	1.782	0.9080
Av.Wt at Wk17	1690.30^a	1442.70^b	1063.80^c	7.660	3.9100
Av.Wt Gain at Wk17	168.87^a	142.07^b	114.80^c	1.599	0.8150
Av.Wt at Wk18	1878.40^a	1606.20^b	1190.70^c	8.440	4.3000
Av.Wt Gain at Wk18	186.91^a	164.51^b	130.84^c	2.160	1.1010
Av.Wt at Wk19	2017.20^a	1796.90^b	1360.30^c	23.560	12.0100
Av.Wt Gain at Wk19	193.80^a	171.80^b	136.73^c	1.762	0.8980
Av.Wt at Wk20	2260.10^a	1963.80^b	1488.60^c	11.160	5.6900
Av.Wt Gain at Wk20	199.49^a	182.73^b	155.87^c	1.818	0.9270

$^{a-c}$ Means with different superscripts are significantly different (P<0.05); LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.5.3 Body Measurements

The average body length, body width and shank length values were significantly higher (P<0.05) in F_2 birds with the naked neck phenotype (*NaNa, Nana)* than those with the frizzle phenotype (*FF*, *Ff*), (Table 4.5.3a and Appendix 2). However, the difference in average shank length between *Nana* and *Ff birds* was not significant (P>0.05).

Table 4.5.3a: Body Measurements of Homozygous Naked Neck, Heterozygous Naked Neck, Homozygous Frizzle and Heterozygous Frizzle F_2 Birds

Parameters/Genotype	*NaNa*	*Nana*	*FF*	*Ff*	LSD	SEM
Av.Body Length (cm)	39.72^a	40.06^b	36.00^c	36.22^d	0.149	0.07570
Av.Body Width (cm)	14.89^a	14.89^a	14.22^c	14.44^b	0.153	0.07770
Av.Shank Length (cm)	8.62^a	8.53^{bc}	8.46^b	8.57^c	0.0780	0.03980

$^{a-c}$ Means with different superscripts are significantly different (P<0.05); LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.5.3.1 <u>The Effect of Management System on Body Measurements</u>

Birds that were kept under the extensive system had significantly lower (P<0.05) values in average body length compared to those kept under the intensive and the semiintensive systems (Table 4.5.3b and Appendix 2). While average body width value was significantly higher (P<0.05) in birds that were kept under the intensive system than those raised under semi-intensive which had significantly higher (P<0.05) average body width value than those reared under the extensive systems. Shank length did not differ significantly (P>0.05) among birds that were kept under the three management systems (Table 4.5.3b and Appendix 2).

Table 4.5.3b: The Effect of Management System on Body Measurements of F_2 Birds

Parameters/M. System	Int	Semi-Int	Ext	LSD	SEM
Av.Body Length (cm)	37.83^{a}	37.93^{a}	37.07^{b}	0.115	0.05860
Av.Body Width (cm)	14.90^{a}	14.67^{b}	14.20^{c}	0.118	0.06020
Av.Shank Length (cm)	8.54	8.48	8.48	0.0604	0.03080

$^{a-c}$ Means with different at 5% level of significance; MS=Management System; INT=Intensive; EXT= Extensive; LSD=Least Significant Difference

4.5.4 <u>Egg Laying Performance</u>

Layers showing the naked neck phenotype (*NaNa*, *Nana*) had significantly (P<0.05) better values in average number of eggs per clutch, egg size, egg size to body weight ratio, hen-housed rate of lay and hen-day rate of lay compared to those with the frizzle phenotype (*FF*, *Ff*); however, the difference in egg size to body weight ratio was not significant (P>0.05) between *Nana* and *Ff* layers (Table 4.5.4a and Appendix 2). Phenotypes (Naked necks & Frizzles) of the F_2 birds did not affect average age at first egg significantly (P>0.05), (Table 4.5.4a and Appendix 2).

Table

4.5.4a: Egg Laying Performance of F_2 Naked Necks (*NaNa*, *Nana*) and Frizzles (*FF*, *Ff*)

Parameters/Genotype	*NaNa*	*Nana*	*FF*	*Ff*	LSD	SEM
Av.Age at First Egg (days)	137.78	138.36	136.71	137.05	2.291	1.1660
Av.Eggs per Clutch	20.22^a	19.64^a	17.56^b	17.67^b	0.746	0.3800
Av.Egg Size (g)	58.22^a	57.83^a	54.14^b	53.50^b	0.885	0.4510
Av.Body to Egg Size Ratio	25.51^a	26.20^{bc}	26.41^b	26.00^c	0.329	0.1676
Av.Hen-housed Rate of Lay (%)	59.47^a	58.67^a	54.56^c	53.62^b	0.869	0.4430
Av.Hen-day Rate of Lay (%)	66.00^b	65.13^b	61.07^b	59.42^c	1.286	0.6550

$^{a-c}$ Means with different superscripts are significantly different at 5% level of significance; Av.=Average; LSD=Least Significant Difference; SEM=Standard Error of the Mean

4.5.4.1 The Effect of Management System on Laying Performance

Average age at first egg, number of eggs per clutch, egg size, egg size to body size ratio, hen-housed rate of lay and hen-day rate of lay were significantly better (P<0.05)in layers reared under the intensive system than those kept under the semi-intensive and the extensive systems (Table 4.5.4b). The birds reared under the semi-intensive system had significantly better (P<0.05) values than those reared under the extensive systems for all the traits considered except age at first egg (Table 4.5.4b and Appendix 2).

Table 4.5.4b: The Effect of Management System on Egg Laying Performance of F_2 Birds

Parmeters/M. System	Int	Semi. Int	Ext	LSD	SEM
Av.Age at First Egg (days)	134.69^a	138.57^b	138.74^b	1.774	0.9040
Av.Eggs per Clutch	21.67^a	17.64^b	15.79^c	0.578	0.2940
Av.Egg Size (g)	57.44^a	56.27^b	52.07^c	0.685	0.3490
Av.Body to Egg Size Ratio	25.89^a	25.52^b	26.27^c	0.255	0.1298
Av.Hen-housed Rate of Lay (%)	58.13^a	56.27^b	52.85^c	0.673	0.3430
Av.Hen-day Rate of Lay (%)	64.73^a	62.47^b	58.60^c	0.996	0.5070

[a – c] Means with different superscripts are significantly different (P<0.05); M =Management System; EXT=Extensive; Av=Average; LSD=Least Significant Difference; SEM=Standard Error of the Mean

4.5.5 Egg Quality Parameters

Average values for albumen height, Haugh unit, shell thickness, yolk height, yolk diameter and yolk colour score were significantly higher (P<0.05) in eggs from the layers of the F_2 Naked necks (*NaNa*, *Nana*) compared to eggs from those showing the frizzle phenotype (*FF*, *Ff*), (Table 4.5.5a and Appendix 2).

Table 4.5.5a: Comparison of Some Egg Quality Parameters of F_2 Naked Necks (*NaNa*, *Nana*) and Frizzles (*FF*, *Ff*)

Parameters/Genotype	*NaNa*	*Nana*	*FF*	*Ff*	LSD	SEM
Av.Albumen Height (mm)	7.21^a	7.19^a	6.95^b	6.88^b	0.0974	0.04960
Av.Haugh Unit (%)	83.67^a	82.53^b	79.33^c	78.20^d	0.5902	0.3006
Av.Shell Thickness (mm)	0.37^a	0.37^a	0.32^b	0.32^b	0.00339	0.001726
Av.Yolk Height (mm)	17.29^a	17.49^b	16.37^c	15.45^d	0.175	0.08920
Av.Yolk Diameter (mm)	40.67^a	39.69^b	38.62^c	39.04^d	0.302	0.1537
Av.Yolk Colour Score	7.60^a	6.93^b	6.22^c	5.59^c	0.301	0.1533

[a – c] Means with different superscripts are significantly different (P<0.05); Av=Average; LSD=Least Significant Difference; SEM=Standard Error of the Mean

4.5.5.1 The Effect of Management System on Some Egg Quality Parameters

Eggs from layers reared under the intensive system had significantly higher (P<0.05) values in albumen height, Haugh Unit and yolk height than eggs from those reared under the extensive system whose eggs had significantly (P<0.05) higher average values in the traits mentioned compared to eggs from layers raised under the semi-intensive system except Haugh unit (Table 4.5.5b and Appendix 2). Average value for yolk colour score was significantly (P<0.05) higher in eggs from layers that were reared under the extensive system than eggs from those kept under the semi-intensive system whose eggs were

Table

significantly (P<0.05) better than eggs from layers reared under the intensive system (Table 4.5.5b and Appendix 2). Average values for yolk diameter and shell thickness did not differ significantly (P>0.05) between eggs from layers that were kept under the three management systems.

4.5.5b: Effect of Management System on Egg Quality Parameters of F_2 Birds

Parameters/M. Systems	**Int.**	**Semi Int.**	**Ext.**	**LSD**	**SEM**
Av.Albumen Height (mm)	7.20^a	6.85^b	7.04^c	0.0754	0.03840
Av.Haugh Unit (%)	82.00^a	80.07	80.09	0.457	0.2328
Av.Shell Thickness (mm)	0.34	0.34	0.34	0.00263	0.001337
Av.Yolk Height (mm)	16.57^a	16.19^b	16.42^c	0.136	0.06910
Av.Yolk Diameter (mm)	39.40	39.13	39.29	0.234	0.1190
Av.Yolk Colour Score	5.60^a	6.46^b	7.74^c	0.233	0.1188

$^{a-c}$ Means with different superscripts are significantly different (P<0.05) ;M=Management; INT=Intensive; EXT=Extensive Av=Average; LSD=Least Significant Difference; SEM=Standard Error of the Mean

4.5.6 <u>Some Carcass Parameters</u>

The naked necks (*NaNa*, *Nana*) had significantly (P<0.05) higher average values for defeathered weight, dressed weight, thigh and drumstick weight, breast muscle weight and weight of wings than the frizzles (*FF*, *Ff*), (Table 4.5.6a and Appendix 2). Average values for weight of intestines, gizzard weight, heart weight and liver weight were significantly (P<0.05) higher in birds with the frizzle phenotype (*FF*, *Ff*) compared to those showing the naked neck phenotype (*NaNa*, *Nana*); however, average weight of intestines was not significantly (P>0.05) different between *NaNa* birds and the frizzles (*FF*, *Ff*), (Table 4.5.6a).

Table 4.5.6a: Some Carcass Parameters of F_2 Naked Neck (*NaNa*, *Nana*) and

Frizzle (*FF*, *Ff*) Birds

Parameters/Genotype	*NaNa*	*Nana*	*FF*	*Ff*	LSD	SEM
Av. Defeathered Wt (%)	96.83^{a}	95.26^{b}	92.32^{b}	91.21^{b}	0.1221	0.0622
Av. Dressed Wt (%)	81.99^{a}	80.16^{b}	74.33^{c}	72.58^{d}	0.3762	0.1916
Av. Thigh and Drumstick Wt (%)	25.65^{a}	26.15^{b}	26.15^{b}	25.72^{c}	0.2266	0.1154
Av. Breast Muscle Wt (%)	19.24^{a}	18.69^{b}	14.82^{c}	14.33^{d}	0.1553	0.0791
Av. Wings Wt (%)	10.16^{a}	10.06^{b}	9.99^{c}	9.97^{c}	0.0901	0.0459
Av. Intestines Wt (%)	4.33^{a}	4.22^{b}	4.36^{a}	4.35^{a}	0.0854	0.0435
Av. Gizzard Wt (%)	3.56^{a}	3.72^{b}	4.36^{c}	4.49^{d}	0.0684	0.0348
Av. Heart Wt (%)	1.33^{a}	1.39^{b}	1.62	1.65	0.0340	0.01733
Av. Liver Wt (%)	1.61^{a}	1.68^{b}	1.97^{c}	2.03^{d}	0.0441	0.02247

$^{a-d}$ Means with different superscripts are significantly different (P<0.05); LSD=Least Significant Difference; SEM=Standard Error of the Mean; Av=Average

4.5.6.1 The Effect of Management System on Some Carcass Parameters of F_2 Birds

Average values of defeathered weight, eviscerated weight, dressed weight, and thigh and drumstick weight were significantly higher (P<0.05) in birds that were reared under the intensive system than those kept under the semi-intensive system which were significantly better (P<0.05) in all the traits listed than those reared under the extensive system (Table 4.5.6b). Average weight of intestines, gizzard and heart values were significantly higher (P<0.05) in birds that were reared under the semi-intensive system than those reared under the extensive and intensive systems; also, birds raised under the extensive system were significantly better (P<0.05) than those reared under the intensive system in all the traits just mentioned except average weight of gizzard (P>0.05), (Table 4.5.6b and Appendix 2). Average values for breast muscle weight and weight of wings did not differ significantly (P>0.05) between birds that were raised under the three management systems (Table 4.5.6b and Appendix 2).

Table 4.5.6b: Effect of Management System on Carcass Parameters of F_2 Birds

Parameters/M. System	Int	Semi. Int	Ext	LSD	SEM

Table

Av.Live Weight (kg)	2.29[a]	1.97[b]	1.43[c]	0.0208	0.01059
Av.Defeathered Wt (%)	93.75[a]	93.25[b]	91.83[c]	0.0946	0.04820
Av.Eviscerated Wt (%)	86.74[a]	85.61[b]	85.17[c]	0.1707	0.08690
Av.Dressed Wt (%)	78.12[a]	76.79[b]	72.68[c]	0.2914	0.14840
Av.Thigh and Drumstick Wt (%)	26.32[a]	25.92[a]	25.29[c]	0.1755	0.08940
Av.Breast Muscle Wt (%)	16.35	16.27	16.36	0.1203	0.06130
Av.Wings Wt (%)	10.01	10.02	10.05	0.0698	0.03560
Av.Intestines Wt (%)	4.23[a]	4.46[b]	4.31[c]	0.0661	0.03370
Av.Gizzard Wt (%)	3.95[b]	4.12[a]	3.98[b]	0.0530	0.02700
Av.Heart Wt (%)	1.30[a]	1.53[b]	1.49[c]	0.0264	0.01343
Av.Liver Wt (%)	1.69[a]	1.86[b]	1.86[b]	0.0342	0.01741

[a – c] Means with different superscripts are significantly different ($P<0.05$); M= Management ; INT=Intensive System; EXT=Extensive System; Av=Average; LSD=Least Significant Difference; SEM=Standard Error of the Mean

4.5.7 Mortality (Effects of Genotype and Management system)

Mortality was significantly lower (P<0.05) in birds with *NaNa & Nana* genotypes than in those with *FF& Ff* genotypes (Table 4.5.7 and Appendix 2). Birds reared under the extensive system had significantly higher (P<0.05) mortality rates than those reared under intensive and semi-intensive systems (Table 4.5.7 and Appendix 2).

Table 4.5.7: The Effects of Genotype and Management System on Mortality of F_2 Birds

Parameter/ Genotype	***NaNa***	***Nana***	***FF***	***Ff***	**LSD**	**SEM**
Mortality (%)	6.89^{a}	6.22^{b}	10.44^{c}	11.44^{d}	0.558	0.2841
Parameters/M. Systems	**Int.**	**S. Int.**	**Ext.**	**LSD**	**SEM**	
Mortality (%)	7.87^{b}	7.89^{b}	12.73^{a}	0.432	0.2201	

$^{a-d}$ Means with different superscripts are significantly different (P<0.05); LSD= Least Significant Difference; SEM= Standard Error of the Mean; M = Management; Int. = Intensive; S. Int. = Semi-Intensive; Ext. = Extensive;

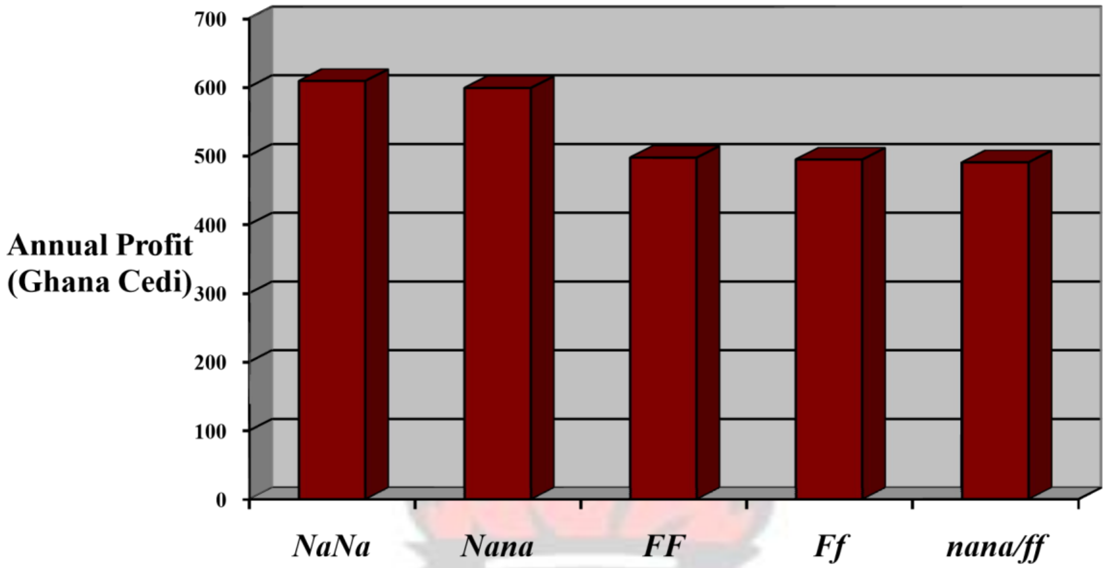
4.5.8 Economics of Production

Annual income received from the sale of birds and eggs as well as the annual profit made were higher in the naked necks (*NaNa*, *Nana*) than in frizzles (*FF*, *Ff*) and normals (*nana/ff*), (Table 4.5.8a, Fig. 4.5.4 and Appendix 2). However, birds showing the frizzle phenotypes (*FF*, *Ff*) had higher average values in the traits listed than the normal feathered (*nana/ff*) ones (Table 4.5.8a, Fig. 4.5.4 and Appendix 2). Annual cost of production was similar in the three phenotypes.

Table 4.5.8a: Economics of Production of *NaNa, Nana, FF, Ff* and *nana/ff* F2 Birds

Parameters/Genotype	***NaNa***	***Nana***	***FF***	***Ff***	***nana/ff***
Av.Cost of Feeding (GH¢)	413.37	413.37	413.37	413.40	413.37
Av.Income (GH¢)	1021.85	1011.70	910.33	907.58	903.55
Av.Profit (GH¢)	608.52	598.40	496.96	494.22	490.19

P'TERS = Parameters; G'TYPE=Genotype; Av=Average; LSD= Least Significant Difference; SEM=Standard Error of the Mean



F_2 Birds Fig.4.5.3: A Bar Showing the Annual Profit Made from Rearing Five Different

F_2 Genotypes (*NaNa*, *Nana*, *FF*, *Ff*, *nana/ff*)

4.5.8.1 <u>The Effect of Management System on Economics of Production</u>

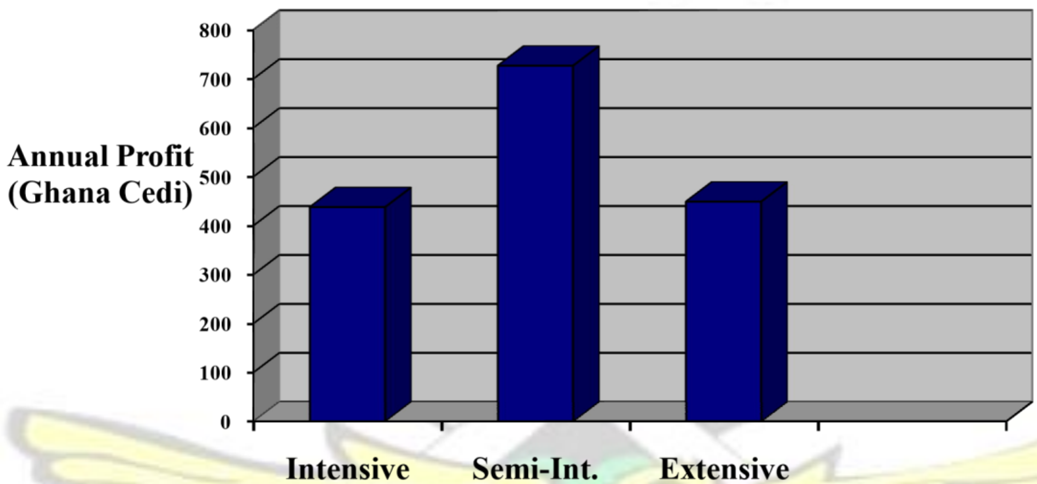
Average amount for annual cost of production and annual income received from the sale of birds and eggs were higher in birds reared under the intensive system than in those raised under the semi-ntensive and extensive systems (Table 4.5.8b, Fig 4.5.5 and Appendix 2). However, producing the birds under the semi-intensive system resulted in higher average amounts in the traits just mentioned than those reared under the extensive system. The average amount for annual profit made was higher in birds kept under the semi-intensive system compared to those reared under the extensive system whose average performance in this parameter was better than birds kept under the intensive system (Table 4.5.8b, Fig. 4.5.5 and Appendix 2).

Table 4.5.8b: The Effect of Management System on Economics of Production of

F$_2$ Birds

Parameters/ M. System	**Int**	**Semi. Int**	**Ext**
Av. Cost of Feedin (GH¢)	718.88	333.58	187.66
Av. Income (GH¢)	1156.49	1060.16	636.36
Av. Profit (GH¢)	437.59	726.60	448.80

MS= Management System; INT=Intensive; EXT=Extensive; LSD=Least Significant Difference; SEM=Standard Error of the Mean



Management Systems Fig.4.5.4: A Bar Chart Showing the Annual Profit Made from Rearing F$_2$ Chickens Under Intensive, Semi-intensive and Extensive Systems

CHAPTER FIVE

5.0 DISCUSSION

5.1 STUDY ONE

5.1.1 Number of Years in Local Chicken Production

The average number of years that the villagers in the Ashanti region of Ghana have been in local chicken production (Table 4.1.1) was affected by the wiping out of an entire flock by Newcastle disease during some harmattan periods; which made keepers sometimes lose their entire flock and might have to restart production. When this happens, the villagers had to wait until they obtain new pullet(s) either through purchase or from relatives and friends, to restart production of local birds. During the survey, most of the villagers gave the ages of their new beginnings in local chicken production. The keeping of indigenous local fowls has long been part of the life of Ghanaian village dwellers.

5.1.2 **Management**

5.1.2.1 **Flock Size**

Even though 92% of the respondents stated that they have had flock sizes larger than fifty birds before, the average flock size was low during the survey as can be seen from the results (Table 4.1.1). This might have been due to the fact that the survey was conducted in the months of December and January; because according to Gondwe *et al.* (2005) the major constraint to the production of local chickens in Africa are outbreaks of Newcastle disease among chickens in the months of September to December every year. This can lead to about 60 to 70 percent mortality of the entire flock (FAO, 2002).

According to 50% of the keeper they lost greater percentages of their flock before they were interviewed. The villagers have the pattern of replenishing their flock by using virtually all eggs for reproduction. It seems impossible to have a stable flock size in local chicken production since the cycle of losing a high percentage of the flock every year, either through predators or Newcastle disease, continues unabated. According to FAO (1998) with four to five reproductive cycles per year, only about nine replacement pullets may be obtained. This trend, according to the keepers is what sometimes makes local chicken production unprofitable.

5.1.2.2 <u>Management System</u>

The extensive system, under which the birds scavenge for their own feed, used by the local chicken keepers in Ghana is similar to the system common in other countries. It has been indicated that free-ranging local chickens are known for their ability to survive under various types of shelter, including makeshift chicken houses, kitchens and even roosting on trees (Andrews, 1990; Musharaf, 1990; Yongolo, 1996). Atunbi and Sonaiya (1994) found that it was common for local birds to be reared without provision of housing or shelter and indicated that where housing was provided to village chickens, the houses were made with locally available materials such as wood, mud bricks, sugarcane stems, bamboo and cereal stovers, and concluded that cane cages were cheaper than wooden cages. It was observed that those who provided shelter for their flock were able to maintain a higher flock size than those who did not since their birds were protected from predators especially thieves and hawks. Mburu and Ondwasi (2005) stated that proper chicken housing should keep birds, especially young chickens, secure from wild animals, hawks, and theft.

Birds scavenge on a variety of feed if allowed to move freely, these include green leaves, worms, insects, termites and kitchen leftovers (fruit and vegetable waste, cereal grains and by-products, fishmeal, tubers and roots, brewers waste). It is therefore true that the scavenging feed resource base depends on the household food status as stated by Gondwe and Wollny (2005).

5.1.2.3 <u>Types of Feed Supplements</u>

Most of these chicken keepers eke out a living and will hardly use their meager earnings to buy feed supplements. The majority of them gave whole maize because they are farmers who cultivate maize every year and therefore used some of the harvested maize as a supplement for the birds. Those who used maize bran obtain it either from their own houses, relatives, neighbours, or corn millers. The maize bran is a by- product of some local dishes prepared from maize such as “nkyekyerawa”, “obrayo”, etc. A small minority (10.37% of the respondents) will pay a token amount to corn mill operators for the milling leftovers. They will then collect dry fish waste from sellers, mill it and mix it with the milling waste. This supplement is more nutritious than the first two mentioned. About one- third of those interviewed do not give any supplement at all.

Apparently, giving feed supplements to local birds enhances production. Gondwe and Wollny (2005) found that feeding management contributes to about 30% of their growth potential and added that growth of local chickens can be enhanced through improved management under free-ranging conditions. It was observed during the survey that birds given daily feed supplement always stayed inside or around the house instead of going far away or into the bushes to be either knocked by a vehicle, stolen, or killed by a wild animal. This confirms the findings of Mburu and Ondwasi (2005) that local chickens perform very well when extra feed, proper housing and disease-free environment are provided.

5.1.2.4 Health of Birds

5.1.2.4.1 Survivability of Chicks and Total Mortality

As can be seen from Table 4.1.1, 50% of chicks under local chicken production do not survive to the grower stage. According to the chicken keepers, disease is not the main cause of chick mortality among indigenous local birds but rather predators and accidents. Hawks, crows and snakes were mentioned as the main predators that prey on the chicks.

Since local birds mix with people either in the kitchen or on the compound, people sometimes mistakenly step on the chicks and kill them. Hardy hens with good mothering abilities are sometimes able to protect their chicks from hawks and crows by giving them cover when they sense their presence. Birds that are given supplements everyday do not go into the bush and therefore are protected from snakes and other wild animals. Chicks that stay in coops are not easily seen by hawks and crows and are therefore better protected than those that roam outside. It seems obvious that with good management, chick mortality could be reduced markedly.

Growers and matured birds can be attacked by predators and also die of accidents; however, the main cause of their mortalities is the Newcastle disease, especially during the harmattan season. As can be noted from Table 4.1.1, it can kill about 65% of the flock and in some cases it wipes-off the entire flock. According to Gondwe *et al.* (2005), the outbreaks of Newcastle disease among local chickens in Africa in the months of September to December every year is one of the major constraints to the production of local chickens. The keepers testified that the outbreak of Newcastle disease was intense between the months of September to January every year. Chaheuf (1990) described Newcastle disease as the most devastating disease of village chickens in Africa. Even though through many years of exposure to poultry diseases, local birds have been able to develop resistance to various diseases of poultry, they hardly survive the attack of Newcastle disease during the months of September to January.

5.1.2.4.2 <u>Disease Control</u>

It is not clear how the chicken keepers got to know the efficacy of tetracycline and vitamin B-complex in treating poultry diseases, and yet almost all the respondents (92%) were aware of their usage and had one time or another made use of them in treating diseases. It is imperative that veterinarians look into the efficacy and safety of using these drugs in controlling poultry diseases. However, according to the chicken keepers these orthodox drugs had been efficient in curing diseases in most cases. The traditional medicines are also sometimes able to control certain diseases. For instance, pawpaw leaves can effectively control worms according to the chicken keepers. Local birds are easily infected with a number of worms because of their scavenging nature. Studies by Tona (1995) in some African countries revealed that worm species such as

Ascaridia galli, Prosthogonium spp., Strongyloids avium, Heterakis gallinarum, Raillietina spp, Davainea progglottina, Tetrameres Americana, and species of *Trichuridae* were common in village chickens. Therefore the keepers' assertion that pawpaw leaves can serve as a dewormer may be true.

5.1.3 <u>Performance</u>

5.1.3.1 <u>Weight of Birds and Eggs</u>

The results show that the weights of local birds and their eggs are generally low. These results confirm the characteristics of local birds given by the FAO (1998). The average weights of cocks and hens in this survey were similar to what have been found in other African countries. Wilson *et al*. (1987) reported average weights of 1.6 and 1.02 kg for local cocks and hens respectively in Mali. However, the finding of Minga *et al.* (1989) in the United Republic of Tanzania was different from that obtained in this study, they found average weights of cocks and hens to be 1.2 kg and 2.2 kg respectively due to high deposit of abdominal fat in the hens. The egg weight obtained in this study was also similar to what have been reported in other African countries such as Ethiopia, 40-49g (Shanawany and Banerjee, 1991); Burkina Faso, 30- 40g (Bourzat and Saunders, 1990); United Republic of Tanzania, 41g (Minga *et al*, 1989) and Sudan, 40.6g (Wilson,1979). The average weight of 34.6g obtained in Mali (Wilson et al., 1987) is lower than that obtained in this study. The average chick weight was low (35g) and this may be due to the smaller eggs laid by the local birds.

Local birds have lower genetic potential and also have low feed conversion efficiency. However, their small sizes is partly due to inadequate availability of balanced feed, since in most cases the birds are allowed to scavenge without giving any nutritionally balanced feed supplement. According to Gondwe and Wollny (2005) the growth potential of local chickens is not fully exploited under free-range (scavenging) conditions due to inadequate feeds. Mwalusanya *et al.* (2002) reported that apart from genetics the low productivity of local chickens was due to the prevailing poor management practices particularly, lack of proper health care, poor nutrition and housing. Due to their smaller sizes, local birds have low nutritional maintenance requirement. This is a survival strategy under the scavenging free- range conditions. As stated in one FAO (2000) report, it is difficult to imagine birds better adapted for survival under scavenging free-range conditions than the breeds that have evolved under the very same conditions, and are still surviving as proof of their ability to do so. This survival ability of local birds, under scavenging free-range conditions, is what makes it possible for rural smallholders, landless farmers and industrial labourers to keep them.

5.1.3.2 <u>Number of Layers and their Performance</u>

The number of layers accounts 50% of the entire flock excluding the chicks, and the remaining 50% is made up of pullets, cockerels and cocks. This is because layers are hardly sold as compared to cocks, and their mortality is quite low as compared to chicks, pullets and cockerels. The clutch size of 2 to 3 found in this survey was similar to the 2.5 clutch size found earlier by van Veluw (1987) and also closer to the values of 2.1 and 2.7-3.0 reported in other African countries (Wilson *et al*.,1987; Bourzat and Saunders, 1990). It was however different from the 4.5 clutch size reported in Sudan by Wilson (1979).

Van Veluw (1987) found average eggs per clutch of 10, which was close to the range 913 found in this survey. Values of 12-18 (Bourzat and Saunders, 1990), 6-20 (Minga *et.al*., 1989), 8.8 (Wilson *et al*., 1987), and 10.87 (Wilson, 1979) have been reported in Burkina Faso, Tanzania, Mali and Sunda respectively, which were also not too different from what was reported in this survey. The lower number of clutches per year and eggs per clutch, which resulted in fewer eggs per year, was due to broodiness associated with local hens. This results in lengthening of the reproductive cycle. According to Horst (1999), the egg brooding (incubation) and chick rearing activity increases the length of the reproductive cycle by 58 days to about 74 days in total. This means that local birds use a whole year less 17 days to complete two laying cycles, and in each of these cycles, a local hen will rarely lay more than 15 eggs.

The average hatchability of 77% observed in this study is close to the 72% reported earlier by van Veluw (1987) to be the hatchability of local eggs in Ghana. Similar values have been reported in Burkina Faso, Tanzania, Mali and Sunda: 60-90% (Bourzat and Saunders, 1990), 50-100% (Minga *et al*., 1989), 69.1% (Wilson *et al*., 1987) and 90% (Wilson, 1979) respectively. However, the 39- 42% hatchability reported in Ethiopia by Shanawany and Banerjee (1991) was far lower than what was realized in this study. The high percentage of hatchability among the local birds may be due to the fact that, the hen does the incubation of eggs naturally. It knows by instinct when to provide the right temperature for its eggs by sitting-on and turning the eggs with the beak. Turning of eggs and provision of required humidity (60-80%) by splashing water on the eggs via her beak, for the developing embryo are done perfectly by the broody hen than any man-made incubator. Broody hens that are large so as to cover all the eggs set and keep them warm enhance natural incubation; according to FAO (2000), hatchability declines with more than ten eggs depending on the size of the hen. Under favourable conditions, the broody hen hatches all fertile eggs. However, according to FAO (2000) a hatchability of 80 percent (of eggs set) from natural incubation is normal, but a range of 75 to 80 percent is considered satisfactory.

5.1.3.3 Economics of Production

Apart from feed supplementation, other costs of production came from purchasing of pharmaceutical products such as tetracycline (anti- biotic) and B-complex (vitamin). Prices of cocks and hens were not fixed but dependent on some factors such as age, size, season, location of the village (distance from the city or the main road leading to the city), colour and the phenotype of bird. For instance, two birds may be of the same size but villagers do not appreciate tender chicken meat and therefore if the difference in age is wide, the older one may be sold at a higher price. Body size was the main factor in determining the price of local chickens. Females are not normally sold but if it is done, the sex is not given any special preference most of the time and therefore size

(weight) still becomes the determining factor for pricing. During Christmas, Easter, Ramadan, and Idl-Adhar birds are sold at higher prices since there is a high demand for them and therefore the effect of demand-supply relationship on price comes in. Birds are sold for higher prices in villages close to the city or along the main road leading to the city because the birds are purchased by city dwellers who drive along the road or visit the villlage. For example, within the Asante- Akim South district a bird may be sold at three Ghana cedis (GH¢3.00) in a village called Nkwanta which is quite distant from the city and the main road. This same bird may be sold for four Ghana cedis (GH¢4.00) in Yawkwei, which is in between Konongo and Juaso, also relatively closer to Kumasi, and along the Kumasi- Accra road. Birds with special plumage colours such as all white and all black, and phenotypes such as naked neck and frizzle are sold at higher prices since it is believed that one only looks for a bird with a special colour or phenotype when it is needed for rituals.

A fresh egg was sold for ten Ghana pesewas (GHp10) or three for twenty Ghana pesewas (GHp 20.00). After selecting enough eggs for natural incubation, the keeper has the option of using the surplus eggs to supplement his diets, or sell for petty cash. Local eggs are either sold in the market during market days, or within the keeper's neighbourhood. The price of a local egg during the survey was somewhat the same as that of a commercial egg (GHp 10), even though the latter is far bigger than the former. This is because the villagers believe that eggs from local chickens are more nutritious, tasty and appealing (yellow yolk) than commercial eggs.

The results show that most chicken keepers get very little monetary profit from their business. This is partly due to the reason that almost all the villagers interviewed hardly sell their birds. According to them, there are two main reasons that sometimes impel them to sell their birds: 1) when they are in urgent need of money and there is no alternative; and 2) if the flock size is too large to maintain (>30 birds). To most of the respondents, the main reason for keeping local birds is to use the meat and surplus eggs as an animal protein source for the family. This confirms an earlier finding in Ghana by van Veluw (1987); he reported that the main function of village chickens from the farmer's perspective is the provision of meat and eggs for home consumption. It seems that the only way keepers of local chickens can make reasonable monetary gains is the availability of crossbred birds (exotic × local) with improved meat and egg production potentials. In this way what the villagers will get from the crossbred birds in terms of meat and eggs will be too much to be consumed by the family alone and will therefore be compelled to sell the surplus meat and eggs for money.

5.1.4 Reasons for Keeping Birds

The study revealed that the main reason for keeping local birds is for home consumption and this confirmed an earlier report within Ghana by van Veluw (1987).

Higher consumption of chicken meat and eggs occurred during celebrations such as Christmas, New year, Easter, Ramadan, Idl-Adhar, birth days, etc. As one keeper narrated, smiles come upon the faces of all the family members in anticipation of that special dinner, if not for anything they will soon enjoy a tasty soup with ‘fufu’ and meet their daily animal protein requirement for once. According to FAO (1997), chicken meat and egg contain 19% and 12.1% of protein respectively and contain appreciable amounts of energy, vitamins and minerals. In South Africa, resource-poor households with small poultry production units of 12 laying hens per unit have higher levels of consumption of animal protein and reduced incidence of malnutrition (MacGregor and Abrams, 1996). It is therefore envisaged that if the local birds are improved in terms of meat and egg production, the malnutrition situation in the country will be reduced drastically if not eliminated.

Chicken keepers sometimes receive income from selling birds and surplus eggs. This is normally done during festive occasions when the number of cocks are more than what the family will need for the festival or when they need to pay a debt or do something that requires money urgently or when some one is in need of a particular colour, age, or phenotype of chicken in the flock for rituals. Most of the chicken keepers were poor and could not buy enough meat to prepare a dinner for an important guest but having chickens in the house makes it possible to honour the guest with a delicious dinner. Guests who cannot enjoy dinner with them due to some circumstances are given live birds as gifts. Indigenous beliefs are common in the villages of Ghana and the villagers often use local birds for rituals when necessary. Obviously, they find it more convenient when they have the particular kind of bird needed for the ritual in their own flock. Some of the villagers keep birds because seeing them and admiring their feather colour and nature make them happy. One percent (1%) of the respondents were of the opinion that local birds have a special way of alerting people when a dangerous animal like a snake comes into the house. According to them the birds do this by crowing, panting, and running away from where the danger is; to them this is enough reason to always have birds in the house.

5.1.5 <u>Challenges in Local Chicken Production and their Suggested Solutions</u>

5.1.5.1 <u>Challenges</u>

According to the respondents, predators such as crows, hawks, fox and snakes prey on the chicks and therefore only about one- third or less of chicks hatched are able to survive to the matured stage. Newcastle disease attacks the birds at all stages and very severely during the harmattan season, within which an entire flock can be wiped-out. Various studies on local chicken production within the country and other African countries have reported these problems (van Veluw, 1987; Chabeuf, 1990; FAO, 1998; Awuni, 2002; Gondwe *et. al.*, 2005). The major constraints to the production of local chickens are outbreaks of Newcastle disease among chickens in the months of September to December every year, predators that feed on chickens, poor housing and prolonged weaning periods for chickens (Gondwe *et al*., 2005).

Abdelqader *et al*. (2005) reported that in Cameroon, 40% of the flock of local birds under local management system is dies before reaching 6 months of age, and mortality from diseases, predators, parasites, and cold stress for chicks accounted for 49 %, 31.6 %, 10 %, and 9.4% of the total loss, respectively. They added that, the most frequent outbreak of diseases, as perceived by the keepers, was in the order of severity: Newcastle Disease (51 %), Infectious Bronchitis (21 %), Fowl Typhoid (18 %) and other diseases (10 %). The main predators were foxes (25% of the cases), and wild cats (11.5%). Wirsiy and Fonba (2005) observed that, under the Tanzanian local system of producing chickens, disease outbreaks are common and often erase stocks of chicken from an entire household. However, according to FAO (1998) malnutrition, infections, predators, and accidents result in mortality rates of 60 to 70 percent during the rearing stage. According to Abdelqader *et al*. (2005) the significant nutritional and economic functions of local chicken production in rural communities are constrained markedly by mortality due to diseases and predation and added that in Malaysia the mean annual financial loss per flock due to mortality is 42 US dollars (Abdelqader *et al*., 2005).

According to the chicken keepers, having access to funds will enhance their production since provision of feed supplement improves performance and proper housing protects the birds from predators. New stock including sound males can also be purchased to maintain or increase flock size and also solve the problem of low fertility that some of them had. Some of these chicken keepers sometimes buy cockerels from commercial poultry farms and put them under scavenging conditions and according to them the performance of their offspring in terms of body weight, egg size, and number of eggs laid are superior to those of the local breeds. They lamented that, sometimes, a local cock not less than six months old is not able to prepare a sufficient dinner for a family of six. This was similar to a report by INFPD (1999), which stated that the productivity of local chickens is low with regard to egg production, egg weight, growth rate and chick survival rate; chicken housing, feeding, and health care are below standard. The assertion of the local chicken keepers therefore was that if the management problems are solved, getting a hybrid with improved body weight, egg size, and number of eggs laid will make the local chicken production more lucrative than it is now.

Those without problems argued that they do not spend any money on their birds and are therefore satisfied with the little benefits they get.

5.1.5.2 Solutions

The various solutions suggested by the chicken keepers were not out of place since they are in conformity with what other researchers have suggested or recommended. For instance, Wirsiy and Fonba (2005) stated that vaccination of local fowls against major poultry diseases like Newcastle, infectious bronchitis, gumboro, etc. can prevent these losses. According to FAO (1998), if balanced feed, good health-care supplies and dayold chicks of hybrid varieties are locally available, then managing local chickens intensively is an option. It however cautioned that, if these things are not available, raising local breeds under scavenging free-range systems would still be the best choice. This is imperative since according to Mwalusanya *et al*. (2004) the low productivity of local chickens is partly due to poor management practices, in particular the lack of proper health care, poor nutrition and housing.

Njenga *et al.* (2005) stated that, one way of overcoming the challenges in local chicken production was improving sustainable productivity through genetic selection and development of suitable indigenous parent stock. The improvement of these poultry should be in line with the existing rural conditions to avoid the likelihood of maladjusted management. Selection over time may yield a stock that fits local conditions. Rural poultry offers a wide range of genetic potential, as the local chickens are genetically heterogeneous, offering a wide range of phenotypes and genotypes to select from.

From the above suggestions for improving local chicken production, it is clear that all the problems enumerated by the local farmers can be grouped into two: management and genetics. As suggested by the local farmers, if these problems in local chicken production are solved, it could be harnessed to augment poverty reduction strategies in the country.

5.2 STUDY TWO

5.2.1 Percentages of *Nana, Ff & nana/ff* Birds in the Population of Local Birds

The results show that a high percentage of indigenous chickens are normal feathered (78.33%) compared to naked neck (13.33%) and frizzles (8.33%) phenotypes. This means that the naked neck and frizzle genes are present within the random-mated indigenous chicken population but their combined frequency within the population is low. Fayeye and Oketoyin (2006) had a much lower frequency for these phenotypes (<0.1) when they characterized Fulani-ecotypes of chickens in Nigeria; while Nsoso *et al.* (2003) had 8.41% of the naked neck phenotype within the local chicken population in Botswana. These thermoregulatory genes are at the brink of extinction (Adesina, 2002; Ojo, 2002; Fayeye and Oketoyin, 2006) and this may have been caused partly by random drift. However, non-genetic factors such as diseases, and religious and social activities might have played a role in the lower frequencies of these phenotypes. For instance, flocks of local birds are easily wiped-out by Newcastle disease and anyone starting a new flock of birds will more likely use normal birds instead of these mutants due to their low phenotypic frequencies within the population of local chickens. Naked neck and frizzle birds are often used for rituals by traditionalist resulting in the dwindling of their phenotypic frequencies. Socially, naked neck and frizzle birds are normally stolen due to their uniqueness within the population of indigenous birds, resulting in the reduction of these phenotypes.

5.2.2 Average Weights of Birds and Eggs

The average weight of chicks (0-5days) was significantly lower for the indigenous *Nana* (naked neck) chicks compared to the *Ff* (frizzle) and *nana/ff* (normal feathered) chicks due to the differences in the sizes of eggs. The hens from the various chicken phenotypes that produced the eggs and consequently the chicks were not of the same age, and since age and egg size, and also egg size and weight of day-old chicks are positively correlated (Fairfull, 1990), the differences in chick weight (0-5days) among indigenous chicken phenotypes (naked neck, frizzle and normal feathered) could shift to any direction at any point in time.

The average weight of cocks did not differ significantly (P>0.05) among the three indigenous chicken phenotypes (numerical values were higher in *Nana* birds than *Ff* & *nana/ff* ones) while the average weight of *Nana* hens were significantly (P<0.05) higher than those of *Ff* birds and this indicates that, even under scavenging conditions where the birds scavenge for their own feed for growth and development, the naked neck phenotype has an advantage over the frizzle and the normal feathered phenotypes. This might have been due to the 20 to 40 percent less feather coverage in naked neck birds which would considerably reduce the need for dietary nutrients to supply protein inputs for feather production. It is imperative that the indigenous naked neck phenotype is utilized in providing suitable birds for village chicken production since protein is a limiting factor in many scavenging feed resource bases (FAO, 2002).

The observed matured body weights of indigenous naked neck (*Nana*), frizzle (*Ff*) and normal feathered (nana/ff) chickens were similar to those reported in the few studies that had compared available native chicken phenotypes. For instance, Desai *et al*. (1961), Yoshimura *et al*. (1997) and Njenga (2005) compared the naked neck birds with other native chicken phenotypes including frizzle and normal feathered birds and concluded that the naked neck birds were heavier than the other native chickens. However, Singh *et al*. (1996) and Mohammed *et al*. (2005) reported that all the indigenous chicken phenotypes were similar in body weight.

5.2.3 <u>Egg Laying Performance</u>

The naked neck layers had significantly higher ($P<0.05$)values for egg weight, number of eggs per clutch and number of eggs per bird per year than those of the frizzle and the normal feathered layers because naked neck birds might have had a better ability to thrive well under adverse environmental, poor housing, bad management and poor nutritional conditions. It could also be due to the 20 to 40 percent reduction in feather coverage which conserves more protein for egg production. Singh *et al*. (1996), Yoshimura *et al*. (1997) and Njenga (2005) compared the performance of indigenous chicken phenotypes including the naked neck, frizzle and normal feathered birds reported that the naked neck birds were significantly superior to the other phenotypes in terms of egg weight followed by the frizzle birds. Yoshimura *et al*. (1997) and Moreki and Masupu (2003) concluded that among indigenous chickens the naked neck laid a significantly higher ($P<0.05$) number of eggs (number of eggs per clutch and number of eggs per bird per year) compared to the other phenotypes including frizzle and normal feathered. Desai *et al*.

(1961) found *Nana* birds to be superior to all other indigenous phenotypes in terms of number of eggs per bird per year. However, in the studies of Singh *et al*. (1996) and Mohammed *et al*. (2005) involving indigenous chicken phenotypes (including naked neck, frizzle and normal feathered), annual egg production, and hen-housed and hen-day egg production did not differ significantly (P>0.05).

The absence of significant difference in the number of clutches of eggs per year among the local chickens studied shows that the pause in egg laying of local birds caused by broodiness which results from an increase in plasma prolactin hormone level, affects various phenotypes within the population of indigenous birds in Ghana, in a similar way.

Eggs from the indigenous frizzle birds had significantly (P<0.05) higher hatchability values than eggs from naked neck birds as a result of the modification of their plumage structure (curled feathers). Hachability under natural incubation is influenced to a large extent by the hen's ability to cover all the eggs-set. The frizzled feathers extend outwards and away from the body and therefore as the hen sits on the eggs, the protruding feathers give better cover to a larger number of eggs and thereby a higher percentage of the eggs hatch sucessfully.

5.2.4 Egg Quality Performance

The superiority of the eggs from indigenous naked neck birds in albumen height and Haugh unit over the eggs from their frizzle and normal feathered counterparts may be due to the 20 to 40% reduction in plumage of naked neck birds, since this reserves protein which would have been used for feather formation, for productive activities such as the development of the egg albumen (Akhtar-Uz-Zaman, 2002). Additionally, chickens do not have sweat glands and therefore lack the ability to regulate their body temperature through sweating and are therefore stressed when the ambient temperature is high. Apparently, stress in birds affects egg formation and therefore egg quality parameters such as albumen height, Haugh unit, shell thickness, yolk height and yolk diameter are adversely affected. The feather reduction in naked neck birds enhances heat loss by conduction through the bare skin, preventing stress and its eventual consequence on egg quality parameters.

Yolk height and diameter were similar in the naked neck and frizzle birds. The frizzle birds also have their feathers modified and are therefore able to regulate their body temperature under high ambient temperatures, though not to the same extent as the naked neck birds. This may account for their superiority over the normal feathered phenotype in Haugh unit, yolk height and yolk diameter. Yolk colour score was not significantly different among the three phenotypes. This may be due to the fact that, under the scavenging system all the birds have access to green leaves and therefore the yellowish carotene pigmentation appears in their eggs at almost the same level.

Egg shell thickness being significantly higher in naked neck birds confirms the findings of Njenga (2005) and Sharifi (2006), who concluded that the indigenous naked neck birds were significantly superior in shell thickness compared to the frizzle and the normal feathered birds. Akhtar-Uz-Zaman (2002) explained that, the reduction in feather coverage of naked neck birds enables them to receive more solar radiation, which may facilitate greater vitamin D3 synthesis and in turn, contribute to the better shell quality.

5.2.5 Carcass Parameters

Relative defeathered weight, dressed weight and breast muscle weight were significantly higher in the indigenous naked neck compared to the indigenous frizzle and the normal feathered birds because of the higher proportion of muscle found in the pectoral region of naked neck birds. According to Merat (1986), this gives them 1.8-7.1 percent more meat than normal feathered birds when their carcasses are dressed. Furthermore, the reduction of plumage (20-40%) in naked neck birds conserves protein which is used for the development of muscle tissues. According Merat (1986), this gives them 1.5-3.0% more carcass yield than their normal feathered counterparts regardless of the temperature. Barrio *et al.* (1991) noted that, naked neck birds are significantly superior to their normal feathered counterparts in carcass traits. Fathi *et al*.

(2008) reported that the naked neck birds (*NaNa or Nana*) exhibit higher relative weight of dressed carcass, drumstick and breast muscles compared to normally feathered individuals (*nana*). According to N'Dri *et al*. (2005) carcass yield of naked neck birds were higher than that of normally feathered birds (81.6 % vs. 80.0 %).

The frizzle birds had significantly higher relative defeathered weight, eviscerated and dressed weight than the normal feathered birds due to the modification in plumage coverage of frizzle birds that helps them to regulate their body temperature under high ambient temperatures. Since a bird's ability to regulate its body temperature determines how stress-free it would be, the frizzle birds might have consumed more feed and utilized it better which resulted in good muscle development (higher values for defeathered and dressed weights) than their normal feathered counterparts. Additionally, since live weight was not significantly different between the two phenotypes, frizzle birds may have had relatively fewer feathers than their normal feathered counterparts and this eventually affected the differences in relative defeathered and dressed weights.

The frizzle birds had significantly higher relative weight of intestines, gizzard weight, heart weight and liver weight. Benedict *et al*. (1932), Boas and Landauer (1933), (1934), Landauer and Aberle (1935) and Landauer and Upham (1936) reported similar results and had concluded that, this was due to the acceleration of basal metabolism in frizzle birds that led to increased production of both thyroid and adrenal gland hormones. They added that, feed intake, oxygen consumption, heart rate and volume of circulating blood were increased, resulting in enlargement of heart, spleen, gizzard and alimentary canal in frizzled birds.

5.2.6 <u>Mortality</u>

The lower chick mortality observed in the frizzle birds compared to the naked neck and normal feathered birds may be due to the good mothering ability of the frizzle hens. This is because under the conditions of local chicken mortality of chicks is mostly due predation and therefore survivability of chicks depends on the ability of the hen to protect them. The lower total mortality observed in the naked neck birds compared to the frizzle and normal feathered birds is in agreement with and explained by earlier findings in other countries. Singh (1996) and Sharifi (2006) reported that the survival ratio of naked neck hens was significantly superior to their normal feathered counterparts. According to Barrio *et al*. (1991) and Banga Mboko (1996), the naked neck gene has a higher resistance to coccidiosis-causing protozoa- *E. tanella and E. necatrix*. Haushi *et al.* (2002) studied the naked neck and the normal feathered birds for general immunocompetence and reported that a significantly higher haemolytic complement level in serum was observed in birds carrying a copy of the *Na* mutation as compared to the normally feathered birds. Naked neck birds are superior to normal feathered birds for viability, immunocompetence, blood biochemical parameters and mortality (Barrio *et al.*, 1991). Barrio *et al.* (1987) stated that, there is less frequent cannibalism among naked neck birds and that this may have a relation to survival rate.

5.3 STUDY THREE, FOUR AND FIVE

5.3.1 Parental Generations ($P_{1\&2}$)

The indigenous male parents used in the first matings with normal Lohmann Commercials (Experiments Three & Four) varied in colour because indigenous birds are produced as a result of random mating among indigenous chickens. Therefore many colours appear even within chicks from the same parents. They were quite old since almost all of them were a year or more old. Their average weights (1.50 kg - naked neck & 1.42kg - frizzle) were far below the body weight of some standard breeder males whose weight range between two and three kilograms (LPSMP, 1999).

The average fertility was quite high (94%). Males showing these thermoregulatory genes (*Na* & *F*) have been associated with high fertility (Singh *et al.*, 1996; Sharifi, 2006); even though Njenga (2005) associated them with low fertility when various phenotypes of indigenous birds were compared. Average hatchability was low especially in the naked necks (66% for naked necks & 74% for frizzles). However, the naked neck gene has been found to influence hatchability positively (Singh *et al*., 1996; Moreki and Masupu, 2003). Therefore, this low hatchability value might have been caused by faulty incubator and faulty hatchery operations since the commercial hatchery where the birds were hatched had generally low hatchability records.

The females used as the first generation parents (In Experiment Three and Four) were Lohmann commercial layers which were uniformly brown in colour. They were 52 weeks old. This explains their larger egg sizes (62g) and moderate rate of lay (66.67%), because egg size increases with the age of birds while rate of lay is inversely proportional to age after the peak laying period. Fertility was good (94%) even though it was lower than that of original Lohmann parent stock (95-98%). However, this might have been affected by their age and the fact that they were commercial layers but not selected female parent stock. The low hatchability realized within the Lohmann females (66% compared to the 78-82% for original Lohmann parent stock) may be due to environmental factors (hatchery problems) but not genetics.

The values for egg quality parameters such as albumen height (7.11mm), Haugh unit (77%), shell thickness (0.32mm), yolk height (40mm), yolk diameter (15mm) and yolk colour score (5) for the Lohmann layers used as the female parents during the first mating show that the eggs were of good quality.

The second generation of parents (P_2) was selected from the F_1 heterozygous naked neck and heterozygous frizzle birds. The selection was done during the seventh week and was therefore based on growth rate and general appearance. However, the objective of the selection was not only for meat production but also for egg production. This objective was achieved because the parents of this second parental generation were widely unrelated and therefore their offspring took advantage of heterosis, which made them perform above the average of the two parents in both meat and egg production. Naked neck and frizzle hybrids producing both eggs and meat is possible because Báldy *et al*. (1954) improved egg production together with body weight to a level that did not affect meat quality. Their work resulted in a good dual-purpose (meat and egg) Hungarian naked neck chicken breed, which was propagated all over the country and abroad.

As hybrids from indigenous chickens and exotic ones, hen-housed rate of lay of 60 (frizzle) and 65% (naked neck), hen-day rate of lay of 64 and 68% and egg size of 55 and 58g were on the higher side. Age at first egg of 138 and 148 days shows especially that naked neck birds are generally not early maturers and this might have contributed to their bigger egg sizes since according to Oni *et al*. (1991), late maturers normally lay bigger eggs than early maturers. Mortality from week seven through the laying period was very low (Tables 4.3.3a & 4.4.3a) and this explains the closeness of hen-housed and hen-day rates of lay (65% vs 68% & 60 vs 64%). The low mortality also confirms the positive influence of the naked neck and the frizzle genotypes on survivability of chickens as observed by Barrio *et al*. (1987), (1991); Banga Mboko (1996); Singh (1996); Haushi *et al*. (2002); and Sharifi (2006).

Fertility (92%- naked neck & 92.67%- frizzle) and hatchability (72%-naked neck & 77.70-frizzle) of these parents were moderate, which is in line with some published results on the fertility and hatchability of naked neck and frizzle birds that are sometimes found to be moderate (Singh, 1996; Njenga, 2005; Mohammed, 2005) and other times found to be high (Hammade, 1987; Sharifi, 2006). Hybrid progenies had been associated with higher fertility compared to their exotic parents (Trail, 1961; Kicka *et al.* 1978). On the other hand, hatchability of fertile eggs has been reported by many authors to be influenced by genetic factors, storage temperature, handling of eggs, quality of eggs, age of bird, season, nutrition, pre-incubation warming, humidity, etc. (Hyre, 1962; Byng and Nash, 1962; Simkova, 1962; Gringer, 1964; Laxi, 1964; Reddy *et al.*, 1965). However, crossbreeding improves hatchability by 5 to 20% in most crosses (Byng and Nash, 1962). Bice and Tower (1939) observed higher hatchability in crossbred birds than in indigenous birds. The above discussion shows that fertility and hatchability results for the second generation of parents (P_2) were affected by multiple factors: genetic factors (*Na* & *F* genes), crossbreeding and non-genetic factors.

The eggs of these parents were of high quality (Table 4.3.3b & 4.4.3b) and this might have been due to the positive influence of the naked neck and frizzle genotypes on egg quality performance in chickens as a result of pleiotropy or linkage (Fraga and Lam, 1987; Singh *et al.*, 1996; Njenga, 2005). Additionally, these birds were first filial generation hybrids and might have been influenced by heterosis, which according to Burrell (1999) is highest in hybrids for egg quality traits.

5.3.2 First and Second Generation (F_1 & F_2) Birds

5.3.2.1 Plumage Colour

The naked necks (*NaNa* & *Nana*), frizzles (*FF* & *Ff*) and normals (*nana/ff*) produced in the first and second filial generations had varying plumage colours as a result of the variation in sire colours. To obtain a single colour for male and female offspring, the colours of the sires and dams should be taken into consideration during the mating. For instance brown sires (*ss*) and white dams (*S* -) when mated will produce white males (*Ss*) and brown females (*s* -) in the offspring since the gold gene (colour brown) is recessive to the silver gene (white).

5.3.2.2 Body Weight and Body Weight Gain

The F_1 and F_2 naked neck birds were significantly heavier than normal feathered (Tables 4.3.2.2a-c & 4.3.4.2a-c) and frizzle (Tables 4.5.2a1 & 2) ones because the 2040 percent less feather coverage in naked neck birds reduces considerably the need for dietary nutrition to supply protein input for feather production. This makes naked neck birds save protein, which may result in faster growth (Horst, 1987; Merat, 1990; Ajang *et al*., 1993; Cahaner *et al.*, 1993) leading to improved body weight. Secondly, the naked neck gene (*Na*) may have a linkage with some of the genes which control body weight and body weight gain in chicken (Crawford, 1976). Further more, reduction in feather coverage increases the rate of irradiation of internally produced heat, thus improving thermoregulation under high (30^{o}C) or even moderate (22^{o}C), ambient temperatures. Therefore, naked neck chickens have a better capacity to maintain their body temperature at high ambient temperatures (Yahav *et al*., 1998) due to the absence of feathers on their neck, and also the absence of scattered down and semiplume feathers on the apteria, which radiate heat that are normally held-in by the feathers of chickens. According to Bordas *et al*. (1978), the reduction in feather coverage of naked neck birds by 20-30% and 30-40% respectively for the heterozygous (*Nana*) and homozygous (*NaNa*), facilitates better heat dissipation and improves thermoregulation resulting in better relative heat tolerance under hot climates. This, according to Ward *et al*. (2001) results in relief from heat stress, which enhances the productive and reproductive performance of birds; since chickens minimize endogenous heat production, to avoid a lethal increase in body temperature, by reducing feed intake, resulting in decreased growth and meat yield in birds (Yahav *et al*., 1998).

This result is similar to that of Njenga (2005) who compared the growth of naked neck, frizzle, dwarf and normal feathered birds from day-old to week 5, and concluded that the naked neck birds were significantly heavier (P<0.05) than all the other chicken phenotypes. In studies involving slow growing birds under fluctuating temperatures, N'Dri *et al*. (2005) and Sharifi (2006) observed that heterozygous naked neck birds reached the weight of 2 kg 3.3 days sooner than normal feathered birds. Merat (1986) and Rauen *et al*. (1986) reported that heterozygous naked neck birds had significantly higher (P<0.05) values in growth performance than their normal feathered counterparts at temperatures of 30^{o}C and higher. Somes (1988), Hareen-Kiso (1991) and Mathur (2003) found that under constant heat stress, heterozygous naked neck birds perform significantly better than their normal feathered counterparts in terms of growth performance.

The F_1 heterozygous frizzle birds were significantly heavier ($P<0.05$) than the normal feathered birds in body weight from day-old to the twentieth week (Tables 4.4.2.2a-c) because the frizzle gene may have a linkage with some genes which control growth in chickens. Additionally the frizzling gene is a feather structure gene (Horst, 1988) that causes a reduction in tropical heat stress by improving the bird's ability to convect heat, resulting in improved feed conversion and better performance (Merat, 1990). Benedict *et al*. (1932) found a considerable increase in energy metabolism for frizzled birds, implying that they will respond differently from normal feathered birds to high temperatures. This result is similar to that of Sharifi (2006) who stated that, weight of chicks improves by the presence of the *F*-gene. According Njenga (2005) the frizzle birds have higher chick weights within the first week of life among indigenous local birds such as the naked neck, dwarf and normal feathered. Somes (1988) and Mathur (2003) reported that the frizzle gene has favourable effect on body weight.

However, body weight gain between the two phenotypes was only higher in the frizzle birds within the first six weeks while those of weeks 8 to 20 were not significantly different ($P>0.05$), and this shows that the positive influence of the frizzle phenotype on growth under the conditions of this experiment may have occurred only during the first six weeks. Therefore, the *F*-gene may only affect growth in chickens under natural environmental conditions in the tropics, during the juvenile stages (day old - 6wks). This result agrees with that of Sharifi (2006) who found that under moderate temperatures the frizzle gene in heterozygous form has no significant impact on growth performance.

The F_2 frizzle phenotypes were not significantly different (P>0.05) from their normal feathered siblings in the twenty weeks study of body weight and weight gain (Tables 4.4.4.2a-c). Where there were significant differences (P<0.05), it was either *Ff* birds or *ff* birds or both which were heavier than the other phenotypes; and this might be due to the fluctuating nature of the temperature which might have masked the influence of the frizzle gene on body weight and weight gain. These birds were hatched in the raining season and reared through both rainy and dry seasons and therefore the heat load was not strong enough to cause the level of stress that would make the *F*-gene more advantageous. This result presupposes that the frizzle phenotype may not always be superior to the normal feathered one in growth performance under natural tropical conditions where chickens are not constantly under heat stress. Mathur (2003) studied frizzle birds in different countries (Turkey, Egypt, Cuba, Burundi, Bolivia and Malaysia) and concluded that under natural conditions there are large differences in the performance of frizzle birds in terms of body weight and productivity index at different locations.

5.3.2.2.1 <u>Effect of Management System on Body Weight and Weight Gain</u> The significantly better performance of the birds reared under the intensive management system compared to those reared under the semi-intensive and extensive systems may be due to the reason that, birds reared under the intensive system were fed *ad libitum* with a commercial diets that was high in protein (15%) and energy (2650kcal ME/kg) compared to the local mash that was given to those reared under semi-intensive and extensive systems in a controlled manner.

5.3.2.3 Body Measurements

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

The F_1 and F_2 frizzles (*FF* & *Ff*) and the normal feathered (*ff*) birds had a similar genetic background, therefore their similar performances in body measurements such as body length, body width and shank length means that the frizzle gene did not have any significant influence on these traits. However, in the F_2 birds body length value was significantly higher ($P<0.05$) in *Ff* birds than *FF* and *ff* ones, and this clarifies the report of Baldy *et al*. (1954) that it was the heterozygous frizzle birds which were used as game cocks but not the homozygous ones, since game cocks are selected based on body conformation aside the feather modifications which only frizzle birds possess.

5.3.2.3.1 Effect of Management System on Body Measurements

Birds reared under intensive and semi-intensive systems had higher values in body length and body width than those reared under extensive system because they were given diets that were balanced nutritionally and this made the birds grow bigger and faster compared birds reared under the extensive system. The diet given to birds reared under the intensive system had a higher quantity of protein (17%), and also the birds ate more feed per day (fed *ad libitum*) compared to the birds reared under the semiintensive system. This result also show that body measurements of birds are not only influenced by genes but also management.

5.3.2.4 <u>Laying Performance</u>

The naked neck phenotype had positive effects on number of eggs per clutch, egg size and rate of lay than the frizzle (Table 4.5.4a) and normal feathered (Table 4.3.2.4a, 4.3.4.4a) ones because the *Na* gene which is located on the third chromosomes in chickens may have a linkage with some genes that control egg production which are located on the same chromosome (Crawford, 1976). Secondly, part of dietary protein is used in feather formation and the reduction of feathers in naked neck birds releases more protein which can be used for egg formation. Furthermore, the average day temperatures during the study ranged from 25 to 32^{o}C which could have caused heat stress in the the layers. However, due to feather reduction in naked neck layers, they were able to dessipate heat properly which alleviated heat stress under the high ambient temperatures and therefore improved feed intake, feed utilization, egg formation and egg laying.

The results were similar to those of Somes (1988), Haaren-Kiso (1991), Mathur (2003) and Sharifi (2006) who found that under constant heat stress, heterozygous naked neck birds perform significantly better than their normal feathered counterparts in terms of egg numbers. Rauen *et al*. (1986) observed that the advantage of the *Na* gene at high temperatures for egg production mainly involves persistency of laying. Somes (1988), Hareen-Kiso (1991), Rauen *et al*. (1986), Yoshimura (1997) and Mathur (2003) associated the naked neck genotype with bigger egg size compared to the normal feathered birds. Rauen *et al*. (1986) reported that under high temperatures the heterozygous naked neck birds are superior in rate of lay compared to their normal feathered counterparts.

Age at first egg was better for the heterozygous naked neck birds than the homozygous ones because the former reached sexual maturity earlier than the latter. These F_2 birds were hatched in the rainy season with average early morning ambient temperatures of 15-18^oC which because of inadequate heating during brooding affected the growth of the homozygous naked neck birds and therefore resulted in a delay in sexual maturity. The usefulness of the naked neck genotype in stress management at higher ambient temperatures has already been explained in this section. Stress in birds during high ambient temperatures affects egg production markedly; therefore, the 1% higher production of the homozygous naked neck birds in hen-day egg production compared to the heterozygous naked neck genotype was due to the extensive feather mass reduction (40%) in the former compared to the latter (20% feather mass reduction).

The naked neck birds being inferior to the normal feathered (Tables 4.3.2.4a & 4.3.4.4a) and frizzle birds (Table 4.5.4a) in age at first egg may be due to the fact that naked neck birds are associated with bigger egg sizes; because according to Oni *et al*. (1991) breeds that attain sexual maturity early end up laying lighter eggs than late maturers.

The F_1 and F_2 frizzle (*FF* & *Ff*) birds had significantly higher values for number of eggs per clutch, hen-housed rate of lay and hen-day rate of lay than their normal feathered counterparts because the frizzle gene may have a positive linkage with some genes which control egg production in the chicken. Also, the frizzle gene curls the feathers of chickens which assist in thermo-regulation. This in turn improves feed intake and feed utilization which would eventually improve egg production. This finding is similar to what had earlier been found by Somes (1988) and Mathur (2003) who reported that under natural conditions the frizzle gene had favourable effects on production traits such as egg number and productivity index but less pronounced than the naked neck gene. Horst (1987) found that under high temperatures, the frizzle gene caused an increase in egg number. Sharifi (2006) stated that under high ambient temperatures, the frizzle gene in heterozygous form (*Ff*) had a positive effect on laying performance, but added that this advantage was not significant under moderate temperatures. Missohou *et al.* (2003) studied frizzle, sex-linked dwarfism, normal feathered, normal size and combined frizzle and sex- linked dwarfism birds under Senegalese natural conditions and found that, the interaction between the two genes was positive for egg number.

The results on egg weight which did not differ significantly between frizzles and normals in both F_1 and F_2 generations show that the frizzle gene may not have significant influence on this trait in the fluctuating ambient temperature under which the study was conducted, since this comparison was done between birds from similar genetic backgrounds. On the contrary, Somes (1988) and Mathur (2003) reported that under natural conditions the frizzle gene had favourable effect on egg weight.

Age at first egg was significantly better in F_1 frizzle (*Ff*) birds than the normals (*ff*), however, in the F_2, normals (*ff*) had a better value in this trait than the frizzles (*FF* & *Ff*); the birds had similar genetic background and therefore the trait being superior in each of the two phenotypes for one of the two generations shows that the differences might have been caused by environmental but not genetic factors. Secondly, the frizzle gene could influence this trait only in F_1 birds but not in birds from any other generation. However, Sharifi (2006) concluded that the presence of the *F*-gene especially in the homozygous dominant form (*FF*) delays age at first egg.

The heterozygous frizzle birds had higher average value in number of eggs per clutch than the homozygous frizzles under the conditions of this study because their feathers were extremely curled which exposed parts of their skin and were therefore pecked by themselves and other phenotypes. This slightly affected their feed intake and feed utilization and eventually number of eggs per clutch. Furthermore, since the heterozygous frizzle birds performed better than their two homozygous counterparts (*FF* & *ff*), it could be due to overdominance.

5.3.2.4.1 <u>Effect of Village and Sire on Laying Performance</u>

The villages where the F_1 birds (Naked necks, frizzles and Normals) were reared affected their laying performance significantly, which showed under local management conditions is not only affected by the genetic make-up of the birds, but also a wide range of environmental factors such as the micro-climate (rainfall, temperature and relative humidity), sanitation (cleanliness of pen or coop, feeders and waterers) and scavenging feed resource base. According to Mathur (2003), under natural conditions there are large differences in the performance of chickens in terms of egg number, egg weight, egg mass and productivity index at different locations. The four sires used also affected egg production performance of the F_1 birds significantly indicating the possibility of the offspring inheriting some egg production genes from their sires.

Location (village) affected the laying performance of F_2 birds with regards to number of eggs per clutch and egg size, which were significantly better in birds reared in Nkwanta as compared to Yawkwei and Juaso because some of the farmers in Nkwanta used very spacious rooms to keep their birds, which reduced stocking density significantly. This in turn reduced heat stress and cannibalism and consequently enhanced feed intake and feed utilization. Additionally, they gave their birds a lot of green leaves including “nkontomire” (cocoyam leaves), which are quiet nutritious. These environmental factors might have improved number of eggs per clutch and egg size of the birds raised in that village.

5.3.2.4.2 <u>Effect of Management System on Laying Performance</u>

Laying performance was significantly better ($P<0.05$) in birds reared under the intensive system than those reared under the semi-intensive system which were better than those reared under the extensive system because layers reared under intensive system were giving diets containing relatively higher amounts of protein (17%) compared to diets given to those reared under the semi-intensive (14% CP) and the extensive systems. Birds that met their daily demand for protein laid bigger eggs and also laid more consistently than those that were served with relatively lower protein diets. The results also indicate that improving the genetics of local birds without any improvement in management might not raise their productive and reproductive performance

significantlty.

5.3.2.5 <u>Egg Quality Performance</u>

The F_1 and F_2 naked necks had higher values in albumen height, Haugh unit, shell thickness, yolk height and yolk diameter because the naked neck gene may have a positive linkage with some of the genes which control the quality of an egg. Additionally, ambient temperature during the experiment was high (25-32^oC of day ambient temperature) and could therefore lead to stress in layers and eventually affect egg formation and quality. However, the presence of the naked neck gene improves heat dissipation in birds which alleviates stress due to heat and results in improvement in egg formation and quality.

This result is similar to that of Somes (1988), Hareen-Kiso (1991), Mathur (2003) and Njenga (2005), who reported that under constant heat stress heterozygous naked neck birds performed better in egg mass and productivity index than their normal feathered counterparts. Fraga and Lam (1987) and Sharifi (2006) found better egg shell strength for the heterozygous naked neck genotype under high temperature conditions compared to its normal feathered counterpart. According to Singh *et al.* (1996) the naked neck gene has a positive influence on egg quality traits.

F_1 frizzle (*Ff*) birds had higher values for albumen height, Haugh unit and yolk height than the normals (*ff)* while in the F_2 generation the frizzles (*FF, Ff*) had higher values in Haugh unit and shell thickness than the normals (*ff*) which indicate that the frizzle gene has positive influence on egg quality. According to Isikwenu *et al.* (1999) Haugh unit is one of the best indicators of internal egg quality; and the higher the Haugh unit the more desirable the egg quality. The superior Haugh unit in the frizzle phenotype in this study is contrary to the finding of Missohou *et al.* (2003) who studied frizzles, sex- linked dwarfs, normal feathered and normal sized birds and combined frizzle and sex- linked dwarf birds under Senegalese conditions and found that, the frizzle gene does not significantly influence egg quality. However, Mathur (2003) who studied the frizzle phenotype under natural conditions in different countries stated that under natural conditions there are large differences in the performance of frizzle birds in terms of productivity index at different locations.

The frizzle birds performed better in egg quality within this study because the frizzle gene may have a positive linkage with some genes which control egg quality in chickens genetically (Benedict *et al.,* 1932). Additionally, the high ambient temperatures during the experiment could have caused stress in laying birds and affects egg formation and quality negatively. However, birds showing the frizzle phenotype have been found to respond differently from normals under heat stress due to their curled feathers which help in thermo-regulation to reduce heat stress and alleviate its eventual consequence on egg formation and quality.

The homozygous frizzles had higher values in shell thickness than the heterozygous ones, thereby deepening the fact that the frizzle gene has a positive influence on egg shell thickness. The contrary results reported by Sharifi (2006) might have been due to the variability in the performance of frizzle genotypes at different locations (Mathur, 2003).

Results on yolk diameter and yolk colour score showed that the frizzle genotypes do not influence these traits significantly. This is in agreement with the findings of Missohou *et al.* (2003). However, the most important egg quality traits are the Haugh unit and shell thickness which the frizzle phenotypes influenced positively in this study.

5.3.2.6 Some Carcass Parameters

The F_1 and F_2 naked necks had higher values for defeathered weight, dressed weight, thigh and drumstick weight, breast muscle weight than their frizzle (Table 4.5.6a) and normal feathered counterparts (Table 4.3.2.6 & 4.3.4.6) because the reduction of plumage (20-40%) in naked neck birds saves protein that may be used to develop meat tissues. Also, the fewer feathers of naked neck birds gave them higher carcass yield than their normal feathered and frizzle counterparts. Additionally, naked neck birds have a higher proportion of muscle in the pectoral region and this gives them more meat. The effect of the reduction in feather mass caused by the *Na* gene on breast muscle yield mimics the effect of reducing ambient temperature (AT). Several studies with normally feathered birds have shown that breast muscle yield is higher at low to moderate AT than at high AT (Howlider and Rose, 1989; Leenstra and Cahaner, 1992). Therefore, the higher meat yield of the naked neck birds, especially because it is even higher in the *NaNa* genotype than in the *Nana*, also indicates that their ability to endure heat stress under high ambient temperatures has an effect equivalent to that of a lower environmental temperature.

The result is similar to that of Fathi *et al.* (2008) who found the two naked neck genotypes to be superior in relative drumstick weight compared to their normal feathered counterparts. They also found dressing percentage and relative breast muscle weight to be higher in the naked neck genotypes (*NaNa and Nana*) compared to their normal feathered counterpart which is similar to what was found in this study.

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

Values for weight of intestines and liver weight were higher in frizzle birds than the normals because basal metabolism of frizzle birds is accelerated leading to increased production of both thyroid and adrenal gland hormones. According to Benedict *et al*. (1932), Boas and Landauer (1933,1934), Landauer and Aberle (1935) and Landauer and Upham (1936) this condition leads to increased food intake, oxygen consumption, heart rate and volume of circulating blood, resulting in enlargement of internal organs and alimentary canal in frizzle birds.

5.3.2.6.1 <u>Effect of Management System on Carcass Parameters</u>

Carcass parameters differed among birds reared under the three management systems which show that carcass parameters are influenced by the management system. Therefore, any attempt to improve the productivity of local birds should consider improving both genetic factors and management. The breast muscle weight that did not differ among birds reared under the various management systems shows that this carcass trait is not influenced by environmental factors (management).

5.3.2.7 <u>Mortality</u>

Chick mortality was higher in F_1 and F_2 naked neck chicks than normal feathered ones, which might have been due to electrical power failures during the brooding period. However, total mortality was lower in naked neck birds than frizzles (*FF*, *Ff*), (Table 4.5.7) and normals (*nana*), (Tables 4.3.2.7 & 4.3.4.7) because the presence of the *Na* gene in the birds might have increased their resistance against diseases (Mahrous, 2008). Additionally, the naked neck birds were very docile, which made them less prone to pecking despite their bare necks and this might have increased their survivability.

The F_1 frizzle (*Ff*) birds had higher values for chick mortality than the normal feathered ones (*ff*), (Table 4.4.2.7a) due to inadequate heating during brooding. Additionally, the frizzles died more than the normals during the entire experiment (Table 4.4.2.7) because the *F* gene only influences mortality positively under high ambient temperatures when the birds are stressed because of heat load (Horst, 1987; Haaren – Kiso *et al*., 1988). Unlike the naked neck gene, the frizzle gene does not seem to influence the immunity in birds (Haushi *et al.*, 2002). However, the ambient temperature during the experiment was fluctuating and therefore during the rainy and harmattan seasons when most of the poultry diseases occured, the frizzle birds were disadvantaged since the ambient temperatures at dawn and early morning were low (14-18°C) and therefore they died more than the other phenotypes because of diseases. Furthermore, the birds were kept on a deep litter and quite a number of the frizzle birds died through pecking. Njenga (2005) had a similar experience when he studied four indigenous chicken genotypes including the frizzle. Due to the modification of its feathers, the skin of frizzle birds are easily exposed, making them more prone to pecking. This result is similar to that of Sharifi (2006) who stated that under moderate temperatures the frizzle gene has no effect on mortality.

Total mortality recorded for the F_2 normals (*ff*) was higher than what was recorded for the F_2 frizzles (*FF*, *Ff*), which was contrary to what was observed in the F_1. Birds used in this study were reared under natural conditions under the semi-intensive system and did not suffer much heat stress. The result on mortality might have been influenced by other factors aside phenotypes; for instance, the keepers reported high incidence of thefts which could have affected the total mortality of the normal feathered phenotypes. This also explains why chick mortality was not significantly different among the frizzles and normals. However, the positive influence of the frizzle genotype on survivability had been reported by Horst (1987) and Haaren – Kiso *et al*. (1988).

5.3.2.7.1 Effect of Management System on Mortality

Mortality was lower in birds reared under the intensive and semi-intensive systems compared to those kept under the extensive system because birds reared under the intensive and semi-intensive systems had good nutrition and could therefore withstand infections better than their counterparts that were reared under the extensive system. Furthermore, birds that were reared under the extensive system were affected very much by theft and accidents and these factors increased the mortality. The results show that improvement in nutrition, housing, sanitation and general husbandry practices will reduce mortality under the local chicken production system. Experience has shown that vaccination of local fowls against major poultry diseases like Newcastle disease, infectious bronchitis, Gumboro, etc. can prevent some of these losses (Wirsiy and Fonba, 2005). Birds that were used for this study were vaccinated against Newcastle disease and Gumboro, which led to the general improvement in survivability even in birds reared under the extensive system.

5.3.2.8 Economics of Production

5.3.2.8.1 Effect of Phenotype

It was more profitable to rear the naked neck birds followed by frizzles and normal feathered birds respectively; this was due to the positive influence of the naked neck gene on body weight, egg production traits and survivability under tropical conditons, which has been discussed in various sections of this study. It has also been discussed in various sections of this study that the frizzle genotype influences productive and reproductive traits positively under tropical conditions but less pronounced as compared to the naked neck genotype. Scientist in this field of study have long been advocating the use of these genotypes in the tropics for higher productivity and profitability (Horst, 1982, 1987; Cahaner *et al.*, 1993; Mathur, 2003).

5.3.2.8.2 Effect of Management System on Economics Production

It was more profitable to produce the birds under the semi-intensive system compared to the extensive system which was also significantly more profitable than the intensive one. The birds which were 50% local and 50% exotic could not perform to the level of exotic commercial birds especially in terms of egg production and therefore feeding them with a commercial poultry diet made the business unprofitable under the intensive management system. On the other hand, the local mash used under the semi-intensive system was prepared from local ingredients. For instance, palm kernel cake could be obtained within the villages free of charge and thereby reduce the cost of production and consequently maximize profit.

In this study, birds that were kept under the extensive system were given concentrate to supplement scavenging. It was found that when the scavenging birds were given concentrate twice or thrice a day, they scavenged around the source of feed. This served as a fence of protection from predators including thieves, for the birds, and it reduced losses markedly. This coupled with the low cost of production under the extensive system made it more profitable to rear the birds under this system than the intensive one.

According to Branckaert and Guèye (1999) the management systems under local chicken production frequently overlap. Therefore, free-range with feed supplementation and night confinement as was the case in this study actually improved profitability but not as much as that of the semi-intensive system. According to Ramlah (2005) freerange and semi-intensive systems of keeping local chickens are still the most popular and viable production systems for rural households.

5.4.0 <u>Contributions of the Various Studies in Achieving the Main Objective</u>

The main objective of the study was to assess the productive potential of indigenous chickens and to determine the magnitude of improvement that can be obtained by mating them with commercial hybrid layers.

The first study established that local chicken production provides immense benefits for the keepers in the form increased dietary intake of animal protein and also generation of petty cash through the sales of surplus eggs and cockerels. However, the keepers have various challenges which could be grouped broadly under genetics and management. Local birds were found in almost every household in the villages surveyed, which means that if the genetic and management problems are solved, local chicken production could easily be harnessed as a poverty alleviation tool in Ghana.

In the second study it was found that local birds possessing naked neck (*Na*) and frizzle (*F*) genes performed significantly better ($P<0.05$) than their normal feathered counterparts in traits of economic importance. It became clear that multiplying the *Na* and *F* genes which are found in the genome of local chicken population in Ghana could improve productivity significantly.

The third, fourth and fifth studies proved that introducing genes from the genome of exotic birds into local ones in addition to the *Na* and *F* genes through crossbreeding would enhance the productivity of local birds to a magnitude which is far beyond what they are producing currently.

Furthermore, it was established in the fifth experiment, that using semi-intensive system where the crossbred chickens are given supplement prepared from available local ingredients up to 75g per bird per day would help solve most of the management problems associated with the production of local birds. This would help translate the genetic improvement which has been made into profitability.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary and Conclusion

6. 1.1 Study One

All the chicken keepers interviewed reared their birds under the extensive system of production with flock sizes averaging 22 in the ratio of 4 cocks: 6 hens: 12 chicks. The foremost benefit derived by the keepers was the improved levels of animal protein in the diets of their families through the consumption of meat and surplus eggs. Survivability of chicks and total mortality were 50% and 65% respectively. Average weights of cocks, hens, chicks and eggs were 1.55kg, 1.13kg, 35.00g and 42.80g respectively. The average number of eggs per clutch ranged from 9 to 13. Challenges faced by local chicken keepers included diseases, predators, theft, lack of funds to increase stock and construct structures, smaller sizes of birds and eggs and smaller numbers of eggs laid. It can therefore be concluded that local birds provide immense benefits for keepers but their productivity is significantly hindered by genetic and management problems.

6.1.2 Study Two

Body weight, egg weight, egg production, survivability, carcass yield and egg quality were significantly higher ($P<0.05$) in birds with the naked neck phenotype than in those with the frizzle phenotype which were better ($P<0.05$) than those that had the normal feathered phenotype. It can therefore be concluded that naked neck and frizzle genes improve the productivity of local birds but the naked neck gene appears to be more effective than the frizzle gene.

6.1.3 Study Three

Homozygous (*NaNa*) and heterozygous naked neck (*Nana*) birds were reared under the local system of production with improved housing and feeding. It was found that the F_1 *Nana* birds and F_2 *Nana* and *NaNa* birds were significantly superior ($P<0.05$) to their normal feathered (*nana*) counterparts in body length, body width, body weight, body weight gain, number of eggs per clutch, hen-housed and hen-day rates of lay, egg size, albumen height, Haugh unit, shell thickness, yolk height, yolk diameter, survivability and carcass yield. However, age at first egg and egg size to body weight ratio were significantly better ($P<0.05$) in the *nana* birds compared to the *NaNa* and *Nana* ones. Shank length, yolk colour score, chick mortality and relative weights of intestines, heart and liver did not differ significantly ($P>0.05$) between the two phenotypes. Therefore, using birds that show the naked neck phenotype in local chicken production will enhance productive and reproductive performance significantly.

6.1.4 Study Four

Homozygous (*FF*) and heterozygous frizzle (*Ff*) birds were produced in the first and second generation (F_1 & F_2) of a mating between indigenous frizzle (*Ff*) males and Lohmann commercial females. It was observed that the F_1 *Ff* birds were significantly ($P<0.05$) better than their normal feathered (*ff*) counterparts in terms body weight, age at first egg, number of eggs per clutch, hen-housed and hen-day rates of lay, egg size to body weight ratio, albumen height, Haugh unit, yolk height and carcass yield, under the conditions of this experiment. However, survivability was significantly better ($P<0.05$) in the *ff* birds compared to the *Ff* ones, while traits such as body length, body width, shank length, egg size, shell thickness, yolk diameter and yolk colour score did not differ significantly (P>0.05) between the two phenotypes. The F_2 *FF* and *Ff* birds were significantly superior (P<0.05) to their *ff* counterparts in number of eggs per clutch, hen-housed and hen-day rates of lay, Haugh unit, shell thickness, survivability and carcass yield. However, age at first egg was significantly better (P<0.05) in the *ff* birds compared to the *FF* and *Ff* genotypes; while body length, body width, shank length, body weight, body weight gain, egg size, egg size to body weight ratio, albumen height, yolk height, yolk diameter, yolk colour score and chick mortality were not significantly different (P>0.05) between the frizzles and the normal feathered birds. It can therefore be concluded that using frizzle (*FF*, *Ff*) hybrids in local chicken production will increase productivity, though to a lesser extent than when naked necks (*NaNa*, *Nana*) are used.

6.1.5 <u>Study Five</u>

The *NaNa* and *Nana* birds were significantly superior (P<0.05) to their *FF* and *Ff* counterparts in body weight, body weight gain, body length, body width, shank length, number of eggs per clutch, hen-housed and hen-day rates of lay, egg size, albumen height, Haugh unit, shell thickness, yolk height, yolk diameter, yolk colour score, carcass yield and economics of production. However, age at first egg was not significantly different (P>0.05) between the naked neck and the frizzle phenotypes; while egg size to body weight ratio, and relative weights of heart and liver were significantly superior (P<0.05) in the *FF* and *Ff* birds compared to their *NaNa* and *Nana* counterparts. It was most economically viable to rear all the genotypes (*NaNa*, *Nana*, *FF*, *Ff* & *nana/ff*) under the semi-intensive system than the extensive system.

Rearing the birds under intensive system, where the birds are housed and fed under commercial poultry standards was the most economically unprofitable. It can therefore be concluded that aside genetic improvements, rearing local birds under the semiintensive system will improve profitability significantly.

6.2 Recommendations

1. It is recommended that the Ministry of Food and Agriculture collaborates well with scientists who are interested in researching into local chicken production, since it has the potential of being harnessed to improve the livelihood of the poor in our society.

2. Crossbred birds with naked neck (*NaNa* and *Nana*) and frizzle (*FF* and *Ff*) phenotypes are recommended as suitable birds for local chicken production due to their high productive and reproductive performance as well as survivability under the tropical environment.

3. The results of this study indicate that the semi-intensive system is the best for the rearing of local birds, where the birds will be vaccinated against two or three prevailing diseases especially Newcasle disease, and housed in an improved infrastructure which will protect them from thieves and predators.

4. The birds were transferred to the villages from KNUST for this study at the end of the sixth week; therefore this work should be repeated where the birds will be reared in the local environment from day-old to maturity.

5. The introduction of the naked neck (*Na*) gene into meat and egg type commercial poultry parent stock in the tropics and comparing their performance with those of parent stocks being used currently is recommended.

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APPENDIX

APPENDIX 1A: QUESTIONAIRE FOR STUDY ONE

TOPIC: ASSESSING THE CURRENT PERFORMANCE OF INDIGENOUS CHICKENS IN THE ASHANTI REGION OF GHANA

Town/Village…………………………………………………………………………….
District……………………………………………………………………………………
Name of Respondent…………………………………………………………………….
Educational Background…………………………………………………………..
Main Occupation…………………………………………………………………...

1. When did you start rearing chickens?……………………………………………........
2. How many birds do you have?...

   And how many of them are (a) cocks ………, (b) hens ……… and (c) chicks …........

3. Do you have naked neck birds? Yes ( ) No ( )

   If yes , how many of them do you have?...

4. Do you have frizzle birds? Yes ( ) No ( )

   If yes , how many of them do you have?...

5. What system of management do you use? Extensive ( ) Semi-intensive ( ) Intensive ( )
6. Do you give any feed supplement to your birds? Yes ( ) No ( )

   If yes, how often do you give them? Everyday ( ) Once a week ( )

   Two or more days within the week ( ) Occasionally ( )

7. What kind of feed supplement do you give them?……………………………………
8. What is the cost of the supplement per year?...
9. Do you buy any verterinary drugs for the birds when they are sick? Yes ( ) No ( )

   If yes, how much do you spend on the drugs per year?………………………………

10. Aside feed and drugs, do you incur any additional cost on the birds? Yes ( ) No ( ). If yes, how much do you spend per year?..
11. What is the average weight of your cocks?..
12. What is the average weight of your hens?...
13. What is the average weight of your chicks?..

14. Do you sell some of your birds? Yes ( ) No ( )
    If yes, how much do you sell: (a) one hen?.................. and (b) one cock…………

And on the average, how many birds do you sell within a year?............................

15. What is the criteria for pricing?...
16. How many layers do you have?...
17. What is the average clutch size of your layers?...
18. What is the average eggs per clutch of your layers?...
19. What is the average eggs per bird per year of your layers?………………………..
20. What is the average weight of an egg from your layers?..
21. How do your layers brood? (a) Good brooders ( ) (b) Poor brooders ( )
22. What percentage of eggs set is normally hatched?...
23. What percentage of chicks normally survives to adulthood? ……………………...
24. What are the symptoms of diseases that normally attack your birds?……………

    ………………………………………………………………………………………….

25. What is the mortalities per year? ……………………………………………………
26. Aside diseases, what are the other causes of mortalities (in descending order)?

………………………………………………………………………………………………

27. Why do you keep indigenous chickens? ……………………………………………..

    ………………………………………………………………………………………….

28. What are some of the problems that hinder you from getting the maximum benefit (in descending order)?
29. Are you satisfied with what you gain from keeping the chickens? Yes ( ) No ( )

    If No, what do you think should be done to improve local chicken production?

………………………………………………………………………………………………

………………………………………………………………………………………………

APPENDIX 1B: QUESTIONAIRE FOR STUDY TWO

TOPIC: EVALUATING THE POTENTIALS OF INDIGENOUS NAKED NECK (NaNa ,Nana) AND FRIZZLE (FF, Ff) CHICKENS IN THE ASHANTI REGION OF GHANA

Town/Village…………………………………………………………………………….
District……………………………………………………………………………………

Name of Respondent……………………………………………………………………
Educational Background…………………………………………………………..
Main Occupation…………………………………………………………………...

1. How many birds do you have?..

And how many of them are (a) naked neck ………….. , (b) frizzle …………………. and (c) normal feathered …...........................

Naked Neck Birds (Nana)

2. What is the average weight of your *Nana* cocks?..

3. What is the average weight of your *Nana* hens?..

4. What is the average weight of your *Nana* chicks?..

5. How many *Nana* layers do you have?..

6. What is the average clutch size of your *Nana* layers?..

7. What is the average eggs per clutch of your *Nana* layers?..

8. What is the average eggs per bird per year of your *Nana* layers?……………………

9. What is the average weight of an egg from your *Nana* layers?......................................

10. What percentage of eggs from *Nana* layers is normally hatched?...............................

11. What percentage of *Nana* chicks normally survives to adulthood? ………………….

12. What is the percentage mortality per year for *Nana* birds? …………………………

Frizzle Birds (Ff)

13. What is the average weight of your *Ff* cocks?...

14. What is the average weight of your *Ff* hens?...

15. What is the average weight of your *Ff* chicks?..

16. How many *Ff* layers do you have?.. 17. What is the average clutch size of your *Ff* layers?...

18. What is the average eggs per clutch of your *Ff* layers?..

19. What is the average eggs per bird per year of your *Ff* layers?……………………

20. What is the average weight of an egg from your *Ff* layers?.....................................

21. What percentage of eggs from *Ff* layers is normally hatched?.................................

22. What percentage of *Ff* chicks normally survives to adulthood? ………………….

23. What is the percentage mortality per year for *Ff* birds? ……………………………

Normal Feathered Birds (nana/ff)

24. What is the average weight of your *nana/ff* cocks?..
25. What is the average weight of your *nana/ff* hens?..
26. What is the average weight of your *nana/ff* chicks?..
27. How many *nana/ff* layers do you have?...
28. What is the average clutch size of your *nana/ff* layers?..
29. What is the average eggs per clutch of your *nana/ff* layers?.......................................
30. What is the average eggs per bird per year of your *nana/ff* layers?……………………..
31. What is the average weight of an egg from your *nana/ff* layers?.................................
32. What percentage of eggs from *nana/ff* layers is normally hatched?............................
33. What percentage of *nana/ff* chicks normally survives to adulthood? ………………
34. What is the percentage mortality per year for *nana/ff* birds? ………………………

APPENDIX 2: ANOVA TABLES

Experiment Two: Survey on Local Naked neck and Frizzle Birds

Variate: Flock Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	456.000	228.000	41.88	<.001
Phenotype	2	0.000	0.000	0.00	1.000
District.Phenotype	4	0.000	0.000	0.00	1.000
Residual	18	98.000	5.444		
Total	26	554.000			

Variate: % Phenotype within a Flock

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	0.000	0.000	0.00	1.000
Phenotype	2	27450.000	13725.000	5146.88	<.001
District.Phenotype	4	408.000	102.000	38.25	<.001
Residual	18	48.000	2.667		
Total	26	27906.000			

Variate: Average Weight of Chicks (g)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	16.258200	8.129100	6417.71	<.001
Phenotype	2	19.224800	9.612400	7588.74	<.001

District.Phenotype	4	16.089400	4.022350	3175.54	<.001
Residual	18	0.022800	0.001267		
Total	26	51.595200			

Variate: Average We of Cocks (kg)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	0.101267	0.050633	9.10	0.002
Phenotype	2	0.024067	0.012033	2.16	0.144
District.Phenotype	4	0.002133	0.000533	0.10	0.983
Residual	18	0.100200	0.005567		
Total	26	0.227667			

Variate: Average Weight of Hens (kg)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	0.01307	0.00653	0.42	0.664
Phenotype	2	0.32107	0.16053	10.29	0.001
District.Phenotype	4	0.07413	0.01853	1.19	0.350
Residual	18	0.28080	0.01560		
Total	26	0.68907			

Laying Performance

Variate: Eggs Per clutch

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	2.667	1.333	1.33	0.288
Phenotype	2	162.667	81.333	81.33	<.001
District.Phenotype	4	3.333	0.833	0.83	0.522
Residual	18	18.000	1.000		
Total	26	186.667			

Variate: Clutches Per Year

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	0.18667	0.09333	7.00	0.006
Phenotype	2	0.04667	0.02333	1.75	0.202

District.Phenotype	4	0.05333	0.01333	1.00	0.433
Residual	18	0.24000	0.01333		
Total	26	0.52667			

Variate: Eggs Per Bird Per Year

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	8.667	4.333	4.33	0.029
Phenotype	2	1644.667	822.333	822.33	<.001
District.Phenotype	4	21.333	5.333	5.33	0.005
Residual	18	18.000	1.000		
Total	26	1692.667			

Variate: Hatchability (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	104.667	52.333	10.47	<.001
Phenotype	2	72.667	36.333	7.27	0.005
District.Phenotype	4	25.333	6.333	1.27	0.319
Residual	18	90.000	5.000		
Total	26	292.667			

Variate: Average Weight of [illegible] (g)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	20.2881	10.1440	91.22	<.001
Phenotype	2	57.5701	28.7850	258.86	<.001
District.Phenotype	4	2.5157	0.6289	5.66	0.004
Residual	18	2.0016	0.1112		
Total	26	82.3755			

Variate: Average Albumen Height (mm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	0.3172667	0.1586333	1586.33	<.001
Phenotype	2	0.6304667	0.3152333	3152.33	<.001
District.Phenotype	4	0.5001333	0.1250333	1250.33	<.001
Residual	18	0.0018000	0.0001000		
Total	26	1.4496667			

Variate: Haugh Unit (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	42.667	21.333	21.33	<.001
Phenotype	2	290.667	145.333	145.33	<.001
District.Phenotype	4	3.333	0.833	0.83	0.522
Residual	18	18.000	1.000		
Total	26	354.667			

Variate: Shell Thickness (mm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	0.0004667	0.0002333	1.75	0.202
Phenotype	2	0.0020667	0.0010333	7.75	0.004
District.Phenotype	4	0.0003333	0.0000833	0.62	0.651
Residual	18	0.0024000	0.0001333		
Total	26	0.0052667			

Variate: Yolk Height (mm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	1.85407	0.92704	18.40	<.001
Phenotype	2	2.89407	1.44704	28.73	<.001
District.Phenotype	4	1.22815	0.30704	6.10	0.003
Residual	18	0.90667	0.05037		
Total	26	6.88296			

Variate: Yolk Diameter (mm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	88.667	44.333	33.25	<.001
Phenotype	2	116.667	58.333	43.75	<.001
District.Phenotype	4	21.333	5.333	4.00	0.017
Residual	18	24.000	1.333		
Total	26	250.667			

Variate: Yolk Colour Score

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	2.667	1.333	1.09	0.357
Phenotype	2	2.667	1.333	1.09	0.357
District.Phenotype	4	3.333	0.833	0.68	0.614

Residual	18	22.000	1.222
Total	26	30.667	

Mortality

Variate: Chick Mortality (%)

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
District	2	114.000	57.000	42.75	<.001
Phenotype	2	62.000	31.000	23.25	<.001
District.Phenotype	4	10.000	2.500	1.88	0.159
Residual	18	24.000	1.333		
Total	26	210.000			

F pr.

Variate: Total Mortality (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	168.000	84.000	84.00	<.001
Phenotype	2	776.000	388.000	388.00	<.001
District.Phenotype	4	64.000	16.000	16.00	<.001
Residual	18	18.000	1.000		
Total	26	1026.000			

Carcass Performance

Variate: Defeathered Weight as % of Live Weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	0.464	0.232	1160.67	<.001
Phenotype	2	1.186	5.930	2.965	<.001
District.Phenotype	4	6.559	1.640	8198.17	<.001
Residual	18	0.360	0.200		
Total	26	1.256			

Variate: Eviscerated Weight as % of Live Weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	4.0491	2.0245	9.10	0.002
Phenotype	2	88.5195	44.2597	198.99	<.001
District.Phenotype	4	11.8023	2.9506	13.27	<.001
Residual	18	4.0036	0.2224		
Total	26	108.3745			

Variate: Dressed Weig
We ight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	1.1008667	0.5504333	3302.60	<.001
Phenotype	2	84.9968667	42.4984333	2.550	<.001
District.Phenotype	4	12.0181333	3.0045333	1.803	<.001
Residual	18	0.0030000	0.0001667		
Total	26	98.1188667			

Variate: Thigh and Drumstick Weight as a % of Live Weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

District	2	2.7168000	1.3584000	8150.40	<.001
Phenotype	2	0.7706000	0.3853000	2311.80	<.001
District.Phenotype	4	1.4338000	0.3584500	2150.70	<.001
Residual	18	0.0030000	0.0001667		
Total	26	4.9242000			

Variate: Chest Muscle Weight as a % of Live Weight

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
District	2	3.2558000	1.6279000	9767.40	<.001
Phenotype	2	67.4538000	33.7269000	2.024	<.001
District.Phenotype	4	2.9602000	0.7400500	4440.30	<.001
Residual	18	0.0030000	0.0001667		
Total	26	73.6728000			

Variate: Wings Weight as a % of Live Weight

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
District	2	1.8749	0.9374	1.69	0.213
Phenotype	2	0.2289	0.1144	0.21	0.816
District.Phenotype	4	1.3069	0.3267	0.59	0.676
Residual	18	10.0026	0.5557		
Total	26	13.4133			

Variate: Intestines Weight as a % of Live Weight

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
District	2	0.112867	0.056433	24.54	<.001
Phenotype	2	0.205067	0.102533	44.58	<.001
District.Phenotype	4	0.017733	0.004433	1.93	0.149
Residual	18	0.041400	0.002300		
Total	26	0.377067			

Variate: Gizzard Weight as a % of Live Weight

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
District	2	0.414067	0.207033	90.01	<.001
Phenotype	2	1.021667	0.510833	222.10	<.001
District.Phenotype	4	0.427733	0.106933	46.49	<.001
Residual	18	0.041400	0.002300		

					F pr.
Total	26	1.904867			

Variate: Heart Weight as a % of Live Weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	0.0340667	0.0170333	170.33	<.001
Phenotype	2	0.0970667	0.0485333	485.33	<.001
District.Phenotype	4	0.0255333	0.0063833	63.83	<.001
Residual	18	0.0018000	0.0001000		
Total	26	0.1584667			

Variate: Liver Weigght as a % of Live Weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
District	2	0.0481407	0.0240704	209.65	<.001
Phenotype	2	0.0909407	0.0454704	396.03	<.001
District.Phenotype	4	0.0742815	0.0185704	161.74	<001
Residual	18	0.0020667	0.0001148		
Total	26	0.2154296			

Experiment Three: Comparative Studies on F1 Naked neck and Frizzle Birds Growth Performance

Variate: Body Weight at Day-old

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	182.3185	60.7728	485.70	<.001
Phenotype	1	13.6353	13.6353	108.97	<.001
Sire_Line.Phenotype	3	5.0905	1.6968	13.56	<.001
Residual	16	2.0020	0.1251		
Total	23	203.0464			

Variate: Body Weight at Week 1

Source of variation	d.f.	s.s.	m.s.	v.r.	
Sire_Line	3	31.636912	10.545637	4036.61	<.001
Phenotype	1	29.106037	29.106037	1.114	<.001
Sire_Line.Phenotype	3	7.363913	2.454638	939.57	<.001
Residual	16	0.041800	0.002613		
Total	23	68.148663			

Variate: Body Weight Gain at Week 1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	73.590450	24.530150	1.784E	<.001
Phenotype	1	2.898150	2.898150	2107.75	<.001
Sire_Line.Phenotype	3	3.266850	1.088950	791.96	<.001
Residual	16	0.022000	0.001375		
Total	23	79.777450			

Variate: Body Weight at Week 2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	1.294	4.312	1.674	<.001
Phenotype	1	1.574	1.574	6.114	<.001
Sire_Line.Phenotype	3	5.518	1.839	7143.55	<.001
Residual	16	0.412	0.257		
Total	23	1.506			

Variate: Body Weight Gain at Week 2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	1.676	5.587	4.858	<.001
Phenotype	1	5.116	5.116	4.449	<.001
Sire_Line.Phenotype	3	1.013	3.376	2.936	<.001
Residual	16	0.184	0.115		
Total	23	1.828			

Variate: Body Weight at Week 3

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	2.853	9.510	7.111	<.001
Phenotype	1	2.768	2.768	2.070	<.001
Sire_Line.Phenotype	3	3.066	1.022	7640.18	<.001
Residual	16	0.214	0.134		
Total	23	3.161			

Variate: Body Weight Gain at Week 3

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

					F pr.
Sire_Line	3	3502.4570	1167.4857	9305.46	<.001
Phenotype	1	16.7334	16.7334	133.37	<.001
Sire_Line.Phenotype	3	155.8791	51.9597	414.15	<.001
Residual	16	2.0074	0.1255		
Total	23	3677.0769			

Variate: Body Weight at Week 4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	6.625	2.208	2.208	<.001
Phenotype	1	5.104	5.104	5.104	<.001
Sire_Line.Phenotype	3	2.281	7.604	7.604	<.001
Residual	16	0.160	0.100		
Total	23	1.401			

Variate: Body Weight Gain at Week 4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	1.391	4.636	1.801	<.001
Phenotype	1	3.004	3.004	1.167	<.001
Sire_Line.Phenotype	3	2.198	7.325	2.845	<.001
Residual	16	0.412	0.258		
Total	23	6.592			

Variate: Body Weight at Week 5

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	1.442	4.806	4.806	<.001
Phenotype	1	6.376	6.376	6.376	<.001
Sire_Line.Phenotype	3	2.099	6.998	6.998	<.001
Residual	16	0.160	1.000		
Total	23	2.289			

Variate: Body Weight Gain at Week 5

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	1.598	5.328	3.674	<.001
Phenotype	1	6.956	6.956	4.798	<.001
Sire_Line.Phenotype	3	9.444	3.148	2.171	<.001
Residual	16	0.232	0.145		
Total	23	2.612			

Variate: Body Weight at Week 6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	5.575	1.858	1.858	<.001
Phenotype	1	9.299	9.299	9.299	<.001
Sire_Line.Phenotype	3	3.469	1.156	1.156	<.001

					F pr.
Residual	16	0.160	0.100		
Total	23	1.834			

Variate: Body Weight Gain at Week 6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sire_Line	3	3.115	1.038	3.611	<.001
Phenotype	1	2.768	2.768	9.629	<.001
Sire_Line.Phenotype	3	6.736	2.245	7.809	<.001
Residual	16	0.460	0.288		
Total	23	4.065			

Variate: Chick Mortality (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	
Sire_Line	3	0.00458	0.00153	0.02	0.995
Phenotype	1	0.03375	0.03375	0.52	0.480
Sire_Line.Phenotype	3	0.01458	0.00486	0.08	0.972
Residual	16	1.03333	0.06458		
Total	23	1.0862			

Variate: Body Weight at We :k 7

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	956	239	0.00	
Sex stratum	1	336297	336297	2.12	
Batch.Sex stratum	4	635848	158962	155.59	
Batch.Sex.*Units* stratum					
Village	2	48690	24345	23.83	<.001
Sire_Line	3	55602	18534	18.14	<.001
Phenotype	1	229417	229417	224.54	<.001
Village.Sire_Line	6	35685	5947	5.82	<.001
Village.Phenotype	2	3336	1668	1.63	0.196
Sire_Line.Phenotype	3	32971	10990	10.76	<.001
Village.Sire_Line.Phenotype	6	23154	3859	3.78	0.001
Residual	687	701907	1022		

Total	719	2103864

Variate: Body Weight at Week 8

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	1013	253	0.00	
Sex stratum	1	435324	435324	2.15	
Batch.Sex stratum	4	808854	202214	139.56	
Village	2	31715	15858	10.94	<.001
Sire_Line	3	65641	21880	15.10	<.001
Phenotype	1	378710	378710	261.38	<.001
Village.Sire_Line	6	52474	8746	6.04	<.001
Village.Phenotype	2	2216	1108	0.76	0.466
Sire_Line.Phenotype	3	29111	9704	6.70	<.001
Village.Sire_Line.Phenotype	6	20226	3371	2.33	0.031
Residual	687	995390	1449		
Total	719	2820675			

Variate: Body Weight at Week Gain Week 8

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	59.07	14.77	0.00	
Sex stratum	1	7562.16	7562.16	2.15	
Batch.Sex stratum	4	14041.11	3510.28	44.37	
Batch.Sex.*Units* stratum					
Village	2	5058.00	2529.00	31.97	<.001
Sire_Line	3	1299.27	433.09	5.47	0.001
Phenotype	1	24512.84	24512.84	309.84	<.001
Village.Sire_Line	6	4211.22	701.87	8.87	<.001
Village.Phenotype	2	3436.33	1718.17	21.72	<.001
Sire_Line.Phenotype	3	1227.18	409.06	5.17	0.002
Village.Sire_Line.Phenotype	6	753.70	125.62	1.59	0.148
Residual	687	54351.03	79.11		
Total	719	116511.91			

Variate: Body Weight at Week 9

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	2078	519	0.00	
Sex stratum	1	640414	640414	2.12	

					F pr.
Batch.Sex stratum	4	1207855	301964	189.61	
Batch.Sex.*Units* stratum					
Village	2	23017	11509	7.23	<.001
Sire_Line	3	91771	30590	19.21	<.001
Phenotype	1	731227	731227	459.14	<.001
Village.Sire_Line	6	80275	13379	8.40	<.001
Village.Phenotype	2	6781	3391	2.13	0.120
Sire_Line.Phenotype	3	35801	11934	7.49	<.001
Village.Sire_Line.Phenotype	6	26874	4479	2.81	0.010
Residual	687	1094111	1593		
Total	719	3940204			

Variate: Body Weight gain ıt Wee ¢ 9

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	122.7	30.7	0.00	
Sex stratum	1	16807.4	16807.4	2.15	
Batch.Sex stratum	4	31304.5	7826.1	49.49	
Batch.Sex.*Units* stratum					
Village	2	2772.0	1386.0	8.76	<.001
Sire_Line	3	1442.0	480.7	3.04	0.028
Phenotype	1	45318.4	45318.4	286.58	<.001
Village.Sire_Line	6	6583.9	1097.3	6.94	<.001
Village.Phenotype	2	2595.7	1297.9	8.21	<.001
Sire_Line.Phenotype	3	184.1	61.4	0.39	0.762
Village.Sire_Line.Phenotype	6	619.8	103.3	0.65	0.688
Residual	687	108639.4	158.1		
Total	719	216389.9			

Variate: Body Weight at Week 10

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	3195	799	0.00	
Sex stratum	1	925253	925253	2.13	
Batch.Sex stratum	4	1740551	435138	179.25	
Batch.Sex.*Units* stratum					
Village	2	23605	11802	4.86	0.008
Sire_Line	3	103934	34645	14.27	<.001
Phenotype	1	1267662	1267662	522.19	<.001

Village.Sire_Line	6	119806	19968	8.23	<.001
Village.Phenotype	2	19139	9570	3.94	0.020
Sire_Line.Phenotype	3	38739	12913	5.32	0.001
Village.Sire_Line.Phenotype	6	40197	6700	2.76	0.012
Residual	687	1667756	2428		
Total	719	5949835			

Variate: Body Weight gain at Week WG10

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	192.2	48.1	0.00	
Sex stratum	1	26405.9	26405.9	2.18	
Batch.Sex stratum	4	48430.6	12107.6	50.61	
Batch.Sex.*Units* stratum					
Village	2	7000.0	3500.0	14.63	<.001
Sire_Line	3	816.3	272.1	1.14	0.333
Phenotype	1	60876.4	60876.4	254.46	<.001
Village.Sire_Line	6	8177.1	1362.8	5.70	<.001
Village.Phenotype	2	8456.3	4228.2	17.67	<.001
Sire_Line.Phenotype	3	273.0	91.0	0.38	0.767
Village.Sire_Line.Phenotype	6	1428.6	238.1	1.00	0.427
Residual	687	164356.0	239.2		
Total	719	326412.4			

Variate: Body Weight at Week 11

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	5569	1392	0.00	
Sex stratum	1	1329122	1329122	2.15	
Batch.Sex stratum	4	2471526	617881	161.32	
Batch.Sex.*Units* stratum					
Village	2	31603	15802	4.13	0.017
Sire_Line	3	116827	38942	10.17	<.001
Phenotype	1	2068550	2068550	540.08	<.001
Village.Sire_Line	6	185837	30973	8.09	<.001
Village.Phenotype	2	53311	26655	6.96	0.001
Sire_Line.Phenotype	3	40554	13518	3.53	0.015
Village.Sire_Line.Phenotype	6	47871	7979	2.08	0.053
Residual	687	2631250	3830		
Total	719	8982021			

Variate: Body Weight gain at Week 11

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

					F pr.
Batch stratum	4	456.7	114.2	0.01	
Sex stratum	1	36614.0	36614.0	2.26	
Batch.Sex stratum	4	64764.9	16191.2	59.56	
Batch.Sex.*Units* stratum					
Village	2	8627.5	4313.8	15.87	<.001
Sire_Line	3	549.1	183.0	0.67	0.569
Phenotype	1	100368.5	100368.5	369.23	<.001
Village.Sire_Line	6	11948.2	1991.4	7.33	<.001
Village.Phenotype	2	10711.0	5355.5	19.70	<.001
Sire_Line.Phenotype	3	173.8	57.9	0.21	0.887
Village.Sire_Line.Phenotype	6	920.5	153.4	0.56	0.759
Residual	687	186750.3	271.8		
Total	719	421884.5			

Variate: Body Weight at Week 12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	7630	1907	0.00	
Sex stratum	1	1763522	1763522	2.17	
Batch.Sex stratum	4	3255329	813832	132.04	
Batch.Sex.*Units* stratum					
Village	2	74190	37095	6.02	0.003
Sire_Line	3	144914	48305	7.84	<.001
Phenotype	1	3256978	3256978	528.41	<.001
Village.Sire_Line	6	257667	42944	6.97	<.001
Village.Phenotype	2	132769	66385	10.77	<.001
Sire_Line.Phenotype	3	28052	9351	1.52	0.209
Village.Sire_Line.Phenotype	6	73856	12309	2.00	0.064
Residual	687	4234446	6164		
Total	719	13229352			

Variate: Body Weight Gain at Week 12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

					F pr.
Batch stratum	4	322.6	80.7	0.00	
Sex stratum	1	40012.0	40012.0	2.26	
Batch.Sex stratum	4	70946.3	17736.6	55.04	
Batch.Sex.*Units* stratum					
Village	2	35740.9	17870.5	55.46	<.001
Sire_Line	3	395.1	131.7	0.41	0.747
Phenotype	1	106627.5	106627.5	330.91	<.001
Village.Sire_Line	6	11166.9	1861.1	5.78	<.001
Village.Phenotype	2	11821.7	5910.8	18.34	<.001
Sire_Line.Phenotype	3	681.0	227.0	0.70	0.550
Village.Sire_Line.Phenotype	6	1466.7	244.5	0.76	0.603
Residual	687	221370.0	322.2		
Total	719	500550.7			

Variate: Body Weight at Week 13

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	8715	2179	0.00	
Sex stratum	1	2203954	2203954	2.17	
Batch.Sex stratum	4	4066955	1016739	110.06	
Batch.Sex.*Units* stratum					
Village	2	238161	119081	12.89	<.001
Sire_Line	3	218127	72709	7.87	<.001
Phenotype	1	4576207	4576207	495.34	<.001
Village.Sire_Line	6	390671	65112	7.05	<.001
Village.Phenotype	2	288782	144391	15.63	<.001
Sire_Line.Phenotype	3	34932	11644	1.26	0.287
Village.Sire_Line.Phenotype	6	152174	25362	2.75	0.012
Residual	687	6346810	9238		
Total	719	18525488			

Variate: Body Weight Gain at Week 13

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	717.2	179.3	0.01	
Sex stratum	1	44366.6	44366.6	2.30	
Batch.Sex stratum	4	77236.9	19309.2	49.38	
Batch.Sex.*Units* stratum					
Village	2	79202.7	39601.4	101.28	<.001
Sire_Line	3	938.9	313.0	0.80	0.494
Phenotype	1	124645.7	124645.7	318.79	<.001
Village.Sire_Line	6	14144.0	2357.3	6.03	<.001
Village.Phenotype	2	13570.9	6785.5	17.35	<.001
Sire_Line.Phenotype	3	355.3	118.4	0.30	0.823
Village.Sire_Line.Phenotype	6	1628.7	271.5	0.69	0.654
Residual	687	268617.7	391.0		
Total	719	625424.8			

Variate: Body Weight at Week 14

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	13217	3304	0.00	
Sex stratum	1	2919149	2919149	2.18	
Batch.Sex stratum	4	5358679	1339670	101.66	
Batch.Sex.*Units* stratum					
Village	2	437333	218666	16.59	<.001
Sire_Line	3	270023	90008	6.83	<.001
Phenotype	1	6146697	6146697	466.42	<.001
Village.Sire_Line	6	395119	65853	5.00	<.001
Village.Phenotype	2	357374	178687	13.56	<.001
Sire_Line.Phenotype	3	41287	13762	1.04	0.372
Village.Sire_Line.Phenotype	6	221760	36960	2.80	0.011
Residual	687	9053660	13179		
Total	719	25214297			

F pr.

Variate: Body Weight gain at Week 14

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	839.7	209.9	0.01	
Sex stratum	1	50700.8	50700.8	2.35	
Batch.Sex stratum	4	86354.3	21588.6	55.14	
Batch.Sex.*Units* stratum					
Village	2	139344.8	69672.4	177.95	<.001
Sire_Line	3	3330.3	1110.1	2.84	0.037
Phenotype	1	120634.5	120634.5	308.11	<.001
Village.Sire_Line	6	13073.4	2178.9	5.57	<.001
Village.Phenotype	2	9141.0	4570.5	11.67	<.001
Sire_Line.Phenotype	3	329.4	109.8	0.28	0.840
Village.Sire_Line.Phenotype	6	2900.4	483.4	1.23	0.286
Residual	687	268978.8	391.5		
Total	719	695627.4			

Variate: Body Weight at Week 15

Source of variation	d.f.	s.s.	m.s.	v.r.	
Batch stratum	4	17810	4452	0.00	
Sex stratum	1	3663680	3663680	2.21	
Batch.Sex stratum	4	6644307	1661077	96.32	
Batch.Sex.*Units* stratum					
Village	2	973983	486991	28.24	<.001
Sire_Line	3	337234	112411	6.52	<.001
Phenotype	1	7887680	7887680	457.37	<.001
Village.Sire_Line	6	488394	81399	4.72	<.001
Village.Phenotype	2	453020	226510	13.13	<.001
Sire_Line.Phenotype	3	46394	15465	0.90	0.442
Village.Sire_Line.Phenotype	6	232626	38771	2.25	0.037
Residual	687	11847807	17246		

					F pr.
Total	719	32592933			

Variate: Body Weight Gain at Week 15

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	689.7	172.4	0.01	
Sex stratum	1	39083.9	39083.9	2.34	
Batch.Sex stratum	4	66846.0	16711.5	37.43	
Batch.Sex.*Units* stratum					
Village	2	113049.5	56524.7	126.61	<.001
Sire_Line	3	7396.4	2465.5	5.52	<.001
Phenotype	1	137626.5	137626.5	308.26	<.001
Village.Sire_Line	6	7528.0	1254.7	2.81	0.010
Village.Phenotype	2	4950.8	2475.4	5.54	0.004
Sire_Line.Phenotype	3	1238.4	412.8	0.92	0.428
Village.Sire_Line.Phenotype	6	3537.3	589.5	1.32	0.245
Residual	687	306718.1	446.5		
Total	719	688664.5			

Variate: Body Weight at Week 16

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	26034	6509	0.00	
Sex stratum	1	4487992	4487992	2.22	
Batch.Sex stratum	4	8077003	2019251	87.51	
Batch.Sex.*Units* stratum					
Village	2	1630602	815301	35.33	<.001
Sire_Line	3	404284	134761	5.84	<.001
Phenotype	1	10414853	10414853	451.35	<.001
Village.Sire_Line	6	611721	101953	4.42	<.001

					F pr.
Village.Phenotype	2	629131	314565	13.63	<.001
Sire_Line.Phenotype	3	61714	20571	0.89	0.445
Village.Sire_Line.Phenotype	6	252414	42069	1.82	0.092
Residual	687	15852377	23075		
Total	719	42448124			

Variate: Body Weight Gain at Week 16

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	888.9	222.2	0.01	
Sex stratum	1	41937.5	41937.5	2.40	
Batch.Sex stratum	4	69968.9	17492.2	33.38	
Batch.Sex.*Units* stratum					
Village	2	85888.8	42944.4	81.94	<.001
Sire_Line	3	6864.3	2288.1	4.37	0.005
Phenotype	1	176563.4	176563.4	336.90	<.001
Village.Sire_Line	6	9626.5	1604.4	3.06	0.006
Village.Phenotype	2	16490.9	8245.5	15.73	<.001
Sire_Line.Phenotype	3	1380.7	460.2	0.88	0.452
Village.Sire_Line.Phenotype	6	2565.5	427.6	0.82	0.558
Residual	687	360040.5	524.1		
Total	719	772215.8			

Variate: Body Weight at Week 16

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	26034	6509	0.00	
Sex stratum	1	4487992	4487992	2.22	
Batch.Sex stratum	4	8077003	2019251	87.51	
Batch.Sex.*Units* stratum					
Village	2	1630602	815301	35.33	<.001
Sire_Line	3	404284	134761	5.84	<.001
Phenotype	1	10414853	10414853	451.35	<.001
Village.Sire_Line	6	611721	101953	4.42	<.001
Village.Phenotype	2	629131	314565	13.63	<.001
Sire_Line.Phenotype	3	61714	20571	0.89	0.445
Village.Sire_Line.Phenotype	6	252414	42069	1.82	0.092
Residual	687	15852377	23075		
Total	719	42448124			

Variate: Body Weight Gain at Week 17

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	1073.7	268.4	0.04	
Sex stratum	1	18150.3	18150.3	2.53	
Batch.Sex stratum	4	28652.6	7163.2	13.34	

Batch.Sex.*Units* stratum					
Village	2	112794.0	56397.0	105.02	<.001
Sire_Line		1340.1	446.7	0.83	0.477
Phenotype	1	191916.7	191916.7	357.37	<.001
Village.Sire_Line	6	22336.9	3722.8	6.93	<.001
Village.Phenotype	2	22423.8	11211.9	20.88	<.001
Sire_Line.Phenotype	3	188.7	62.9	0.12	0.950
Village.Sire_Line.Phenotype	6	2718.7	453.1	0.84	0.536
Residual	687	368939.1	537.0		
Total	719	770534.7			

Variate: Body Weight at Week 18

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
Batch stratum	4	49431. 1	12358.0	0.00	
Sex stratum	1	6001514. 6	6001514.0	2.26	
Batch.Sex stratum	4	10621987.0	2655497.0	73.98	
Batch.Sex.*Units* stratum					
Village	2	2907765.0	1453883.0	40.50	<.001
Sire_Line	3	455981.0	151994.0	4.23	0.006
Phenotype	1	17259272.0	17259272.0	480.82	<.001
Village.Sire_Line	6	906241.0	151040.0	4.21	<.001
Village.Phenotype	2	1226180.0	613090.0	17.08	<.001
Sire_Line.Phenotype	3	37878.0	12626.0	0.35	0.788
Village.Sire_Line.Phenotype	6	396466.0	66078.0	1.84	0.089
Residual	687	24660102.0	35895.0		
Total	719	64522817.0			

Variate: Weight Gain at Week 18

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
Batch stratum	4	1096.4	274.1	0.03	
Sex stratum	1	26220.9	26220.9	2.48	
Batch.Sex stratum	4	42328.6	10582.2	19.02	
Batch.Sex.*Units* stratum					
Village	2	143595.2	71797.6	129.02	<.001
Sire_Line	3	2615.7	871.9	1.57	0.196
Phenotype	1	187695.3	187695.3	337.29	<.001
Village.Sire_Line	6	22503.4	3750.6	6.74	<.001
Village.Phenotype	2	20116.5	10058.2	18.07	<.001
Sire_Line.Phenotype	3	282.9	94.3	0.17	0.917
Village.Sire_Line.Phenotype	6	4039.9	673.3	1.21	0.299
Residual	687	382305.0	556.5		

Total	719	832799.7

Variate: Body Weight at W :ek 19

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	43146.0	10787.	0.00	
Sex stratum	1	6272000.0	6272000.	2.04	
Batch.Sex stratum	4	12319860.0	3079965.	52.18	
Batch.Sex.*Units* stratum					
Village	2	2528308.0	1264154.0	21.42	<.001
Sire_Line	3	266733.0	88911.0	1.51	0.212
Phenotype	1	19827042.0	19827042.0	335.90	<.001
Village.Sire_Line	6	785660.0	130943.0	2.22	0.040
Village.Phenotype	2	1436874.0	718437.0	12.17	<.001
Sire_Line.Phenotype	3	209809.0	69936.0	1.18	0.315
Village.Sire_Line.Phenotype	6	545507.0	90918.0	1.54	0.162
Residual	687	40551026.0	59026.0		
Total	719	84785964.0			

Variate: Weight Gain 19

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	1393.9	348.5	0.02	
Sex stratum	1	40575.0	40575.0	2.36	
Batch.Sex stratum	4	68902.2	17225.6	29.22	
Batch.Sex.*Units* stratum					
Village	2	86052.2	43026.1	72.99	<.001
Sire_Line	3	9387.0	3129.0	5.31	0.001
Phenotype	1	131625.3	131625.3	223.29	<.001
Village.Sire_Line	6	11900.3	1983.4	3.36	0.003
Village.Phenotype	2	4031.5	2015.7	3.42	0.033
Sire_Line.Phenotype	3	924.3	308.1	0.52	0.667
Village.Sire_Line.Phenotype	6	7264.4	1210.7	2.05	0.057
Residual	687	404981.4	589.5		
Total	719	767037.5			

Variate: Body Weight at W :ek 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	88511.0	22128.0	0.01	
Sex stratum	1	9767128.0	9767128.0	2.27	

Batch.Sex stratum	4	17187554.0	4296889.0	92.42	
Batch.Sex.*Units* stratum					
Village	2	3437221.0	1718611.0	36.97	<.001
Sire_Line	3	1025454.0	341818.	7.35	<.001
Phenotype	1	19658471.0	19658471.0	422.84	<.001
Village.Sire_Line	6	2025585.0	337598.0	7.26	<.001
Village.Phenotype	2	1319650.0	659825.0	14.19	<.001
Sire_Line.Phenotype	3	391142.0	130381.0	2.80	0.039
Village.Sire_Line.Phenotype	6	776860.0	129477.0	2.78	0.011
Residual	687	31939487.0	46491.0		
Total	719	87617062.0			

Variate: Weight Gain 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	1303.3	25.8	0.02	
Sex stratum	1	36266.8	36266.8	2.37	
Batch.Sex stratum	4	61203.3	15300.8	32.49	
Batch.Sex.*Units* stratum					
Village	2	51276.9	25638.5	54.45	<.001
Sire_Line	3	3264.2	1088.1	2.31	0.075
Phenotype	1	96373.5	2395.4	5.09	<.001
Village.Phenotype	2	3895.3	1947.6	4.14	0.016
Sire_Line.Phenotype	3	161.8	53.9	0.11	0.952
Village.Sire_Line.Phenotype	1966.9	327.8	0.70	0.653	
Residual	687	323488.2	470.9		
Total	719	593572.8			

Egg Laying Performance

Variate: Age at 1st Egg

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.125	0.125	0.63	0.484
Residual	3	0.594	0.198	0.02	
Batch.*Units* stratum					
Village	2	7.684	3.842	0.39	0.680
Sire_Line	3	108.476	36.159	3.63	0.013

Phenotype	1	868.186	868.186	87.20	<.001
Village.Sire_Line	6	124.546	20.758	2.08	0.055
Village.Phenotype	2	61.803	30.902	3.10	0.046
Sire_Line.Phenotype	3	6.151	2.050	0.21	0.892
Village.Sire_Line.Phenotype	6	60.466	10.078	1.01	0.417
Residual	332	3305.299	9.956		
Total	359	4543.331			

Variate: Clutch Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.086	0.086	3.89	0.143
Residual	3	0.067	0.022	0.01	
Batch.*Units* stratum					
Village	2	22.832	11.416	5.56	0.004
Sire_Line	3	93.051	31.017	15.12	<.001
Phenotype	1	282.756	282.756	137.81	<.001
Village.Sire_Line	6	3.468	0.578	0.28	0.945
Village.Phenotype	2	2.421	1.211	0.59	0.555
Sire_Line.Phenotype	3	15.796	5.265	2.57	0.055
Village.Sire_Line.Phenotype	6	7.106	1.184	0.58	0.748
Residual	332	681.191	2.052		
Total	359	1108.775			

Variate: Rate of Lay (Hen- housed)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.117	0.117	1.01	0.390
Residual	3	0.350	0.117	0.02	
Batch.*Units* stratum					
Village	2	142.649	71.325	13.16	<.001
Sire_Line	3	236.634	78.878	14.55	<.001
Phenotype	1	899.517	899.517	165.93	<.001
Village.Sire_Line	6	104.180	17.363	3.20	0.005
Village.Phenotype	2	21.271	10.635	1.96	0.142
Sire_Line.Phenotype	3	79.693	26.564	4.90	0.002
Village.Sire_Line.Phenotype	6	41.793	6.965	1.28	0.264

Residual	332	1799.771	5.421		
Total	359	3325.975			

Variate: Rate of Lay (Hen-day)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.076	0.076	0.98	0.396
Residual	3	0.233	0.078	0.02	
Batch.*Units* stratum					
Village	2	190.915	95.457	19.28	<.001
Sire_Line	3	315.435	105.145	21.24	<.001
Phenotype	1	908.990	908.990	183.62	<.001
Village.Sire_Line	6	64.023	10.670	2.16	0.047
Village.Phenotype	2	13.442	6.721	1.36	0.259
Sire_Line.Phenotype	3	39.584	13.195	2.67	0.048
Village.Sire_Line.Phenotype	6	34.397	5.733	1.16	0.329
Residual	332	1643.528	4.950		
Total	359	3210.622			

Variate: Body Weight to Egg Weight Ratio

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.07	0.07	0.19	0.693
Residual	3	1.15	0.38	0.04	
Batch.*Units* stratum					
Village	2	15.97	7.99	0.78	0.458
Sire_Line	3	99.99	33.33	3.26	0.022
Phenotype	1	463.14	463.14	45.34	<.001
Village.Sire_Line	6	38.16	6.36	0.62	0.712
Village.Phenotype	2	42.19	21.10	2.07	0.128
Sire_Line.Phenotype	3	55.14	18.38	1.80	0.147
Village.Sire_Line.Phenotype	6	23.52	3.92	0.38	0.889
Residual	332	3391.58	10.22		

Total	359	4130.92			

Egg Quality Performance

Variate: Egg Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.751	0.751	3.11	0.176
Residual	3	0.723	0.241	0.03	
Batch.*Units* stratum					
Village	2	576.671	288.335	38.31	<.001
Sire_Line	3	395.502	131.834	17.52	<.001
Phenotype	1	859.374	859.374	114.19	<.001
Village.Sire_Line	6	53.761	8.960	1.19	0.311
Village.Phenotype	2	114.123	57.062	7.58	<.001
Sire_Line.Phenotype	3	63.085	21.028	2.79	0.040
Village.Sire_Line.Phenotype	6	29.349	4.891	0.65	0.690
Residual	332	2498.577	7.526		
Total	359	4591.917			

Variate: Albumin Height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.0483	0.0483	3.07	0.178
Residual	3	0.0473	0.0158	0.06	
Batch.*Units* stratum					
Village	2	0.2070	0.1035	0.38	0.685
Sire_Line	3	39.8909	13.2970	48.63	<.001
Phenotype	1	10.4710	10.4710	38.30	<.001
Village.Sire_Line	6	3.3623	0.5604	2.05	0.059
Village.Phenotype	2	4.4379	2.2190	8.12	<.001
Sire_Line.Phenotype	3	6.7794	2.2598	8.26	<.001
Village.Sire_Line.Phenotype	6	8.1184	1.3531	4.95	<.001
Residual	332	90.7758	0.2734		
Total	359	164.1383			

Variate: Haugh Unit

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

Batch stratum					
Phenotype	1	0.72	0.72	1.71	0.282
Residual	3	1.26	0.42	0.03	
Batch.*Units* stratum					
Village	2	54.37	27.18	2.26	0.106
Sire_Line	3	2129.18	709.73	59.02	<.001
Phenotype	1	774.81	774.81	64.44	<.001
Village.Sire_Line	6	702.50	117.08	9.74	<.001
Village.Phenotype	2	33.86	16.93	1.41	0.246
Sire_Line.Phenotype	3	137.64	45.88	3.82	0.010
Village.Sire_Line.Phenotype	6	230.91	38.49	3.20	0.005
Residual	332	3992.04	12.02		
Total	359	8057.29			

Variate: Shell_Thickness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.0000714	0.0000714	2.62	0.204
Residual	3	0.0000817	0.0000272	0.03	
Batch.*Units* stratum					
Village	2	0.0097842	0.0048921	6.23	0.002
Sire_Line	3	0.0615497	0.0205166	26.12	<.001
Phenotype	1	0.0672785	0.0672785	85.65	<.001
Village.Sire_Line	6	0.0187010	0.0031168	3.97	<.001
Village.Phenotype	2	0.0014637	0.0007318	0.93	0.395
Sire_Line.Phenotype	3	0.0442430	0.0147477	18.77	<.001
Village.Sire_Line.Phenotype	6	0.0078436	0.0013073	1.66	0.129
Residual	332	0.2607954	0.0007855		
Total	359	0.4718122			

Variate: Yolk Diameter

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.009	0.009	0.39	0.578
Residual	3	0.067	0.022	0.01	
Batch.*Units* stratum					
Village	2	0.290	0.145	0.06	0.941
Sire_Line	3	58.648	19.549	8.20	<.001
Phenotype	1	37.388	37.388	15.68	<.001
Village.Sire_Line	6	64.679	10.780	4.52	<.001
Village.Phenotype	2	6.150	3.075	1.29	0.277

Sire_Line.Phenotype	3	60.033	20.011	8.39	<.001
Village.Sire_Line.Phenotype	6	17.256	2.876	1.21	0.303
Residual	332	791.604	2.384		
Total	359	1036.122			

Variate: Yolk Height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.0141	0.0141	24.44	0.016
Residual	3	0.0017	0.0006	0.00	
Batch.*Units* stratum					
Village	2	1.5144	0.7572	1.38	0.254
Sire_Line	3	113.1407	37.7136	68.55	<.001
Phenotype	1	6.4000	6.4000	11.63	<.001
Village.Sire_Line	6	2.4376	0.4063	0.74	0.619
Village.Phenotype	2	4.1797	2.0899	3.80	0.023
Sire_Line.Phenotype	3	3.5745	1.1915	2.17	0.092
Village.Sire_Line.Phenotype	6	2.3448	0.3908	0.71	0.642
Residual	332	182.6552	0.5502		
Total	359	316.2627			

Variate: Yolk Colour Score

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.048	0.048	1.74	079
Residual	3	0.083	0.028	0.02	
Batch.*Units* stratum Village					
	2	55.810	27.905	16.61	<.001
Sire_Line	3	6.085	2.028	1.21	0.307
Phenotype	1	1.883	1.883	1.12	0.290
Village.Sire_Line	6	41.861	6.977	4.15	<.001
Village.Phenotype	2	14.557	7.279	4.33	0.014
Sire_Line.Phenotype	3	15.244	5.081	3.03	0.030
Village.Sire_Line.Phenotype	6	14.792	2.465	1.47	0.188
Residual	332	557.636	1.680		
Total	359	708.000			

Body Measurement

Variate: Body Length (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	12.950	3.238	0.01	
Sex stratum	1	726.013	726.013	3.16	
Batch.Sex stratum	4	918.189	229.547	95.88	
Batch.Sex.*Units* stratum					
Village	2	66.369	33.185	13.86	<.001
Sire_Line	3	571.126	190.375	79.52	<.001
Phenotype	1	262.812	262.812	109.77	<.001
Village.Sire_Line	6	54.319	9.053	3.78	0.001
Village.Phenotype	2	3.475	1.738	0.73	0.484
Sire_Line.Phenotype	3	77.449	25.816	10.78	<.001
Village.Sire_Line.Phenotype	6	29.214	4.869	2.03	0.059
Residual	687	1644.749	2.394		
Total	719	4366.665			

Variate: Body Weight (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	4.175	1.044	0.02	
Sex stratum	1	189.112	189.112	3.31	
Batch.Sex stratum	4	228.575	57.144	52.37	
Batch.Sex.*Units* stratum					
Village	2	10.075	5.037	4.62	0.010
Sire_Line	3	87.238	29.079	26.65	<.001
Phenotype	1	46.512	46.512	42.63	<.001
Village.Sire_Line	6	1.225	0.204	0.19	0.980
Village.Phenotype	2	8.125	4.062	3.72	0.025
Sire_Line.Phenotype	3	0.737	0.246	0.23	0.879
Village.Sire_Line.Phenotype	6	3.575	0.596	0.55	0.773
Residual	687	749.637	1.091		
Total	719	1328.987			

Variate: Shank Length (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.6583		0.1646	0.02
Sex stratum	1	41.5200	41.5200	3.88	
Batch.Sex stratum	4	42.7553	10.6888	18.94	

Batch.Sex.*Units* stratum					
Village	2	2.2324	1.1162	1.98	0.139
Sire_Line	3	26.3739	8.7913	15.58	<.001
Phenotype	1	0.3337	0.3337	0.59	0.442
Village.Sire_Line	6	3.1351	0.5225	0.93	0.475
Village.Phenotype	2	0.1041	0.0521	0.09	0.912
Sire_Line.Phenotype	3	0.4706	0.1569	0.28	0.841
Village.Sire_Line.Phenotype	6	0.9434	0.1572	0.28	0.947
Residual	687	387.6727	0.5643		
Total	719	506.1997			

Carcass Performance

Variate: Defeathered (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	1.32	0.33	0.03	
Batch.*Units* stratum					
Village	2	12.91	6.46	0.56	0.574
Sire_Line	3	55.93	18.64	1.61	0.187
Phenotype	1	13.73	13.73	1.18	0.277
Village.Sire_Line	6	48.95	8.16	0.70	0.647
Village.Phenotype	2	257.58	128.79	11.11	<.001
Sire_Line.Phenotype	3	23.21	7.74	0.67	0.573
Village.Sire_Line.Phenotype	6	33.87	5.65	0.49	0.818
Residual	332	3849.49	11.59		
Total	359	4297.00			

Variate: Eviscerated (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	13.11	3.28	0.16	
Batch.*Units* stratum					
Village	2	19.83	9.92	0.49	0.615
Sire_Line	3	70.53	23.51	1.15	0.327
Phenotype	1	41.35	41.35	2.03	0.155
Village.Sire_Line	6	65.85	10.98	0.54	0.778
Village.Phenotype	2	413.31	206.66	10.15	<.001
Sire_Line.Phenotype	3	28.68	9.56	0.47	0.704
Village.Sire_Line.Phenotype	6	38.97	6.49	0.32	0.927
Residual	332	6759.60	20.36		

Total	359	7451.23

Variate: Dressed Weight (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	27.04	6.76	0.35	
Batch.*Units* stratum					
Village	2	38.69	19.34	0.99	0.373
Sire_Line	3	145.96	48.65	2.49	0.060
Phenotype	1	61.67	61.67	3.15	0.077
Village.Sire_Line	6	107.57	17.93	0.92	0.483
Village.Phenotype	2	429.20	214.60	10.97	<.001
Sire_Line.Phenotype	3	37.66	12.55	0.64	0.589
Village.Sire_Line.Phenotype	6	70.18	11.70	0.60	0.732
Residual	332	6493.24	19.56		
Total	359	7411.21			

Variate: Thigh and Drumstick (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.1591	0.0398	0.12	
Batch.*Units* stratum					
Village	2	1.8029	0.9014	2.82	0.061
Sire_Line	3	15.3029	5.1010	15.95	<.001
Phenotype	1	1.5458	1.5458	4.83	0.029
Village.Sire_Line	6	3.8602	0.6434	2.01	0.064
Village.Phenotype	2	3.1543	1.5771	4.93	0.008
Sire_Line.Phenotype	3	6.2590	2.0863	6.52	<.001
Village.Sire_Line.Phenotype	6	3.0955	0.5159	1.61	0.143
Residual	332	106.1588	0.3198		
Total	359	141.3384			

Variate: Wings (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0413	0.0103	0.04	
Batch.*Units* stratum					
Village	2	0.1733	0.0866	0.32	0.726
Sire_Line	3	0.2972	0.0991	0.37	0.778
Phenotype	1	1.7752	1.7752	6.56	0.011
Village.Sire_Line	6	0.1520	0.0253	0.09	0.997

Village.Phenotype	2	0.5533	0.2766	1.02	0.361
Sire_Line.Phenotype	3	4.4021	1.4674	5.42	0.001
Village.Sire_Line.Phenotype	6	1.7124	0.2854	1.05	0.390
Residual	332	89.9090	0.2708		
Total	359	99.0157			

Variate: Breast Muscle (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	2.946	0.736	0.08	
Batch.*Units* stratum					
Village	2	1.553	0.777	0.08	0.919
Sire_Line	3	4.185	1.395	0.15	0.928
Phenotype	1	770.562	770.562	83.94	<.001
Village.Sire_Line	6	4.003	0.667	0.07	0.999
Village.Phenotype	2	35.184	17.592	1.92	0.149
Sire_Line.Phenotype	3	12.416	4.139	0.45	0.717
Village.Sire_Line.Phenotype	6	41.404	6.901	0.75	0.608
Residual	332	3047.602	9.180		
Total	359	3919.855			

Variate: Gizzard (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0545	0.0136	0.11	
Batch.*Units* stratum					
Village	2	1.5082	0.7541	6.07	0.003
Sire_Line	3	1.8547	0.6182	4.97	0.002
Phenotype	1	1.0541	1.0541	8.48	0.004
Village.Sire_Line	6	2.6755	0.4459	3.59	0.002
Village.Phenotype	2	0.7814	0.3907	3.14	0.044
Sire_Line.Phenotype	3	2.5580	0.8527	6.86	<.001
Village.Sire_Line.Phenotype	6	0.8653	0.1442	1.16	0.327
Residual	332	41.2675	0.1243		
Total	359	52.6192			

Variate: Intestines (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.13710	0.03428	1.08	
Batch.*Units* stratum					
Village	2	0.76684	0.38342	12.12	<.001
Sire_Line	3	0.32977	0.10992	3.47	0.016
Phenotype	1	0.06588	0.06588	2.08	0.150
Village.Sire_Line	6	0.51819	0.08637	2.73	0.013
Village.Phenotype	2	0.01131	0.00565	0.18	0.836

Sire_Line.Phenotype	3	0.02362	0.00787	0.25	0.862
Village.Sire_Line.Phenotype	6	0.18690	0.03115	0.98	0.436
Residual	332	10.50378	0.03164		
Total	359	12.54339			

Variate: Heart (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.02763	0.00691	0.45	
Batch.*Units* stratum					
Village	2	0.16870	0.08435	5.49	0.005
Sire_Line	3	0.71317	0.23772	15.48	<.001
Phenotype	1	0.00488	0.00488	0.32	0.574
Village.Sire_Line	6	0.37041	0.06173	4.02	<.001
Village.Phenotype	2	0.19198	0.09599	6.25	0.002
Sire_Line.Phenotype	3	0.21447	0.07149	4.65	0.003
Village.Sire_Line.Phenotype	6	0.11662	0.01944	1.27	0.273
Residual	332	5.09971	0.01536		
Total	359	6.90756			

Variate: Liver (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.07297	0.01824	0.60	
Batch.*Units* stratum					
Village	2	0.81004	0.40502	13.41	<.001
Sire_Line	3	0.24542	0.08181	2.71	0.045
Phenotype	1	0.00831	0.00831	0.28	0.600
Village.Sire_Line	6	1.13863	0.18977	6.29	<.001
Village.Phenotype	2	0.02994	0.01497	0.50	0.610
Sire_Line.Phenotype	3	0.03817	0.01272	0.42	0.738
Village.Sire_Line.Phenotype	6	0.16148	0.02691	0.89	0.501
Residual	332	10.02416	0.03019		
Total	359	12.52912			

Mortality

Variate: Total Mortality (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum					
Phenotype	1	0.064	0.064	1.23	0.349

Residual	3	0.156	0.052	0.01	
Batch.*Units* stratum					
Village	2	1.430	0.715	0.20	0.819
Sire_Line	3	15.890	5.297	1.48	0.219
Phenotype	1	161.392	161.392	45.19	<.001
Village.Sire_Line	6	43.480	7.247	2.03	0.061
Village.Phenotype	2	19.313	9.657	2.70	0.068
Sire_Line.Phenotype	3	8.983	2.994	0.84	0.474
Village.Sire_Line.Phenotype	6	29.187	4.865	1.36	0.229
Residual	332	1185.635	3.571		
Total	359	1465.531			

F_2 Homozygous Naked Neck, Heterozygous Naked Neck and Normal Feathered Birds

Growth Performance

Variate: Weight at Day-old

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
batch stratum	4	2.440	0.610	0.08	
batch.*Units* stratum					
Phenotype	2	104.368	52.184	7.15	0.002
Residual	38	277.202	7.295		
Total	44	384.010			

Variate: Weight at Week 6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
batch stratum	4	27.35	6.84	0.16	
batch.*Units* stratum					
Phenotype	2	1254.93	627.46	14.37	<.001
Residual	38	1659.44	43.67		
Total	44	2941.71			

Variate: Weight Gain at Week 6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
batch stratum	4	7.19	1.80	0.17	
batch.*Units* stratum					
Phenotype	2	330.71	165.36	15.84	<.001

Residual	38	396.59	10.44		
Total	44	734.50			

Variate: Weight at Week 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	154602	38651	0.13	
Sex stratum	1	2408333	2408333	8.38	
Batch.Sex stratum	4	1149137	287284	12.87	
Batch.Sex.*Units* stratum					
Village	2	46734	23367	1.05	0.353
Phenotype	2	607814	303907	13.61	<.001
Village.Phenotype	4	170233	42558	1.91	0.110
Residual	252	5626434	22327		
Total	269	10163287			

Variate: Weight Gain at Week 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	953.3	238.3	0.13	
Sex stratum	1	27200.4	27200.4	14.50	
Batch.Sex stratum	4	7501.5	1875.4	3.29	
Batch.Sex.*Units* stratum					
Village	2	526.7	263.3	0.46	0.631
Phenotype	2	19628.9	9814.4	17.20	<.001
Village.Phenotype	4	4931.1	1232.8	2.16	0.074
Residual	252	143794.8	570.6		
Total	269	204536.7			

Body Measurements

Variate: Body Length (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0000	0.000		
Sex stratum	1	800.8333	800.	8333	

Batch.Sex stratum	4	0.0000	0.0000	0.00	
Batch.Sex.*Units* stratum					
Village	2	3.2667	1.6333	1.74	0.178
Phenotype	2	206.6667	103.3333	109.94	<.001
Village.Phenotype	4	6.5333	1.6333	1.74	0.142
Residual	252	236.8667	0.9399		
Total	269	1254.1667			

Variate: Body Width (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0000	0.0000		
Sex stratum	1	240.8333	240.	8333	
Batch.Sex stratum	4	0.0000	0.0000	0.00	
Batch.Sex.*Units* stratum					
Village	2	1.4000	0.7000	0.89	0.411
Phenotype	2	15.0000	7.5000	9.57	<.001
Village.Phenotype	4	2.8000	0.7000	0.89	0.468
Residual	252	197.4667	0.7836		
Total	269	457.5000			

Variate: Shank Length (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0000	0.0000		
Sex stratum	1	91.8750	91.8750		
Batch.Sex stratum	4	0.0000	0.0000	0.00	
Batch.Sex.*Units* stratum					
Village	2	0.3500	0.1750	0.60	0.548
Phenotype	2	1.2500	0.6250	2.16	0.118
Village.Phenotype	4	0.3500	0.0875	0.30	0.877
Residual	252	73.0500	0.2899		
Total	269	166.8750			

Laying Performance

	d.f.	s.s.	m.s.	v.r.	F pr.

Variate: Age at 1st Egg

Source of variation					
Batch stratum	4	8.400	2.100	0.83	
Batch.*Units* stratum					
Village	2	2.133	1.067	0.42	0.658
Phenotype	2	1114.133	557.067	219.52	<.001
Village.Phenotype	4	39.467	9.867	3.89	0.005
Residual	122	309.600	2.538		
Total	134	1473.733			

Variate: Clutch Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	5.733	1.433	1.12	
Batch.*Units* stratum					
Village	2	13.333	6.667	5.20	0.007
Phenotype	2	243.333	121.667	94.99	<.001
Village.Phenotype	4	1.067	0.267	0.21	0.933
Residual	122	156.267	1.281		
Total	134	419.733			

Variate: Rate of Lay (Hen-housed)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	2.400	0.600	0.26	
Batch.*Units* stratum					
Village	2	4.800	2.400	1.02	0.363
Phenotype	2	1556.800	778.400	331.12	<.001
Village.Phenotype	4	41.600	10.400	4.42	0.002
Residual	122	286.800	2.351		
Total	134	1892.400			

Variate: Rate of Lay (Hen-day)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.400	0.100	0.06	
Batch.*Units* stratum					
Village	2	0.000	0.000	0.00	1.000
Phenotype	2	1213.200	606.600	349.08	<.001

Village.Phenotype	4	28.800	7.200	4.14	0.004
Residual	122	212.000	1.738		
Total	134	1454.400			

Variate: Body Weight to Egg Weight Ratio

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	5.8679	1.4670	3.37	
Batch.*Units* stratum					
Village	2	0.0986	0.0493	0.11	0.893
Phenotype	2	30.8115	15.4057	35.40	<.001
Village.Phenotype	4	2.0027	0.5007	1.15	0.336
Residual	122	53.0887	0.4352		
Total	134	91.8693			

Variate: Egg Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	18.775	4.694	3.40	
Batch.*Units* stratum					
Village	2	13.174	6.587	4.77	0.010
Phenotype	2	938.992	469.496	339.71	<.001
Village.Phenotype	4	0.251	0.063	0.05	0.996
Residual	122	168.610	1.382		
Total	134	1139.803			

Variate: Haugh Unit (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	98.000	24.500	3.54	
Batch.*Units* stratum					
Village	2	104.533	52.267	7.56	<.001
Phenotype	2	1360.533	680.267	98.33	<.001
Village.Phenotype	4	20.267	5.067	0.73	0.572
Residual	122	844.000	6.918		
Total	134	2427.333			

Variate: Shell Thickness (mm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0005333	0.0001333	0.60	
Batch.*Units* stratum					
Village	2	0.0002133	0.0001067	0.48	0.621

Phenotype	2	0.0700933	0.0350467	157.27	<.001
Village.Phenotype	4	0.0001067	0.0000267	0.12	0.975
Residual	122	0.0271867	0.0002228		
Total	134	0.0981333			

Carcass Performance

Variate: Defeatherd , % of I ive W:ight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	9.6052	2.4013	2.43	
Batch.*Units* stratum					
Village	2	3.5354	1.7677	1.79	0.171
Phenotype	2	1310.4112	655.2056	663.61	<.001
Village.Phenotype	4	1.2624	0.3156	0.32	0.864
Residual	122	120.4552	0.9873		
Total	134	1445.2695			

Variate: Dressed (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	63.101	15.775	2.87	
Batch.*Units* stratum					
Village	2	25.725	12.862	2.34	0.100
Phenotype	2	650.137	325.068	59.20	<.001
Village.Phenotype	4	5.034	1.259	0.23	0.922
Residual	122	669.936	5.491		
Total	134	1413.933			

Variate: Breast Muscle (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.8877	0.2219	1.85	
Batch.*Units* stratum					
Village	2	0.3280	0.1640	1.36	0.259
Phenotype	2	536.8357	268.4178	2233.40	<.001
Village.Phenotype	4	0.3334	0.0833	0.69	0.598
Residual	122	14.6624	0.1202		

Total	134	553.0472

Mortality

Variate: Chick Mortality (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
batch stratum	4	0.02667	0.00667	0.42	
batch.*Units* stratum					
Phenotype	2	0.28578	0.14289	9.07	<.001
Residual	38	0.59867	0.01575		
Total	44	0.91111			

Variate: Total Mortality (%

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	4.667	1.167	0.46	
Batch.*Units* stratum					
Village	2	10.015	5.007	1.99	0.141
Phenotype	2	1006.681	503.341	199.81	<.001
Village.Phenotype	4	0.119	0.030	0.01	1.000
Residual	122	307.333	2.519		
Total	134	1328.815			

Experiment Four : Frizzles and Normals Growth Performance Variate: Weight at Week 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sex stratum	1	6954136	6954136	2859.39	
Sex.*Units* stratum					
Village	2	20675	10338	4.25	0.016
Sire_Lines	4	1932781	483195	198.68	<.001
Phenotypes	1	600889	600889	247.07	<.001
Village.Sire_Lines	8	135755	16969	6.98	<.001
Village.Phenotypes	2	4055	2028	0.83	0.436
Sire_Lines.Phenotypes	4	141185	35296	14.51	<.001
Village.Sire_Lines.Phenotypes	8	51492	6436	2.65	0.010
Residual	149	362373	2432		
Total	179	10203341			

Variate: Weight Gain at Week 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sex stratum	1	4500.0	4500.0	30.62	
Sex.*Units* stratum					
Village	2	0.0	0.0	0.00	1.000
Sire_Lines	4	10000.0	2500.0	17.01	<.001
Phenotypes	1	80.0	80.0	0.54	0.462
Village.Sire_Lines	8	3050.0	381.3	2.59	0.011
Village.Phenotypes	2	40.0	20.0	0.14	0.873
Sire_Lines.Phenotypes	4	320.0	80.0	0.54	0.703
Village.Sire_Lines.Phenotypes	8	2110.0	263.7	1.79	0.082
Residual	149	21900.0	147.0		
Total	179	42000.0			

Body Measurements

Variate: Body Length (mm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	787.76	196.94	1.89	
Sex stratum	1	220.03	220.03	2.11	
Batch.Sex stratum	4	417.19	104.30	4.51	
Batch.Sex.*Units* stratum					
Village	2	12.94	6.47	0.28	0.756
Sire_Line	4	90.35	22.59	0.98	0.419
Phenotype	1	8.41	8.41	0.36	0.547
Village.Sire_Line	8	38.04	4.75	0.21	0.990
Village.Phenotype	2	33.95	16.97	0.73	0.480
Sire_Line.Phenotype	4	21.73	5.43	0.23	0.919
Village.Sire_Line.Phenotype	8	94.83	11.85	0.51	0.847
Residual	861	19907.19	23.12		
Total	899	21632.41			

Variate: Body Width (mm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	19.5601	4.8900	0.64	
Sex stratum	1	5.6327	5.6327	0.73	

Batch.Sex stratum	4	30.6558	7.6640	15.78	
Batch.Sex.*Units* stratum					
Village	2	0.6872	0.3436	0.71	0.493
Sire_Line	4	0.7806	0.1951	0.40	0.807
Phenotype	1	0.0196	0.0196	0.04	0.841
Village.Sire_Line	8	3.0441	0.3805	0.78	0.617
Village.Phenotype	2	0.5621	0.2810	0.58	0.561
Sire_Line.Phenotype	4	1.8305	0.4576	0.94	0.439
Village.Sire_Line.Phenotype	8	4.4162	0.5520	1.14	0.336
Residual	861	418.1200	0.4856		
Total	899	485.3089			

Variate: Shank Length (mm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	1.4776	0.3694	0.13	
Sex stratum	1	3.9867	3.9867	1.38	
Batch.Sex stratum	4	11.5638	2.8910	10.71	
Batch.Sex.*Units* stratum					
Village	2	0.2353	0.1176	0.44	0.647
Sire_Line	4	0.3888	0.0972	0.36	0.837
Phenotype	1	0.3640	0.3640	1.35	0.246
Village.Sire_Line	8	2.8538	0.3567	1.32	0.229
Village.Phenotype	2	0.7212	0.3606	1.34	0.263
Sire_Line.Phenotype	4	0.9684	0.2421	0.90	0.465
Village.Sire_Line.Phenotype	8	2.2140	0.2767	1.03	0.415
Residual	861	232.3096	0.2698		
Total	899	257.0831			

Egg Laying Performance

Variate: Age at 1st Egg

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	3.20	0.80	0.04	
Batch.*Units* stratum					
Village	2	13.44	6.72	0.34	0.714
Sire_Line	4	775.80	193.95	9.72	<.001
Phenotype	1	907.38	907.38	45.49	<.001
Village.Sire_Line	8	89.16	11.14	0.56	0.812
Village.Phenotype	2	23.52	11.76	0.59	0.555
Sire_Line.Phenotype	4	88.92	22.23	1.11	0.349
Village.Sire_Line.Phenotype	8	22.68	2.84	0.14	0.997

Residual	416	8298.40	19.95		
Total	449	10222.50			

Variate: Clutch Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	2.72	0.68	0.06	
Batch.*Units* stratum					
Village	2	1.44	0.72	0.06	0.938
Sire_Line	4	51.12	12.78	1.13	0.339
Phenotype	1	273.78	273.78	24.31	<.001
Village.Sire_Line	8	18.96	2.37	0.21	0.989
Village.Phenotype	2	0.48	0.24	0.02	0.979
Sire_Line.Phenotype	4	43.92	10.98	0.98	0.421
Village.Sire_Line.Phenotype	8	7.92	0.99	0.09	1.000
Residual	416	4684.48	11.26		
Total	449	5084.82			

Variate: BodyWeight to Egg Weight Ratio

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	1.95	0.49	0.04	
Batch.*Units* stratum					
Village	2	1.84	0.92	0.08	0.928
Sire_Line	4	384.45	96.11	7.82	<.001
Phenotype	1	596.44	596.44	48.54	<.001
Village.Sire_Line	8	97.49	12.19	0.99	0.442
Village.Phenotype	2	3.89	1.94	0.16	0.854
Sire_Line.Phenotype	4	103.51	25.88	2.11	0.079
Village.Sire_Line.Phenotype	8	9.96	1.24	0.10	0.999
Residual	416	5112.04	12.29		
Total	449	6311.55			

Variate: Rate of Lay (Hen-housed)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	53.37	13.34	0.96	
Batch.*Units* stratum					
Village	2	192.05	96.03	6.87	0.001
Sire_Line	4	423.08	105.77	7.57	<.001
Phenotype	1	1250.00	1250.00	89.47	<.001
Village.Sire_Line	8	117.41	14.68	1.05	0.397
Village.Phenotype	2	0.69	0.35	0.02	0.975
Sire_Line.Phenotype	4	287.40	71.85	5.14	<.001
Village.Sire_Line.Phenotype	8	24.77	3.10	0.22	0.987

Residual	416	5811.70	13.97		
Total	449	8160.48			

Variate: Ratw of Rate (Hen-day)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	48.90	12.23	0.66	
Batch.*Units* stratum					
Village	2	235.85	117.93	6.37	0.002
Sire_Line	4	145.28	36.32	1.96	0.099
Phenotype	1	662.48	662.48	35.79	<.001
Village.Sire_Line	8	97.55	12.19	0.66	0.728
Village.Phenotype	2	28.25	14.13	0.76	0.467
Sire_Line.Phenotype	4	303.52	75.88	4.10	0.003
Village.Sire_Line.Phenotype	8	39.01	4.88	0.26	0.977
Residual	416	7699.23	18.51		
Total	449	9260.08			

Variate: Egg Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	3.52	0.88	0.06	
Batch.*Units* stratum					
Village	2	7.78	3.89	0.26	0.772
Sire_Line	4	1165.04	291.26	19.40	<.001
Phenotype	1	1.55	1.55	0.10	0.748
Village.Sire_Line	8	70.30	8.79	0.59	0.790
Village.Phenotype	2	3.27	1.63	0.11	0.897
Sire_Line.Phenotype	4	53.50	13.37	0.89	0.469
Village.Sire_Line.Phenotype	8	61.24	7.66	0.51	0.849
Residual	416	6246.04	15.01		
Total	449	7612.24			

Egg Quality

Variate: Haugh Unit (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	26.72	6.68	0.15	
Batch.*Units* stratum					
Village	2	63.84	31.92	0.73	0.481
Sire_Line	4	1755.72	438.93	10.10	<.001
Phenotype	1	1067.22	1067.22	24.55	<.001

Village.Sire_Line	8	186.36	23.30	0.54	0.830
Village.Phenotype	2	442.08	221.04	5.08	0.007
Sire_Line.Phenotype	4	458.28	114.57	2.64	0.034
Village.Sire_Line.Phenotype	8	214.92	26.87	0.62	0.763
Residual	416	18086.08	43.48		
Total	449	22301.22			

Variate: Shell Thickness

Source of variation	d.f.(m.v.)	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0000000	0.0000000	0.00	
Batch.*Units* stratum					
Village	2	0.0000000	0.0000000	0.00	1.000
Sire_Line	4	0.0299902	0.0074976	31.32	<.001
Phenotype	1	0.0000000	0.0000000	0.00	1.000
Village.Sire_Line	8	0.0000000	0.0000000	0.00	1.000
Village.Phenotype	2	0.0000000	0.0000000	0.00	1.000
Sire_Line.Phenotype	4	0.0039987	0.0009997	4.18	0.003
Village.Sire_Line.Phenotype	8	0.0000000	0.0000000	0.00	1.000
Residual	386	0.0924000	0.0002394		
Total	419	0.1241333			

Carcass Performance Variate: Defeathered (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.126	0.031	0.02	
Batch.*Units* stratum					
Village	2	0.015	0.008	0.00	0.996
Sire_Line	4	0.752	0.188	0.11	0.978
Phenotype	1	1.378	1.378	0.82	0.366
Village.Sire_Line	8	3.769	0.471	0.28	0.972
Village.Phenotype	2	17.036	8.518	5.06	0.007
Sire_Line.Phenotype	4	2.069	0.517	0.31	0.873
Village.Sire_Line.Phenotype	8	7.556	0.944	0.56	0.810
Residual	416	700.662	1.684		
Total	449	733.361			

Variate: Dressed (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.131	0.033	0.02	

Batch.*Units* stratum					
Village	2	0.064	0.032	0.02	0.981
Sire_Line	4	0.913	0.228	0.14	0.968
Phenotype	1	7.530	7.530	4.55	0.033
Village.Sire_Line	8	14.027	1.753	1.06	0.390
Village.Phenotype	2	13.922	6.961	4.21	0.015
Sire_Line.Phenotype	4	8.033	2.008	1.21	0.304
Village.Sire_Line.Phenotype	8	10.057	1.257	0.76	0.638
Residual	416	687.713	1.653		
Total	449	742.391			

Variate: Breast Muscle (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.04856	0.01214	0.14	
Batch.*Units* stratum					
Village	2	0.03603	0.01801	0.21	0.811
Sire_Line	4	0.42732	0.10683	1.24	0.293
Phenotype	1	0.00454	0.00454	0.05	0.818
Village.Sire_Line	8	1.17514	0.14689	1.70	0.095
Village.Phenotype	2	0.27856	0.13928	1.62	0.200
Sire_Line.Phenotype	4	0.35969	0.08992	1.04	0.384
Village.Sire_Line.Phenotype	8	0.63683	0.07960	0.92	0.497
Residual	416	35.85279	0.08618		
Total	449	38.81946			

Mortality

Variate: Total Mortality (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	4.889	1.222	0.67	
Sex stratum	1	0.004	0.004	0.00	
Batch.Sex stratum	4	7.351	1.838	0.71	
Batch.Sex.*Units* stratum					
Village	2	2.727	1.363	0.53	0.592
Sire_Line	4	2.100	0.525	0.20	0.937
Phenotype	1	25.671	25.671	9.89	0.002
Village.Sire_Line	8	7.307	0.913	0.35	0.945
Village.Phenotype	2	1.069	0.534	0.21	0.814
Sire_Line.Phenotype	4	3.073	0.768	0.30	0.881

Village.Sire_Line.Phenotype	8	15.387	1.923	0.74	0.655
Residual	861	2234.422	2.595		
Total	899	2304.000			

F_2 Frizzles and Normals Growth Performance

Variate: Weight at Day-old

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	3.22	0.80	0.04	
Batch.*Units* stratum					
Phenotype	2	33.34	16.67	0.83	0.443
Residual	38	761.62	20.04		
Total	44	798.18			

Variate: Weight at Week 6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	160.6	40.1	0.19	
Batch.*Units* stratum					
Phenotype	2	1120.1	560.0	2.66	0.083
Residual	38	8015.4	210.9		
Total	44	9296.0			

Variate: Weight Gain at Week 6

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	89.7	22.4	0.15	
Batch.*Units* stratum					
Phenotype	2	590.5	295.2	2.01	0.147
Residual	38	5570.2	146.6		
Total	44	6250.4			

Variate: Weight at Week 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	36.0		9.0	1.00
Sex stratum	1	10632653.0	10632653	1.196	
Batch.Sex stratum	4	36.9.0	0.00		
Batch.Sex.*Units* stratum					
Village	2	63616.0	31808	2.87	0.058
Phenotype	2	23496.0	11748	1.06	0.348
Village.Phenotype	4	57689.0	14422	1.30	0.269
Residual	252	2789622.0	11070		
Total	269	13567147.0			

Variate: Weighty Gain at Week 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	8.9	2.2	1.00	
Sex stratum	1	20280.0	20280.0	9126.00	
Batch.Sex stratum	4	8.9	2.2	0.01	
Batch.Sex.*Units* stratum					
Village	2	15046.7	7523.3	23.74	<.001
Phenotype	2	1182.2	591.1	1.87	0.157
Village.Phenotype	4	1131.1	282.8	0.89	0.469
Residual	252	79862.2	316.9		
Total	269	117520.0			

Body Measurements

Variate: Body Length (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	7.948	1.987	0.64	
Batch.*Units* stratum					
Village	2	22.496	11.248	3.63	0.028
Phenotype	2	47.563	23.781	7.66	<.001
Village.Phenotype	4	2.059	0.515	0.17	0.956
Residual	257	797.419	3.103		
Total	269	877.485			

Variate: Body Width (cm)

	d.f.	s.s.	m.s.	v.r.	F pr.

Source of variation					
Batch stratum	4	0.793	0.198	0.13	
Batch.*Units* stratum					
Village	2	9.119	4.559	3.09	0.047
Phenotype	2	3.052	1.526	1.03	0.357
Village.Phenotype	4	13.304	3.326	2.25	0.064
Residual	257	379.674	1.477		
Total	269	405.941			

Variate: Shank Length (cm)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.3370	0.0843	0.11	
Batch.*Units* stratum					
Village	2	2.3574	1.1787	1.48	0.228
Phenotype	2	2.2741	1.1370	1.43	0.241
Village.Phenotype	4	2.6981	0.6745	0.85	0.495
Residual	257	204.0246	0.7939		
Total	269	211.6913			

Laying Performance

Variate: Age at 1st Egg

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	11.07	2.77	0.06	
Batch.*Units* stratum					
Village	2	26.13	13.07	0.29	0.752
Phenotype	2	323.73	161.87	3.54	0.032
Village.Phenotype	4	29.87	7.47	0.16	0.956
Residual	122	5570.93	45.66		
Total	134	5961.73			

Variate: Clutch Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	5.067	1.267	0.65	

Batch.*Units* stratum					
Village	2	6.933	3.467	1.77	0.174
Phenotype	2	92.133	46.067	23.56	<.001
Village.Phenotype	4	1.067	0.267	0.14	0.969
Residual	122	238.533	1.955		
Total	134	343.733			

Variate: BodyWeight to Egg We1i ;ht Ratio

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	7.156	1.789	1.29	
Batch.*Units* stratum					
Village	2	12.428	6.214	4.49	0.013
Phenotype	2	8.116	4.058	2.93	0.057
Village.Phenotype	4	10.059	2.515	1.82	0.130
Residual	122	168.784	1.383		
Total	134	206.544			

Variate: Hen-housed Rate of Lay

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	1.60	0.40	0.01	
Batch.*Units* stratum					
Village	2	3.73	1.87	0.05	0.947
Phenotype	2	442.53	221.27	6.43	0.002
Village.Phenotype	4	15.47	3.87	0.11	0.978
Residual	122	4195.60	34.39		
Total	134	4658.93			

Variate: Rate of Lay (Hen-Day)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	13.60	3.40	0.22	
Batch.*Units* stratum					
Village	2	19.73	9.87	0.63	0.534
Phenotype	2	323.73	161.87	10.35	<.001
Village.Phenotype	4	7.47	1.87	0.12	0.975
Residual	122	1908.40	15.64		
Total	134	2272.93			

Variate: Egg Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	6.917	1.729	0.21	
Batch.*Units* stratum					
Village	2	11.941	5.970	0.72	0.490
Phenotype	2	48.940	24.470	2.94	0.057
Village.Phenotype	4	2.330	0.582	0.07	0.991
Residual	122	1015.445	8.323		
Total	134	1085.572			

Variate: Haugh Unit

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	37.07	9.27	0.32	
Batch.*Units* stratum					
Village	2	70.93	35.47	1.22	0.299
Phenotype	2	178.53	89.27	3.07	0.050
Village.Phenotype	4	36.27	9.07	0.31	0.870
Residual	122	3548.93	29.09		
Total	134	3871.73			

Variate: Shell Thickness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0005067	0.0001267	0.94	
Batch.*Units* stratum					
Village	2	0.0011200	0.0005600	4.16	0.018
Phenotype	2	0.0163600	0.0081800	60.80	<.001
Village.Phenotype	4	0.0006400	0.0001600	1.19	0.319
Residual	122	0.0164133	0.0001345		
Total	134	0.0350400			

Carcass Performance

Variate: Defeathered (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.00	0.00	0.00	
Batch.*Units* stratum					
Village	2	0.88	0.44	0.01	0.989
Phenotype	2	104.78	52.39	1.36	0.261

Village.Phenotype	4	2.54	0.63	0.02	0.999
Residual	122	4707.64	38.59		
Total	134	4815.83			

Variate: Dressed (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.000	0.000	0.00	
Batch.*Units* stratum					
Village	2	0.718	0.359	0.05	0.951
Phenotype	2	13.466	56.733	7.96	<.001
Village.Phenotype	4	11.839	2.960	0.42	0.797
Residual	122	869.476	7.127		
Total	134	995.499			

Variate: Breast Muscle (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.000	0.000	0.00	
Batch.*Units* stratum					
Village	2	9.891	4.946	1.29	0.280
Phenotype	2	5.895	2.948	0.77	0.467
Village.Phenotype	4	6.369	.592	0.41	0.798
Residual	122	469.057	3.845		
Total	134	491.212			

Mortality

Variate: Chick Mortality (ɔ)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0636	0.0159	0.15	
Batch.*Units* stratum					
Phenotype	2	0.1524	0.0762	0.72	0.496
Residual	38	4.0498	0.1066		
Total	44	4.2658			

Variate:Total Mortality (%

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

Batch stratum	4	4.000	1.000	0.39	
Batch.*Units* stratum					
Village	2	6.933	3.467	1.36	0.260
Phenotype	2	154.533	77.267	30.33	<.001
Village.Phenotype	4	1.067	0.267	0.10	0.981
Residual	122	310.800	2.548		
Total	134	477.333			

EXPERIMENT FIVE: Naked necks, Frizzles and Normals

Growth Performance Variate: Body Weight at Week 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	6.760	1.690	1.00	
Sex stratum	1	5.654	5.654	3.346	
Batch.Sex stratum	4	6.760	1.690	0.02	
Batch.Sex.*Units* stratum					
Village	2	3.133	1.566	21.53	<.001
Mgt_Sytm	2	1.363	6.817	9368.39	<.001
Phenotype	4	4.745	1.186	1630.41	<.001
Village.Mgt_Sytm	4	1.958	4.896	6.73	<.001
Village.Phenotype	8	1.627	2.034	2.80	0.005
Mgt_Sytm.Phenotype	8	9.907	1.238	17.02	<.001
Village.Mgt_Sytm.Phenotype	16	1.822	1.139	1.56	0.071
Residual	1296	9.430	7.276		
Total	1349	2.516			

Variate: Weight Gain at Week 20

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	4.0	1.0	1.00	
Sex stratum	1	105616	1.2	1056161.2	1.056
Batch.Sex stratum	4	4.0	1.0	0.01	
Batch.Sex.*Units* stratum Village					
	2	13875.7	6937.9	35.92	<.001
Mgt_Sytm	2	435819.7	21790	9.9 1128.21	<.001
Phenotype	4	418682.5	10467	0.6 541.92	<.001
Village.Mgt_Sytm	4	2359.4	589.9	3.05	0.016
Village.Phenotype	8	2585.0	323.1	1.67	0.100

Mgt_Sytm.Phenotype	8	23001.0	2875.1	14.89	<.001
Village.Mgt_Sytm.Phenotype	16	2242.1	140.1	0.73	0.770
Residual	1296	250317.5	193.1		
Total	1349	2205052.1			

Egg Laying Performance

Variate: Age at 1st Egg

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	711.89	177.97	1.94	
Batch.*Units* stratum					
Village	2	61.75	30.87	0.34	0.715
Mgt_Sytm	2	2360.73	1180.37	12.85	<.001
Phenotype	4	271.25	67.81	0.74	0.566
Village.Mgt_Sytm	4	3139.28	784.82	8.55	<.001
Village.Phenotype	8	112.91	14.11	0.15	0.996
Mgt_Sytm.Phenotype	8	328.72	41.09	0.45	0.892
Village.Mgt_Sytm.Phenotype	16	651.76	40.74	0.44	0.971
Residual	626	57490.38	91.84		
Total	674	65128.66			

Variate: Clutch Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.053	0.013	0.00	
Batch.*Units* stratum					
Village	2	34.901	17.450	1.79	0.168
Mgt_Sytm	2	4065.301	2032.650	208.62	<.001
Phenotype	4	1197.090	299.273	30.72	<.001
Village.Mgt_Sytm	4	17.988	4.497	0.46	0.764
Village.Phenotype	8	5.914	0.739	0.08	1.000
Mgt_Sytm.Phenotype	8	90.981	11.373	1.17	0.317
Village.Mgt_Sytm.Phenotype	16	15.108	0.944	0.10	1.000
Residual	626	6099.280	9.743		
Total	674	11526.616			

Variate: Clutch Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

Batch stratum	4	0.053	0.013	0.00	
Batch.*Units* stratum					
Village	2	34.901	17.450	1.79	0.168
Mgt_Sytm	2	4065.301	2032.650	208.62	<.001
Phenotype	4	1197.090	299.273	30.72	<.001
Village.Mgt_Sytm	4	17.988	4.497	0.46	0.764
Village.Phenotype	8	5.914	0.739	0.08	1.000
Mgt_Sytm.Phenotype	8	90.981	11.373	1.17	0.317
Village.Mgt_Sytm.Phenotype	16	15.108	0.944	0.10	1.000
Residual	626	6099.280	9.743		
Total	674	11526.616			

Variate: Body Weight to Egg Weight Ratio

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.000	0.000	0.00	
Batch.*Units* stratum					
Village	2	0.000	0.000	0.00	1.000
Mgt_Sytm	2	63.845	31.923	16.85	<.001
Phenotype	4	111.879	27.970	14.76	<.001
Village.Mgt_Sytm	4	266.623	66.656	35.17	<.001
Village.Phenotype	8	0.000	0.000	0.00	1.000
Mgt_Sytm.Phenotype	8	34.570	4.321	2.28	0.021
Village.Mgt_Sytm.Phenotype	16	60.939	3.809	2.01	0.011
Residual	626	1186.276	1.895		
Total	674	1724.132			

Variate: Egg Size

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.77	0.19	0.01	
Batch.*Units* stratum					
Village	2	5.59	2.80	0.20	0.815
Mgt_Sytm	2	3591.19	1795.60	131.07	<.001
Phenotype	4	3620.67	905.17	66.07	<.001
Village.Mgt_Sytm	4	55.70	13.92	1.02	0.398
Village.Phenotype	8	16.54	2.07	0.15	0.997
Mgt_Sytm.Phenotype	8	40.73	5.09	0.37	0.936
Village.Mgt_Sytm.Phenotype	16	53.00	3.31	0.24	0.999
Residual	626	8575.95	13.70		
Total	674	15960.15			

Variate: Rate of Lay (Hen-housed)

Batch stratum	4	0.213	0.053	0.01	
Batch.*Units* stratum					
Village	2	0.320	0.160	0.03	0.974
Mgt_Sytm	2	553.040	276.520	45.35	<.001
Phenotype	4	2831.280	707.820	116.09	<.001
Village.Mgt_Sytm	4	3.200	0.800	0.13	0.971
Village.Phenotype	8	10.880	1.360	0.22	0.987
Mgt_Sytm.Phenotype	8	203.360	25.420	4.17	<.001
Village.Mgt_Sytm.Phenotype	16	108.800	6.800	1.12	0.336
Residual	626	3816.987	6.097		
Total	674	7528.080			

Source of variation	**d.f.**	**s.s.**	**m.s.**	**v.r.**	**F pr.**
Batch stratum	4	0.05	0.01	0.00	
Batch.*Units* stratum					
Village	2	67.23	33.61	2.54	0.080
Mgt_Sytm	2	3226.03	1613.01	121.96	<.001
Phenotype	4	5292.19	1323.05	100.04	<.001
Village.Mgt_Sytm	4	68.13	17.03	1.29	0.273
Village.Phenotype	8	56.77	7.10	0.54	0.829

Mgt_Sytm.Phenotype	8	231.97	29.00	2.19	0.026
Village.Mgt_Sytm.Phenotype	16	62.67	3.92	0.30	0.997
Residual	626	8279.15	13.23		
Total	674	17284.19			

Variate: Rate of Lay (Hen-Day)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	1.33	0.33	0.01	
Batch.*Units* stratum					
Village	2	180.56	90.28	3.12	0.045
Mgt_Sytm	2	4328.00	2164.00	74.81	<.001
Phenotype	4	6609.33	1652.33	57.12	<.001
Village.Mgt_Sytm	4	144.56	36.14	1.25	0.289
Village.Phenotype	8	32.51	4.06	0.14	0.997
Mgt_Sytm.Phenotype	8	270.67	33.83	1.17	0.315
Village.Mgt_Sytm.Phenotype	16	155.97	9.75	0.34	0.993
Residual	626	18107.07	28.93		
Total	674	29830.00			

Egg Quality Performance

Variate: Haugh Unit (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

Variate: Shell Thickness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.0000213	0.0000053	0.03	
Batch.*Units* stratum					
Village	2	0.0000107	0.0000053	0.03	0.974
Mgt_Sytm	2	0.0008107	0.0004053	2.02	0.134
Phenotype	4	0.4006213	0.1001553	498.00	<.001
Village.Mgt_Sytm	4	0.0010853	0.0002713	1.35	0.250
Village.Phenotype	8	0.0002027	0.0000253	0.13	0.998
Mgt_Sytm.Phenotype	8	0.0154027	0.0019253	9.57	<.001
Village.Mgt_Sytm.Phenotype	16	0.0106613	0.0006663	3.31	<.001
Residual	626	0.1258987	0.0002011		
Total	674	0.5547147			

Carcass Performance Variate: Defeathered Weight (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	2.2303	0.5576	2.14	

Batch.*Units* stratum					
Village	2	8.9101	4.4550	17.07	<.001
Mgt_Sytm	2	447.6137	223.8069	857.39	<.001
Phenotype	4	5220.6104	1305.1526	4999.94	<.001
Village.Mgt_Sytm	4	3.1985	0.7996	3.06	0.016
Village.Phenotype	8	4.0089	0.5011	1.92	0.055
Mgt_Sytm.Phenotype	8	157.9996	19.7499	75.66	<.001
Village.Mgt_Sytm.Phenotype	16	9.0596	0.5662	2.17	0.005
Residual	626	163.4069	0.2610		
Total	674	6017.0380			

Variate: Dressed Weight (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	16.820	4.205	1.70	
Batch.*Units* stratum					
Village	2	27.868	13.934	5.63	0.004
Mgt_Sytm	2	3624.516	1812.258	731.64	<.001
Phenotype	4	13548.710	3387.178	1367.46	<.001
Village.Mgt_Sytm	4	15.437	3.859	1.56	0.184
Village.Phenotype	8	13.035	1.629	0.66	0.729
Mgt_Sytm.Phenotype	8	394.988	49.373	19.93	<.001
Village.Mgt_Sytm.Phenotype	16	27.997	1.750	0.71	0.789
Residual	626	1550.596	2.477		
Total	674	19219.968			

Variate: Breast Muscle (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.1636	0.0409	0.10	
Batch.*Units* stratum					
Village	2	0.1636	0.0818	0.19	0.824
Mgt_Sytm	2	1.1107	0.5554	1.32	0.269
Phenotype	4	3164.7708	791.1927	1874.01	<.001
Village.Mgt_Sytm	4	6.8710	1.7177	4.07	0.003
Village.Phenotype	8	0.1344	0.0168	0.04	1.000
Mgt_Sytm.Phenotype	8	1.5010	0.1876	0.44	0.894
Village.Mgt_Sytm.Phenotype	16	3.1104	0.1944	0.46	0.965
Residual	626	264.2925	0.4222		
Total	674	3442.1180			

Variate: Intestines (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.3943	0.0986	0.77	
Batch.*Units* stratum					
Village	2	0.3943	0.1971	1.55	0.214
Mgt_Sytm	2	6.4351	3.2176	25.22	<.001
Phenotype	4	2.7325	0.6831	5.36	<.001
Village.Mgt_Sytm	4	8.4580	2.1145	16.58	<.001
Village.Phenotype	8	0.0954	0.0119	0.09	0.999
Mgt_Sytm.Phenotype	8	2.8369	0.3546	2.78	0.005
Village.Mgt_Sytm.Phenotype	16	3.6828	0.2302	1.80	0.027
Residual	626	79.8531	0.1276		
Total	674	104.8824			

Variate: Gizzard (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.20995	0.05249	0.64	
Batch.*Units* stratum					
Village	2	0.20995	0.10498	1.28	0.279
Mgt_Sytm	2	3.66438	1.83219	22.36	<.001
Phenotype	4	86.09107	21.52277	262.62	<.001
Village.Mgt_Sytm	4	4.60989	1.15247	14.06	<.001
Village.Phenotype	8	0.03389	0.00424	0.05	1.000
Mgt_Sytm.Phenotype	8	4.41954	0.55244	6.74	<.001
Village.Mgt_Sytm.Phenotype	16	3.01071	0.18817	2.30	0.003
Residual	626	51.30353	0.08195		
Total	674	153.55291			

Variate: Heart (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.10703	0.02676	1.32	
Batch.*Units* stratum					
Village	2	0.10703	0.05352	2.64	0.072
Mgt_Sytm	2	6.38221	3.19111	157.38	<.001
Phenotype	4	18.87745	4.71936	232.75	<.001
Village.Mgt_Sytm	4	5.17895	1.29474	63.85	<.001
Village.Phenotype	8	0.02555	0.00319	0.16	0.996
Mgt_Sytm.Phenotype	8	0.34074	0.04259	2.10	0.034
Village.Mgt_Sytm.Phenotype	16	0.32246	0.02015	0.99	0.461

Residual	626	12.69326	0.02028
Total	674	44.03467	

Variate: Liver Weight (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.61383	0.15346	4.50	
Batch.*Units* stratum					
Village	2	0.61383	0.30692	9.00	<.001
Mgt_Sytm	2	4.14497	2.07249	60.80	<.001
Phenotype	4	18.69661	4.67415	137.14	<.001
Village.Mgt_Sytm	4	8.61338	2.15335	63.18	<.001
Village.Phenotype	8	0.01037	0.00130	0.04	1.000
Mgt_Sytm.Phenotype	8	0.07474	0.00934	0.27	0.974
Village.Mgt_Sytm.Phenotype	16	0.14844	0.00928	0.27	0.998
Residual	626	21.33677	0.03408		
Total	674	54.25294			

Mortality

Variate: Mortality

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Batch stratum	4	0.000	0.000	0.00	
Batch.*Units* stratum					
Village	2	248.687	124.343	22.82	<.001
Mgt_Sytm	2	3552.667	1776.333	326.02	<.001
Phenotype	4	4172.000	1043.000	191.43	<.001
Village.Mgt_Sytm	4	405.673	101.418	18.61	<.001
Village.Phenotype	8	85.680	10.710	1.97	0.048
Mgt_Sytm.Phenotype	8	1224.000	153.000	28.08	<.001
Village.Mgt_Sytm.Phenotype	16	174.160	10.885	2.00	0.012
Residual	626	3410.800	5.449		
Total	674	13273.667			

APPENDIX 3

Table 3.1 : The Climatic Conditions of the KNUST Experimental Station During the Study Period

Month/Year	Rainfall (mm)	Temperature (ºC)				Relative Humidity (%)	
		9.00am		3.00pm		9.00am	3.00pm
		Min.	Max.	Min.	Max.		
05/06	143.9	22.0	32.2	24.9	29.3	84	64
06/06	113.0	21.6	31.4	24.9	30.1	82	64
07/06	68.5	20.8	30.3	24.1	28.4	86	69
08/06	75.8	20.5	29.2	23.6	27.9	86	69
09/06	96.8	29.1	30.1	24.5	28.8	88	69
10/06	177.9	21.7	31.5	25.1	30.4	85	64
11/06	60.2	21.8	32.3	24.2	31.6	82	53
12/06	5.4	21.4	32.7	23.6	31.7	82	47
01/07	8.5	16.5	34.0	21.6	33.0	60	34
02/07	65.3	22.4	34.5	24.9	33.4	83	49
03/07	76.7	22.6	35.2	25.1	33.6	89	49
04/07	189.9	22.5	34.0	25.9	32.4	83	58
05/07	84.3	22.2	32.9	25.7	31.5	83	65
06/07	244.2	22.0	31.6	25.0	30.1	85	65
07/07	374.0	21.9	29.7	24.0	27.9	86	72
08/07	127.3	22.0	29.0	23.1	26.0	86	72
09/07	539.8	22.8	30.2	24.3	28.5	90	71
10/07	237.6	22.5	30.9	24.7	29.4	86	67
11/07	48.6	22.8	31.4	25.1	30.7	83	62
12/07	21.9	22.5	32.1	23.7	31.4	83	51

Source: Department of Meteorological Services (2008)