QUALITATIVE MUTANT GENES WITHIN THE LOCAL CHICKEN POPULATION IN GHANA: THEIR INFLUENCE ON GROWTH PERFORMANCE AND EGG PRODUCTION

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHYLOSOPHY DEGREE IN ANIMAL BREEDING AND GENETICS

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BY

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Philosophy(MPhil) 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

A cross sectional survey was carried out to find out the qualitative mutant traits within the indigenous chicken population and their influence on egg and growth performance in the three ecological zones of Ghana. Four hundred and five (405) households were randomly selected across the Guinea Savannah, Semi-deciduous Rain Forest and Coastal Savannah. Structured questionnaires and on-site interviews were used to obtain information from the local chicken keepers. The individual birds were phenotypically observed for the presence of the following phenotypes; frizzle (F), naked neck (Na), silkiness (h), polydactyl (Po), ptilopody (Pti), crest feathered (Cr) and flightless (Fl). Data on flightless chicken were not available except their gene frequencies since the respondents do not keep them for economic purposes. The frequency of the genes responsible for mutant traits were obtained from a count of the proportion of recessive in the population using the Hardy-Weinberg equation. The calculated gene frequencies for the mutant traits were low with naked neck (0.04), frizzle (0.04), crest (0.05), silky (0.02), polydactyl (0.01), ptilopody (0.01) and flightless (0.01) which differed significantly ($P<0.05$) from the expected Mendelian values of 0.75 making these phenotypes prone to extinction. Average clutch size per year, number of eggs set for natural incubation and number of chicks hatched were not significantly different ($p>0.05$) between the three ecological zones. The percentage hatchability for Guinea Savannah and Coastal Savannah were relatively higher ($p<0.05$) compared to Semi-deciduous Rain Forest. Polydactyl phenotypes had better ($p<0.05$) average eggs per clutch per bird, number of eggs set for natural incubation and number of chicks hatched compared with their normal counterparts. Results obtained from mutant traits and zone interaction indicate that, silky and polydactyl birds had superior ($p<0.05$) performance in percentage hatchability within Guinea Savannah and Coastal Savannah than Semi-deciduous Rain Forest. Again, body weight and linear body measurements of the individual birds were measured using weighing scale (kg) and tape measure (cm) respectively. The average body weight for both cocks and hens in Semi-deciduous Rain Forest were significantly higher ($p<0.05$) compared to those in Guinea Savannah and Coastal Savannah zones. The average body length and toe length for adult male chickens were 46.82cm and 5.61cm respectively for Semi-deciduous Rain Forest which were significantly ($p<0.05$) longer than those of Guinea Savannah and Coastal Savannah birds. Polydactyl and ptilopody cocks recorded a longer shank length ($p<0.05$) compared to their recessive counterparts. Again, ptilopody cocks were superior ($p<0.05$) to all the mutant traits in terms of body weight, shank length, body length, wing length, keel length and toe length except body girth which recorded shorter length ($p>0.05$) as compared to their respective counterparts. The correlation coefficients for polydactyl and ptilopody male phenotypes between live body weight and keel length, wing length were positive and significant ($p<0.05$). The highest and positive ($p<0.01$) correlation were recorded between live body weight and body girth (0.978) as well as live body weight and body length (0.905) in polydactyl male phenotypes. There were positive and highly significant differences ($p<0.01$) between live body weight and other traits measured (shank length, body length, wing length, body girth, keel length and toe length) in naked neck phenotypes. The correlation between body weight and body length (0.813) in male silky phenotypes were positive ($p<0.01$). Correlation analysis indicated that, live body weight could best be determined by shank length, body length, body girth and keel length. The results obtained from the study showed that, naked neck, frizzle, silky, crest, ptilopody, polydactyl and flightless mutant traits were present within the local chicken population. The gene frequency for these mutant traits were very low but they had unique potential in egg laying. Therefore the live body weight and other linear body parts can be improved by enhancing village chicken management systems.

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DEDICATION

I dedicate this work to my lovely wife Mrs. Eunice Mensah and to my wards Nana Darko Mensah and Kira Nora Nimoh Mensah for their love, care, patience, encouragement and financial support throughout my academic studies.

May the good Lord unite us according to His Divine purpose. Amen.

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CHAPTER ONE

1.0 INTRODUCTION

Poultry production in Ghana has a large component of village poultry including indigenous chickens kept in a broad framework by all family units in the rural areas. Indigenous chickens raised in rural areas account for 60 to 80 percent of the aggregate poultry populace in the nation (Gyening, 2006). According to Spradbrow (1993), village chickens are by and large indigenous birds living in a close relationship with human societies. These local fowls are present across the African mainland where they are found in all agro ecological regions, extending from villages in the moist and sub-humid tropical downpour timberland of West and Central Africa to the temperate uplands of East Africa and the arid and semi-arid areas of the Sahel and Kalahari deserts (DAGRIS, 2007).

These indigenous birds play essential socio-cultural and economic roles in Ghanaian households. Naazie and Karbo (2002) reported that local chickens do not only provide for the protein requirement of the family on occasions but also act as the ‗poor man‘s bank‘ and animals for sacrifices, festivities and gifts. In spite of their low productivity, farmers living in the rural areas still keep these native birds because they form an essential part of the way of life of the rural farmers. The local chicken lines remain prominent in African villages, in spite of the introduction of breeds of chicken with high-yielding abilities since 1920 as reported by Bourzat and Sounders (1990). Van Veluw (1987) stated that the principal role of the indigenous birds from the farmer‘s point of view in Ghana is to provide meat and eggs for home use. FAO

(1997) reported that local fowl meat and eggs are the staple eating regimens of rural settlers because of the high nutrient content such as protein, calcium, iron, vitamins and energy.

A study done by Horst (1989), recognized the local chicken populace as valuable gene pools, especially of those qualities that have adaptive standards in tropical climatic conditions. Gowe and Fairfull (1995) observed that one of the most obvious constraints to poultry industry in the tropics is the harsh weather conditions. They stated that high ambient temperature, especially when combined with high relative humidity causes serious stress in chickens leading to reduced performance. Indigenous chickens exhibit varieties in feather assembly, feather scattering, feather length, feather arrangement and number of plumages which allow them adapt to various ecological areas. FAO (1998) also reported seven mutant genes that are common among local birds in the tropics and are potentially useful within hot and humid environment. These genes are naked neck (Na), dwarf (dw), slow feathering (K), frizzle (F), silky (h), fayoumi (Fa), and fibromelanosis (Fm). A research conducted by Naazie *et al*., (2007) revealed the existence of the following thermoregulatory genes among

the indigenous birds in Ghana; naked neck, frizzle, silky, crest feathered, and dwarfism and other genes like polydactyl, ptilopody and rose comb. Horst (1988) described the genetic material base of the local chicken in the tropics as rich and ought to form the basis for genetic enhancement and modification to produce a breed that can adjust to tropical conditions.

Various scholars have cited the economic benefits of these mutant genes in modern system of breeding due to their high adaptability to the tropical climatic conditions, average reproductive performance and high disease resistance. Horst (1988) backed the introduction of the naked-neck gene into the local chicken population in the tropics for higher productive adaptability. Ibe (1993) also noted that, naked neck and frizzle genes are connected with earlier sexual maturity in a tropical environment. Moreover, Rauen *et al*., (1986) observed that, the reduced feather coverage of naked neck birds helps them to receive more solar radiations which may encourage more vitamin D synthesis and hence better egg shell quality. They further stated that, feathering concentration and feather structure of these birds increase heat loss, and so indirectly increases feed consumption and yield, which may lead to an improved productive adaptability of laying hens under humid-tropical conditions. Horst (1988) made a submission that frizzle trait is a feather structure trait that causes a decrease in tropical heat stress by enhancing the birds ability for convection which results in improved feed conversion and enhanced performance. Furthermore, Shoffner *et al.*, (1993) showed that polydactyl (five toes) and ptilopody (feathered shank) birds have better body weight and good egg production.

Therefore, many researchers have expressed the need to exploit and conserve these useful mutant genes found within the local chicken population which are becoming endangered species. Information on population size and monitoring of birds possessing these mutant genes within the local chicken population in Ghana is limited. It is important to develop a comprehensive conservation scheme for mutant genetic resources which are mostly thermoregulatory in nature, in the face of climatic uncertainties on our planet especially in the tropics. This would help to maintain mutant chicken diversity in line with the diversity of climatic conditions and social usage of birds carrying these mutant genes.

The main objective of the study was to find out the various mutant genes present in the indigenous chicken population and their influence on growth performance, linear body measurements and egg production.

The specific objectives include;

1. To identify local chickens with mutant genotypes and determine their genetic frequencies within the study area.
2. To compare the egg production performance of the mutant birds with that of their normal feathered counterparts.
3. To evaluate body weight and linear body measurements of birds carrying the mutant genes and those of their normal feathered counterparts.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin of local chickens

Evidence about the source and spread of chicken claims that chickens were initially domesticated in the areas of Indus Basin (Mohenjo-Daro and Harappa**)** and then brought to Mesopotamia and Greece, hence the Celts obtained and spread them all over Europe and lastly to Britain in the late Iron Age (Darwin, 1868; Wood-Gush 1959). Domestic chickens are closely related with human beings, and they depend entirely on humans for their distribution and indirectly for their existence (Mwacharo *et al.,* 2013). According to Cahaner *et al.*, (2008), domestication of birds is believed to have begun in Asia and there is affirmation of domesticated birds in China that goes back to 3000 BC. The local chickens' family line can be traced back to four types of wild jungle fowl from Southeast Asia. However, the Red jungle fowl (*Gallus gallus)* is the most commonly discovered wild species on the planet today and is viewed as the primary ancestor of the domestic chicken.

Domestic chickens are named *Gallus domesticus* and belong to the genus *Gallus* with the family *Phasianidae*. Kitalyi (1997) reported that the entry of European pioneers as a major aspect of the advancement of the terrestrial and sea empires of a many European countries across Africa and Asia from the fifteenth century AD onwards gave further chances to the landing and development of chickens inside Africa. The birds were initially kept for religious and cultural purposes, for example cock fighting was one of the major recreations for America and Europe. However, during that period the game of cockfighting had a colossal impact in the domestication of the chicken as well as on the dissemination of chickens all through the world. Kitalyi (1997) stated that, from the second half of the twentieth century, the African landmass, like other parts of the world, had seen the entry of exotic chicken breeds developed for higher productivity by crossbreeding with local fowls to improve meat and egg production. The arrival of local chickens in the African continent has introduced a noteworthy point of reference in agriculture history and reformed the way of life of most African societies (Mwacharo *et al.*, 2013).

2.2 Local chicken production in Africa

The production of poultry in Africa takes after the position of other emerging countries in Asia as reported by Aini (1990). MacDonald and Edwards (1993) reported that domestication of local chickens in Africa is believed to have been introduced from Europe during the time of colonization, leading to extensive mixing of local chicken population. The indigenous chicken lines remain important in African villages, in spite of the presentation of exotic high-yielding chicken breeds in the 1920's (Bourzat and Sounders, 1990). However, poultry production in Africa is tilted towards chicken production as reported by Branckaert and Gueye (1999).

However the local chickens in Africa showed a wide phenotypic differences in feathers, eye, skin, shank, earlobe, comb, feather distribution and body size. Again, these birds are hardy, high degree of disease resistance and excellent feed conversion rate. The local chickens discover their food via searching round the houses in the village. Again the older birds and the young chicks mostly scavenge together. Very often the local chickens feed on kitchen waste and harvest leftovers. These birds are occasionally vaccinated against diseases. Moreover, local chickens are rarely provided with nests which give way for the birds to lay their eggs on the floor, bushes and outside the houses. The local hens normally go on broody and care for their own chicks (Riise *et al.*, 2004).

Gondwe (2004) stated that chicken production in Africa is divided into two segments, the commercial (high input and high yield) segment and rural (village) area. He further stated that the commercial sector focuses on intensive production of meat and eggs. They use high yielding strains raised and supplied by international breeding organizations. The village poultry sector is synonymously called conventional, rural, scavenger, family, local or extensive poultry production as reported by Gondwe (2004). However, Horst (1988) described the genetic material based of the local chicken in the tropical areas as rich and must form the premise for genetic enhancement and modification to produce a strain adjusted to warmth conditions.

Almost 80 percent of chicken populations in Africa, as in Asia (Aini, 1990) are predominantly local strain raised under free range system. Meanwhile these chickens are kept with very low land, labour and capital inputs, even the poorest social strata of the rural population keep them (Gueye, 1998). Village poultry enterprise is mostly known as a sidelined area among smallholder keepers. Women and children are normally, guardians of these local chickens as reported by Badubi *et al.*, (2006).

2.3 Systems of managing indigenous birds in Ghana

The type of management system adopted by poultry farmers in Ghana depends on the objective of the farmer, land availability, purpose of the enterprise either as an income supplement or full employment. There are three main systems of local poultry keeping, they are: extensive, intensive and semi-intensive (Bessei, 1987).

2.3.1 Extensive system

This is a system where birds are allowed to move freely in search of food over a large area which is either fenced or not. There are two types of extensive system; free range and backyard**.**

2.3.1.1 Free range system

This is a type of extensive system where fowls are housed at night but are allowed to move about freely on large fenced grassland during the day. This system of production is a combined form of the farming framework with little input and low output. Managing of indigenous chickens under free range system is normally centered on available indigenous technical knowledge. This is where the birds make use of household waste those with low quality and convert it into high protein diet. The local chickens are allowed to search for food amid the day time and normally assembled around evening time into a basic housing for safeguard against predators. Deeb *et al.*, (2002) reported that excess heat and cold can have a negative impact on the animals and their productivity.

King'ori (2004) observed that the local chickens normally search for insects, food waste, green grass, leafy vegetables and any dispersed grains. This system of production mostly include mixed type of species such as ducks, turkeys and chickens. Chickens of all ages are allowed to move together to search for food. The birds are usually fed with supplementary diet early in the morning and evening. Sometimes a handful of their supplementary feed include maize, millet, sorghum, cassava meal, cereal bran, broken wheat, blood meal brewers grain fish meal, ripe pawpaw seeds and amaranth's seed.(Ahmed,1990; Moreki *et al*., 2010). Some farmers use the free range poultry droppings to benefit crops. According to _Compassion in World Farming‘ (2011) free range system enables the birds to exhibit some natural behaviours, for example exercise outdoors, pecking, scratching and green foraging.

2.3.1.2 Backyard system

This is the system where chickens are mostly housed inside a fenced yard around evening time but permitted unfenced scavenging during the day. This system is mostly practice in peri-urban centers and not common as compared to free range system. Poultry keepers are challenged to provide enough good feedstuffs for the birds. The birds are normally fed a modest bunch of grains in the morning and night to supplement scavenging. Control of disease normally depends on the area of the homestead. For instance, in the urban areas, the chicken keepers seek for veterinary medication from skilled work force. However, in the rural areas control of disease is not seriously engaged (Busuulwa, 2009).

2.3.2 Semi-intensive system

The semi-intensive system is a mixture of the intensive and extensive systems where chickens are housed to a certain area with right of entry to shelter (Bessei, 1987). This farming system is practiced in urban and peri-urban regions because of the increase interest for poultry eggs and meat (Busuulwa, 2009). Ikani and Annatte (2000) explained that these local chickens are allowed to move freely outside the houses which are usually opened in the morning from 6:00 to 6:30am and closed only in the evening from 5:30 to 6:30pm when the birds returned to roost for the night. Indigenous and crossbreds chicken farmers use this scheme where their flock size range from fifty to thousand birds (Sonaiya, 1990; Kitalyi, 1998) on average with the intention to produce eggs and meat for the business sector. In this system, the farmers practice veterinary and other management systems. Some of them consist of proper disease control, quality food, good housing as well as adequate supply of water. Aini (1999) reported that chickens under this system are fed with formulated diets either purchaseds commercially or made from feed mills.

2.3.3 Intensive system

This system of farming involves complete confinement of birds either in cages or houses. The birds are confined at a high density per unit area. According to the report made by Kitalyi, (1998) , 30% of the total chicken population is reared under the intensive system of production in sub-Saharan Africa. Poultry keepers under this system strictly use national approved medications for instance, antibiotics in feed or drinking water in order to treat disease as well as prevention of disease outbreak. This system is more capital intensive in which rural poultry farmers cannot afford to manage them to meet the standard. There are two types of the intensive system; battery cage system and the deep litter system.

2.3.3.1 Battery cage system

Under this system, 3-5 birds are confined in a cage which is large enough to permit very limited movement of each bird and to allow them to sit and stand comfortably. The cages are usually 450mm deep and 450mm high in front, sloping to 350mm high at the back. The total floor space per bird is about $0.06m^2$. The feeding system may be automatic or manually-operated. Advantages that can be derived from battery cage system comprise easier care for the chickens, floor eggs which are costly to gather are removed, clean eggs are obtained, capture at the end of lay is expedited, normally less feed intake is essential to produce eggs, broodiness is removed, more hens may be housed in a given house floor space, worms are simply treated, and labour requirements are usually reduced. Poultry farmers using battery cage for egg production benefit from more birds per unit area which allows for greater productivity and lower food costs. Animal wellbeing scientists have been critical of battery cage system since the system do not provide hens with enough floor space to stand, walk, flap their wings, perch, or make a nest, and it is widely considered that hens suffer through boredom and frustration through being unable to perform these behaviours as reported by Appleby *et al*., (2004). Hence, this can result in unusual behaviours, some of which are very injurious to the hens or their cage mates.

2.3.3.2 Deep litter system

It is also called the floor confinement system. Here the birds are confined in a large house with a concrete floor covered with litter materials like wood shavings, rice husks, saw dust or chaff. The floor space is 3 to 4 birds/m^2.The litter is usually kept to a depth of 15-20cm. The success of the system depends on efficient management of the litter to ensure that suitable micro-organisms multiply and break down the droppings. This system is based on specialized breeds. The house protects the birds from predators such as hawks, snakes, and thieves. Some houses are furnished with curtain walls, which can be rolled up in good weather to admit natural light and fresh air. Feeding troughs and water troughs are hung well above the litter level at about 45.7cm high. Laying nests are placed at the east end of a deep-litter pen. This system is widely used for commercial poultry which is probably the fastest-developing sector of animal industry in the tropics (Youdeowei *et al.*, 1988)

2.4 Breeding systems in local chicken production

Mukiibi-Muka *et al.*, (2003) reported that, exchange trade, gifts and market places were the fundamental source of indigenous chicken breeding stock. Unplanned random mating is practiced in chickens inside herds and between herds that scavenge together. A study done by Ahlers (1997) stated that farmers normally exchange breeding stock with different keepers in traditional stock sharing systems and this goes with preference for specific phenotypes. Gondwe *et al.*, (1999) demonstrated that sharing breeding stock is more frequently between individuals inside the village than between individuals outside village family units. Gueye (1998) stated that on village chicken flocks, cocks are normally removed from flocks at an early age for sale, home consumption or for social purposes. Keeping hens for long reproductive periods may demonstrate their preference for reproduction (Solkner *et al.*, 1998). The brooding character in indigenous birds is being misused through synchronized incubating when a few females are allowed to hatch around the same time to have a realistic number of new born chicks. Annor-Frempong and Ashley (2002), observed that the brooding activity and rearing of chicks by the local hen increases the length of the reproductive cycle. Hence, most hens produce chicks around four to five periods every year, and just four times if the raising time frame is reached out to two months. However, there is little control over reproduction since these hens brood their own chicks for persistent recovery of the stock.

2.5 Productivity of indigenous chickens

Indigenous chicken productivity in general is known to be low under the free range system (Gueye, 1998). Kitalyi (1998) reported that the profitability of village chicken is determined by the relationship between the biomass of the birds populace and the scavengable feed source base. Indigenous chickens are genetically poor producers of chicken meat and eggs (Busuulwa, 2009). The local chickens take long to achieve sexual development (7 months), with a little mature carcass weight and produce few eggs for each year. Adult hens lay around 2-4 clutches per year, each of around 10-12 eggs (Byarugaba *et al*., 2002). Ikani and Annatte 2000). According to Mukhergee (1990) local chickens in developing countries are generally small in body size, late maturity (up to 36 weeks of age) and have low clutch size per year (25-45 annually). Ikani and Annatte (2000) stated that the level of fertile egg production by local hen is in the range of 20-30 eggs per year i.e. a mean clutch size of 8-9 eggs and 2.5clutches per year. The hens produce small clutch size (2-10 eggs), have long stops between laying of clutches and a common inclination to broodiness. These local chickens have hatchability of 87 percent and wean 6.3 chicks on average after 2.8 months. (Busuulwa, 2009). Their eggs have high breaking strength, high yolk percentage and low cholesterol content (Mukhergee, 1990). A study conducted by Sonaiya *et al.*, (1999) revealed that the yearly egg production per hen ranges from 20 to 100 eggs with normal egg weight ranging from around 34 - 52g.

The adult cocks and hens weighed 2.1kg and 1.4kg (Busuulwa, 2009) and 1.2-3.2kg and 0.7-2.1kg respectively (Gueye, 2000). Sonaiya *et al.*, (1999) found body weights of 1.2kg and 0.8kg were achieved at 32 weeks for usual body size and dwarf breeds of indigenous chickens under extensive system respectively. Kitalyi (1998) conducted a research and found out that the indigenous chicken breeds in Ethiopia reached sexual maturity between 166 to 230days with hatchability and fertility values ranging from 39-44 and 53 – 60 percent respectively. FAO (2000) considered 80% hatchability as normal from natural incubation of local chicken, but a range of 75-80% is satisfactory. Ikani and Annatte (2000) reported 80% hatchability of local chickens which is more comparable with the performance of improved birds. Besides, mortality rate is very high (40-60%) which normally occurred immediately around hatching. Despite the poor reproductive performance reported by Aini (1990), they are good sitters and hatch their individual eggs and brood the chicks. Again they are excellent forages, hardy, resistant to various indigenous chicken diseases and multi-purpose use under the unfenced production framework. Kitalyi (1998) described the indigenous chickens as healthy and are well adjusted to severe climatic conditions, for example rain, periodic feed shortages and hot or cold weather.

2.6 Importance of keeping local chickens

Local chickens provide man with food, fiber and companionship in the form of eggs, meat and feathers. Adomako *et al.*, (2010) stated that rearing of local chickens improve level of animal protein in the diet of people living in the rural areas through the consumption of surplus eggs and chicken meat. However, local chickens have played an important role in the nutrition and protein supply especially pregnant women, babies and children. Native birds also play an essential role as a food reserve for the households, they serve as an important source of protein while other sources of natural food are declining, such as wild birds, rats, fish, mushrooms, wild vegetables etc.

According to Udomsieng *et al.*, (1985) local chickens can also generate supplementary cash income or be used in exchange with other kinds of goods that are necessary for living. Adomako *et al.*, (2009) supported the idea that rural poultry production serve as a reliable source of petty cash for the farmers‘ family. Naazie *et al*, (2002) reported that local birds do not only provide for the protein requirement of the family on occasions but also act as the _poor man's bank' and animals for sacrifices, festivities and gifts. Ekue *et al.*, (2002) re-counted that the primary aim of indigenous fowls among farmers in Cameroun were to sell for income and for home consumption. Again, in Southern Senegal as reported by Missohou *et al.*, (2002) chicken keepers consumed their chickens within their household level and just few of them sold their chickens for income. Local chicken production seeks to be considered as a sign of family wealth among villages. According to Ikani and Annatte (2000) local chickens are less prone to local poultry diseases than the more delicate hybrid birds. Furthermore, indigenous birds are well adapted to local climate and harsh ecological conditions and make good use of garbage than hybrid chickens which make them suitable for extensive system of poultry keeping.

2.7 Poultry Health and Disease control

Infections are often described based on their biology, for example bacteria, virus, parasites, fungi and their causes for example dietary issue. The main constraint in smallholding poultry production in developing nations in general is the presence of different diseases (Ojok, 1993). Riise *et al.*, (2004) stated that the significance of a disease is judged by the rate of death and its impact on production, and normally differ from location to location and from season to season. Dankwa *et al.*, (2000) identified the following health problems facing Ghanaian village poultry production. These include Newcastle disease, Marek's disease, worm infestation, fowl pox, fowl typhoid, and ecto-parasites. The most regularly perceived infection is the Newcastle disease, which has been positioned the most essential as it destroys a greater number of birds. (Dankwa e*t al.*, 2000, Mukiibi-Muka, 1992). Many researchers in different African countries, for example, Benin (Chrysostome *et al.*, 1995), Burkina Faso (Bourzat and

Sounders, 1990), and Mauritania (Bell, Kane and Ie Jean, 1990b) as well as United Republic of Tanzania (Yongolo, 1996) affirmed the contention that Newcastle disease is the most devastating disease of the village fowls.

2.7.1 Common diseases among local chickens

Riise *et al.,* (2004) identified the following poultry diseases which remarkably affect the immune system of local fowls in Africa; Newcastle disease, fowl pox, fowl cholera, marek‘s disease, fowl typhoid, chronic respiratory disease, coccidiosis, and internal parasites (roundworm and tapeworm). Solomon (2003) also reported that local chickens kept under confinement are normally associated with diseases for example coccidiosis, chronic respiratory disease, marek‘s disease and *Salmonella pullorum* as well as nutritious inadequacies. This could bring about more difficult problems in indigenous birds than in exotics stock

2.7.1.1 Newcastle disease

The disease is extremely common during dry seasons, and is frequently found in grower chicks and adults chickens. Death rate is very high, normally somewhere around 30% and 80% of the fowls‘ die, when the infection hits. Permin and Pederson (2002) reported that Newcastle disease alone may kill about 80% of household poultry in the African and Asian countries and is one main cause of low output and low annual off-take in free range birds. Chaheuf (1990) also reported Newcastle infection as the most destroying infection of local fowls in Africa. The outbreak of Newcastle disease is a recurring disease which occurs during the harmattan season (Adomako *et al.*, 2010, Blackie, 2014). However, Dankwa *et al.,* (2000) described Newcastle disease as a contributing factor for decreasing the population of the rural poultry flock yearly leaving small numbers to start building up the population again. Foster *et al.*, (1997) observed that the major factors that discourage peasant farmers from investing much of their time and resources in expanding chicken flock size in Tanzania is due to the outbreak of Newcastle disease. Moreover, Yakubu (2010) recorded 74.4% of the Newcastle disease been the most important and prevalent disease at Nasarawa Agricultural zones of Nigeria.

The affected birds drop desire for food and have poor absorption. They may experience difficulty in breathing, greenish droppings, and occasionally bloody diarrhoea. They may display nervous symptoms, paralysis and die quickly. Chabeuf (1990) and Olabode *et al.*, (1992) described the mode of transmission of Newcastle disease in village chickens as follows; exposure of birds to common habitat comprising wild fauna, flocks of various ages and vulnerable day old chicks and connection through either exchange of live fowls and products or movement between family units and towns. The Newcastle is a viral disease; hence incurable. However it may be prevented through vaccination of all fowls including chicks from two weeks of age. Wilson (2010) reported that inoculation against Newcastle disease would greatly increase indigenous chicken‘s survival rate.

2.7.1.2 Fowl pox

This is frequently found in grower chicks, but also in adults, and appears as pocks (small lumps) on wattles, comb, and face. High body temperature, tiredness followed by sudden death. The disease may be found all year around but common during dry seasons. It is a viral disease and cannot be treated (Riise *et al.*, 2004). The virus can stay active in the pox scabs (which have tumbled off the chickens) for up to ten years, which taint the environment. Again other parasitic insects can spread the virus. Fowl pox infection is one of the major disease in many African countries (Sonaiya and Swan, 2004). Vaccines are available for the treatment of the disease and it is highly effective.

2.7.1.3 Marek's disease

Infection of the disease happens ahead of schedule in life of the bird, and once a bird is infected, it can shed the virus in skin flakes for the duration of its life, in the event that it survives (Sonaiya and Swan, 2004). The disease is seen only in birds older than 16 weeks. At the initial stage of infection, the birds may exhibit paralysis of one or both wings or one or both legs might be paralysed. The infection is caused by a virus and cannot be treated, but commercial vaccines are available for prevention. (Riise *et al.*, 2004).

2.7.1.4 Fowl cholera (Avian Pasteurellosis)

This type of disease is caused by Pasteurella multocida and it is a contagious septicaemia that influences all periods of fowls. It is for the most part transmitted by wild fowls or other local birds. According to Riise *et al.*, (2004) infection normally occurs through contaminated feed and drinking water as well as nasal releases from contaminated birds. The brooding time frame is four to nine days, yet intense flareups can happen inside two days of contamination. At times, local chickens die within a couple hours of displaying the initial symptoms, which change depending on the type of the disease. In the respiratory forms, signs such as wheezing, coughing as well as sniffling are seen but in the septicaemic form loose bowels with wet grey, yellow, or green droppings are seen. In the localized form, warning sign like faltering and swelling of legs or wing joints occur. In extreme conditions, the colour of the head and comb changes to dull red or purple. On the off chance that the contamination is restricted in the area of the ears, a twisted neck can usually be observed. In chronic cases, the comb is normally pale, with swellings around the eyes and a release from the beak or nostril. Fowl Cholera is basic all over the place, because they consist of different strains and are in continuous contact with wild fowls (Sonaiya and Swan, 2004). There is no treatment when it occurs. Riise *et al.*, (2004) reported that proper sanitation and regular vaccination could be the best way to prevent the spread of the disease.

2.7.1.5 Fowl typhoid

According to Sonaiya and Swan (2004) *Salmonella gallinarum,* is the main cause of fowl typhoid and usually affects older birds. When it happens in grower chickens, the symptoms are similar to that of *S. pullorum.* The incubation time frame is four to five days, and after two days the birds become depressed and anorexic. The comb and wattles colour changes to dull red; the droppings become yellowish and the chicken closes their eyes and hold their heads down. Normally the influenced fowl die in three to six days. In free range system of poultry keeping Pullorum and fowl typhoid complex are common. Symptoms include high body temperature, tiredness, blue comb and sudden death. The best prevention methods are enforcing strict hygiene, separation of sick birds from the healthy birds, chicks should not be purchased from unfamiliar source, and eggs from hens that are infected with the disease should not be used for hatching (Riise *et al.*, 2004).

2.7.1.6 Chronic respiratory disease (Mycoplasmosis)

Mycoplasmas diseases are considered as Pleuro-pneumonia-cocci-like organisms (PPLO). These are basically connected with Chronic Respiratory Disease (CRD), a difficult disorder brought about by *Mycoplasma gallisepticum* in connection with microscopic organisms (normally E. coli), fungi and viruses (particularly Infectious Bronchitis). *M. gallisepticum* can be spread through the egg. Keeping different ages of flocks, dietary insufficiency and water restriction are essential elements in the study of disease transmission of the infection in rural poultry flocks (Sonaiya and Swan, 2004). Symptoms include blocked nose, swollen face, closed eyes, drop in egg production as well as rare deaths. The disease can be treated by adding antibiotics in drinking water for the birds (Riise *et al.*, 2004).

2.7.1.7 Coccidiosis (internal parasites)

The coccidiosis diseases are caused by protozoa species *Eimeria tenella* and *E. necatrix*. Coccidiosis is a typical internal parasitic contamination in free range birds. The diseases normally affect new birds. The most common significant signs are emaciation, tiredness, head down, unsettled plumes, bloody diarrhoea, thirst, birds huddling together. However, the disease can be forestalled by consistent and careful cleaning of the feeding and water troughs as well as poultry houses. Keeping different age groups of fowls in the same pen may spread the disease from older fowls to younger chicks. At village level, the major sources of disease transmission among the local chickens are contacts between flocks of different households, exchange of birds as gifts or even entrusting sales and purchase (Kitaly, 1998; Tadelle *et al.*, 2003a; Mapiye and Sibanda, 2005). A survey conducted by Eissa (1987) shows that 73% and 47% of local fowls in Southeast Asia and East Africa respectively, had positive faecal specimens of *Eimeria spp* which demonstrates the existence of the disease.

2.7.1.8 Roundworms and tapeworms (internal parasites)

Internal parasites are very common in all ages in the free range system of keeping poultry at villages. Ssenyonga (1982) noticed that worms were the most important causes of low egg turn out for free range chickens in Uganda and the most frequently found being *Ascaridia galli* (Round Worm), *Heterakis gallinae* (Caecal Worm), *Syngamus trachae* (Tracheal Worm) and *Raillientina spp*. (Tape Worm). The following signs are noticed on birds infected with these parasites; poor health, loss in weight, drop in egg production, and bloody diarrhoea. The best treatment is adding anthelmintics in the drinking water on more than one occasion yearly, at best two weeks before vaccination against ND. Proper sanitation may prevent heavy infection as reported by Riise *et al*., (2004).

2.8 Socio-cultural uses of local chickens

Indigenous chicken products have important role in our rural communities in terms of social and spiritual benefits. In village level, local chickens are used for ceremonies, sacrifices, gifts and as savings in the village. Sonaiya *et al*., (1998) observed that local fowls are offered or received to show or to accept good friendship and to show appreciation for a favour or help. Gueye (1998) reported that local chickens can be used as a medium of exchange in villages where circulation of money does not exist. For instance, in Gambia five adult hens can be exchange for one sheep and 25 hens for one head of cattle. Again, in Ghana a silky cock or hen can be used as an offer to replace sheep to most of the lesser gods or goddess. Furthermore, a cock with spotless white plumage in Uganda as reported by Hans (2012) is utilized as an offer to *mukasa-lord of waters*. Besides, eggs from local chickens play a significant role in most of our traditions, for example some fetish priests request for local eggs to clean or reverse a curse from an individual or a whole community.

2.9 Consumption of local chickens

According to FAO (1997) chicken meat and eggs are considered to be a stable diet of rural areas due to the higher nutrient concentration such as protein, calcium, iron, vitamins and energy. Ikani and Annatte (2000) observed that the meat of local chickens are portable, easily prepared and low in fat. Moreover, Kolawole (2010) reported that the meat of local chickens are said to be more palatable than the meat of exotic broilers breed. A research work done by Ssewanyana *et al.*, (2003b) on usages of indigenous chicken by rural communities demonstrated that 36% are consume at household bases, 33% are sold for money, 16% are used for ceremonies, 13% are given as gift and 2% are used for different reasons. A survey made by van Veluw (1987) stated that the primary aim of the indigenous birds from the farmers' point of view is the provision of meat and eggs for household utilization. Kyarisiima *et al.*, (2004) considered the consumption of local chicken meat and eggs as only source of animal protein for the resource-poor family units. They are a good source of protein for the sick and malnourished in rural zones. In many urban centers the local chicken's meat is preferred to that of commercial broilers because it has better texture and stronger flavor. Hence, this is reflected in the price of the local chicken which is double that of the industrial broiler (Ikani and Annatte, 2000).

2.10 Effect of the environment on local poultry in Africa

The effect of environmental conditions on animal production is well noted. Most environmental conditions in tropics are less favorable for animal production compared with temperate zones. Gowe and Fairfull (1995) reported that the most observable limitations to poultry production in the tropics is the climate. They stated that high ambient temperature especially when coupled with high relative humidity cause severe stress in birds leading to reduced performance. These environmental conditions include the climate (example; air temperature, humidity, air movement, rainfall and light), as well as soil quality and water resources. Chantalakhana and Skunmun (2002) suggested that the major factor that significantly inhibits efficient animal production in tropics is high ambient temperature, both directly and indirectly. Poultry genetic disposition cannot be utilized fully if there is an environmental constraint. Barua and Howlider (1990) reported that the unfavorable environmental conditions do not permit the expression of the full genetic potential of the exotic breeds. Improvement in production and its efficiency generally depends on the quality of environmental management. Heat stress has a marked effect on behaviour, food and water consumption, blood composition, cardio-respiratory behaviour, heat production and body temperature of poultry.

When a bird is exposed to heat, regulatory mechanisms are involved both in specific and non-specific actions. The specific actions dealing with homeostasis include heat loss and cardio-respiratory adjustments. Non-specific actions are dependent on integrative capacities of the nervous and endocrine system. Stability of body temperature is an important factor in production efficiency. The chicken is comfortable when the ambient temperature is in the thermo neutral zone (18^0C to 36^0C), the effects of heat stress include decrease in voluntary feed intake, growth rate, feed efficiency, and metabolizable energy intake, lower egg production including degradation of egg shell quality; increased breathing rate (panting); increased susceptibility to disease and finally death. When there is an increase in heat stress, the blood electrolyte balance is altered, blood potassium can be depressed and immune functions of the birds can also be affected.

2.10.1 Impact of heat stress on productivity of local chickens

Chickens maintain a constant body temperature over a wide range of ambient temperature. In birds, heat loss is restricted by feathering and by absence of sweat gland. Cahaner *at al.*, (2008) stated that, the ability of an animal to maintain its body temperature within the normal range depends on a balanced between internally produced heat and the rate of heat dissipation. A study done by Barbut (1997) shows that hot conditions negatively affect the yield and quality of broiler meat which mostly result to pale, soft, and exudative meat. Deeb and Cahaner (1999) also reported negative effect of high temperature on feather coverage of a broiler chicken. However, heat dissipation in broiler chicken is hindered due to insulation provided by the feather coverage and this insulation is greatly advantageous in slow growing chickens. Cahaner *et al.*, (1994) suggested the introduction of reduced feather coverage into the genetic constitution of fast growing broiler. The author again stated that reduced feather mass also contribute to increased meat yield if the saved protein goes into building more muscles.

2.11 Qualitative mutant genes within the local chicken population of Ghana

Mutations involved changes in the structure of DNA and hence the information coded in the DNA sequences. Mutations of a given trait can be classified into three groups according to Tixier-Boichard (2002); loss of function, dominant negative mutation and gain of function mutation. Loss of function mutation is characterized by a complete absence of the gene product or the production of a totally inactive product. This particular mutation works normally in a recessive manner, since the heterozygous carrier of the normal allele retains its function, and may even be recorded at a higher level than in the normal homozygous. Dominant negative gene action occurs when the gene product of the mutated allele is only partially active and may interfere with the normal gene product. Gain of function is where a new function can be obtained with the production of an abnormal protein either the expression occurs at an unusual age or in an aberrant location. These type of gene mutations normally occurred in a dominant way and may exhibit severe phenotypic effects.

Local chicken population exhibit variations in many observable forms including feather structure, feather distribution and feather length which enable them to adapt to the various environmental conditions. The following qualitative mutant trait are found to be common among the indigenous chicken population. These mutations include; physical mutations (five-toe, multiple spurs), feather mutations (frizzle, silkie, shank feathers, crest feathers, naked neck, nakedness, vulture hocks, muff/beard, slow feathering, rumples, long tail-non-moulting,), size mutations (bantams gens, sexlinked dwarfing), leg colour (sex-linked white/yellow) and eye colour (sex-linked brown) and ear lobe colour (white, red). According to Ndegwa *et al.*, (1998) a large population of indigenous birds carrying genes for frizzling, naked neck, silkiness, crest feathering and slow feathering have been associated with heat dissipation. FAO (1998) reported seven mutant genes commonly found within the local chicken population in tropics which are potentially useful in hot environment. These include: naked neck (Na), dwarf (dw), slow feathering (K), frizzle (F), silky (h), fayounmi (Fa) and fibromelanosis (Fm). However, Pisenti *et al* (1999) also identified some mutant developmental deficiencies within the local chicken population which include ptilopody (feathered shank) and polydactyl which tends to have many advantages in terms of body weight and egg performance (Shoffner *et al.*, 1993; Horst, 1988). Furthermore, Horst (1987), reported nine mutant traits of the local fowls that can be used in genetic advancement programmes. Mathur and Horst (1988) reported a rise in egg performance through integrating naked neck (Na) genes in a crossbreeding programme of indigenous Fayoumi (Fm).

2.11.1 Naked neck gene

The naked neck birds have been around for quite a while. The naked neck gene was first studied by Davenport in 1914 and the symbol (Na) for the gene was assigned by Hortwig in 1933 (Somes, 1990). The gene that causes the neck to be naked and a general reduction of the feather tracts had been isolated by poultry Geneticist F.B.Hutt in 1949. This gene was designated ‗Na' as a dominant gene, and a single dose will cause the offspring to display the bare neck and a reduction in feathers. It is a single autosomal dominant gene. The gene expresses incomplete dominance with the heterozygotes (Na/na^+) showing an isolated tuft of feathers on the ventral side of the neck above the crop and the homozygote (Na/Na) birds either lack this tuft or it is reduced to just a few pinfeathers. The resulting bare skin becomes reddish, especially in males as they approach sexual maturity (Somes, 1990).

The comb of the naked neck is single, of medium size with five well defined points and red in colour as its wattle and ear lobes. The colour of the eye is reddish brown with beak, shanks and toes being yellow in the lighter colours and slate blue in the darker colour varieties. The feather cover reduction is less in heterozygote than the homozygote that is 27% for Na/na^+ females and 22% for Na/na^+ males respectively. Again 41% and 33% for the Na/Na females and males respectively for the homozygote.

The feathers follicles are absent from the head and neck except around the comb, the anterior spinal tract and two small patches on each side above the crop.

The naked neck bird distinctive feather is caused by a mutation in its DNA.

The gene which controls the naked neck trait is located near the middle of chromosome 3. The gene is expressed in chicken neck because the embryonic neck skin of birds produces more retinoic acid (a derivative of vitamin A) which enhances a substance called BMP12 (Bone Morphogenetic Protein) which has the ability to induce bone formation and cartilage. Naked necks are thermo-resistant and have resistance to some diseases. Mathur (2003) observed that the naked neck gene was more suitable for the tropical climatic conditions and their superiority was greater with increasing heat stress.

2.11.1.1 The effects of naked neck gene on productivity

The naked neck hens are good layers of medium to large light brown eggs. They are good mothers when they go on broody. According to Horst (1988), the naked neck gene should be introduced into the local birds in the tropics for higher productive adaptability. Due to the naked neck chicken alertness and fighting characteristics, they appear to be able to defend themselves and their chicks from being preyed on. The naked neck birds are known for its fast growth and good foraging abilities due to their seeking habit scratching for food regardless of hot or cold weather. They are very hardy, and resistance to diseases. The naked neck trait has also been shown to increase breast size and to reduce heat stress in tropical conditions.

In tropical climates, lower body temperatures, better feed conversion rates and increased weight gain are associated with the Na gene. Barrio *et al.*, (1991) reported that naked neck birds are superior to normal feathered birds for growth, feed efficiency, carcass trait, viability, immunocompetence, blood biochemical parameters and mortality. 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 chicks weight as compared to their normal feathered counter parts. According to Adomako (2009) the naked neck layers recorded significantly higher ($p<0.05$) values for egg weight, egg number for each clutch and egg number per bird per year than those of the frizzle and the normal feathered layers. The result indicated that, the naked neck birds might have had a better ability to thrive well under adverse environmental, poor housing, bad management and poor nutritional conditions.

2.11.2 Frizzle gene

The frizzle (F) is an autosomal, incompletely dominant gene. Frizzling appearance can be identified in chicks three to four days after hatching (Galal and Fathi, 2001). There is a modifying gene (mf) which is recessive as described by Hutt 1949. The mf gene when homozygous (two dose) is a strong modifier of the frizzle trait. Birds with one dose of the frizzle gene (F/f^+) and two doses of the modifying gene (mf/mf) may appear predominantly smooth, and may be mistaken for non-frizzle. Frizzle birds homozygous for both F and mf (F/F, mf/mf) may be mistaken for heterozygous F/f^+ (one dose of frizzle gene) with no modifiers (mf+/mf+). The frizzle gene is localized in the feather follicle which causes feather structure abnormality. The frizzle gene which controls the frizzling is located on chromosome 6 (Hagan, 2010). The shafts of the contour feathers are curved instead of being straight. The feathers are more delicate and the barbs eventually wear off the remiges of the outer primaries, leaving the birds unable to fly.

The degree of the frizzling is so pronounced in the homozygous (FF) that the feathers break very simply, and the birds soon lose most of their feathers (Stevens, 1991). In the heterozygous (Ff) state, the feathers have less distinct curling and are sturdier.

According to Horst (1988), the frizzle gene is a feather structure gene that causes a reduction in tropical heat stress by improving the birds ability for convection which result in improved feed conversion and better performance (Merate, 1990). Many researches has reported that, the basal metabolism of frizzle chicken is higher which leads to an increase in thyroid and adrenal gland hormones production (Benedict *et al.*, 1932, Boas and Landauer, 1933). They again found an increased feed intake, oxygen consumption, heart rate, and volume of circulating blood. As a result of this, frizzled birds are expected to have enlargement of the heart, spleen, gizzard and alimentary canal.

2.11.2.1 The effects of frizzle gene on productivity

The effect of frizzle gene on meat and eggs has been shown to be favorable by an increase in egg number and egg mass, alongside a reduction in mortality under hot conditions (Horst, 1987). Haaren-kiso *et al.,* (1988) performed an experiment by introducing frizzle gene into a multi- purpose brown egg layer sire line by repeated backcrossing for seven generations. Thus crossing heterozygous males and high yielding female line under two temperatures (18-20^{0}C and 32^{0}C). It was realized that the birds with frizzle gene raised under hot environment (32^{0}C) laid 24 eggs over 364 days laying period but the frizzle birds raised in the cooler environment laid only 3 eggs on average. They further stated that frizzle genes had greater influenced on egg weight, feed utilization and sustainability under the hot conditions (32^{0}C). Haunshi *et al.*, (2002) worked on the effect of the naked neck and frizzle genes on immunocompetence in chickens and reported that there were significantly higher haemolytic complement levels in serum observed for the frizzle feathered birds than their normally feathered sibs. Mahrous *et al.*, (2008) observed significantly higher carbon clearance index (lower carbon particles in their blood circulation) compared to their normally feathered counterparts. Nwachukwu *et al.,* (2006) also observed that the birds with the frizzle gene outperformed their sibs which were either naked neck or normally feathered in body weights and most of the egg traits evaluated thus indicating that the frizzle gene may be advantageous in poultry production in the humid tropics. Adomako (2009) reported higher hatchability values of frizzle birds than eggs from naked neck birds as a result of the modification of their plumage structure (curled feathers). He further stated that hatchability under natural incubation is influenced to a large extent by the hens' ability to cover all the eggs-set. The frizzle feathers extend outward and away from the body and therefore as the hens sit on the eggs, the protruding feathers give better cover to a larger number of eggs and thereby a higher percentage of the eggs hatch successfully.

2.11.3 Silky gene

The silky chicken (*Gallus gallus var. domesticus*) is a small unique breed of poultry aptly named for its fluffy plumage, which is said to feel like silk. These birds are well known for their calm and friendly temperament. Silky- feather chickens were originated in India and later established in China and Japan (Roberts, 1997). The silky bird was first mentioned by Marco Polo in his Asian travelogues in 1298 as chickens with hair like cats that lay the best of eggs (Haw, 2006). Silky gene (h) is an autosomal recessive gene which causes the barbs of the feathers to be highly modified given the silky and a woolly appearance. Silky chickens are mostly white and black coloured feathers along with several other colours. Phenotypically, Silky birds are easily identified among other chicken breed population. Silky feather is located on chromosome-3. These birds are known for their nutritive and medicinal value (Li *et al.*, 2003). Toyosaki and Koketsu (2004) noticed that, the eggs and meat of white Silky chicken are well known for their high amount of unsaturated fatty acids, vitamins, calcium and potassium compared to other breeds of chicken. Silky chicken meat has been credited with health promoting benefits in terms of its medicinal value. It is known to have very low fat, more collagen, vitamin A, iron and DHA. The weight ratio of egg yolk to whole egg weight of Silky chicken is significantly larger than that of egg yolk of layer egg as reported by Rowshan (2013). Again, the amount of cholesterol of Silky chicken egg is significantly ($P < 0.01$) less than that of other hen egg. The amount of vitamins (B2, B6, D and E), calcium and potassium in Silky chicken eggs are significantly higher than those of hen eggs. Unsaturated fatty acids in Silky chicken eggs are 62.5% among total fatty acids, where the unsaturated fatty acids of other hen eggs are 53.9%. Specifically, the contents of arachidonic acid, docosapentaenoic acid and docosahexaenoic acid in Silky chicken eggs are significantly higher than that of 24 layer eggs (Rowshan, 2013).

The silky hens are excellent brooders and are able to make good mothers. According to Ekarius (2007) the silky feathered birds are used to incubate and raise the offspring of other chickens and waterfowls like ducks, and geese, and game birds such as quail and pheasants. The hybrid strain can lay 120 eggs in an ideal year and reaches slaughter weight at 12 weeks of age. The males and females weigh 1.8kg and 1.36kg respectively (Graham, 2006). The sexual maturity for males and females is about five months. In an ideal period, Silky fowls can produce 40-50 eggs per year (Rowshan, 2013). Nirasawa *et al.*, (1997) reported that the rate of egg production is very low for silky chicken because of its strong low broodiness, and broodiness is a phylogenic trait control by some numbers of autosomal genes.

2.11.4 Crest feathered gene

A feather crested head is a prominent feature exhibited by several wild fowl species as well as varieties of several domesticated birds (Bartels, 2003). In chicken, crest (Cr) is an autosomal incompletely dominant gene that causes a tuft of elongated feathers to sprout from the head, with homozygous individuals often exhibiting a more developed crest than heterozygotes. Homozygosity for crest has been associated with cerebral hernia that causes a malformation of the cranium (Frahm and Rehkamper, 1998).

2.11.5 Polydactyl gene (five toed chicken)

Polydactyly in chicken is where the fifth toe develops on top of the first toe and is longer than the first toe. William Bateson one of the founders of classical genetics from 1861–1926 gave a description of polydactylism in birds including chickens developing five and even six toes (Bateson, 1894). Polydactyl gene is a complex gene influenced by modifier and suppressor genes. According to Crawford (1990) polydactyl genes are autosomal genes (Po) and the basic mode of its inheritance is incomplete dominance. The initial study on complex genetic nature of the polydactyl chicken conditions reported by Huang *et al.,* (2006) have lately been supplemented with molecular studies showing involvement of more than one gene in the polydactyl manifestation. A study conducted by Arisawa *et al.,* (2006) found expression of the sonic hedgehog homolog (Drosophila) (*SHH*), bone morphogenetic protein 2 (*BMP2*), and homeobox protein hoxd13 (*HOXD13*) genes in the presumptive region of the extra digit in the leg buds, and expression of *SHH* and *HOXD13* in the presumptive area of the extra digit in the developing wing bud of Japanese Silky embryos. Landauer (1948) noticed that, the five-toed trait expression in chickens is also influence by environmental factors. Columella (1977) described chickens with five toes as one of the most fertile and prolific birds, hence do not have transverse spurs sticking out from their legs

2.11.6 Ptilopody (feathered shank)

Ptilopody is an autosomal dominant mutation been controlled by two different genes. They are not allelic but they belong to different loci of the chromosome. When both genes are present, heavy feathering appeared but if only one is present the feathering is weak. Hutt (1949) phenotypically described shank feathering as a condition in which the hock, the tarso-metatasus, and the outer toe of the chicken is feathered. According to report made by Ikeobi *et al.*, (1997) chickens with feathered feet had better meat characters as compared with their recessive counterparts which had significantly higher egg production and hatchability advantage. They further stated that the additional feathers appearing on the shank hinder the effort of the birds to release excess body heat, thereby adversely affecting survival, adaptation and general performance of the birds.

2.11.7 Dwarfism gene

Dwarfism in chicken is an inherited trait found in chickens consisting of a significant delayed growth, resulting in adult individuals with a distinctive small body size as compared with normal chickens of the same breed. The birds with dwarfism gene do not show any signs at the first week of age. Dwarf chickens can be identified at 8-10 weeks of age, but classification is more precise when the chicks are five months old or more (Hutt, 1949). Poultry breeders use short shanks and small body size to separate dwarf birds from normal counterparts (Leenstra and Pit, 1984). Dwarfism in chickens has been found to be controlled by multiple alleles. The two types of dwarf genes are autosomal dwarf (adw) which is accompanied either by semilethality (cp) or by a poor hatchability (adw) or by very poor viability and hatchability (Cole, 1966) and sexlinked dwarf gene (dw) which are located on the sex chromosome.

The position of the locus dw was determined by Hutt's 1959 and 1960. This mutation reduces body weight in hens by 26 to 32%, but the impact is still greater in homozygous cocks by about 42 to 43%. The dwarf gene reduces body size with lower maintenance requirements and more adjusted to harsh tropical environment is now well recognized in the poultry industry. Islam (2004) observed a reduction in body weight of sex-linked dwarf gene (dw) of dam in temperate zone of 30% and 29% at high ambient temperature zone. Adult body weight is reduced by 30% in the hen and 40% in the cock (Merate and Bordas, 1974). Dwarf birds consumed 37.2g less feed and show 8.4% higher feed utilization than the normal feathered counterparts (Katongole *et al.*, 1990). Horst and Mathur (1992) stated an ideal impact of naked neck (Na) and frizzle (F) trait on egg production performance as well as egg weight and high feed utilization for dwarf (dw) chickens have been reported under warmth
stress.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study location and period of study

A survey was conducted within three ecological zones of Ghana namely Guinea Savanna, Semi-deciduous Rainforest and Coastal Savanna. The Guinea Savanna zone lies between longitude 10^0 1‘ W and latitudes 10^0 3‘ and 11^0 10‘N. It is the biggest ecological zone in Ghana with a land area cover of 147,900km^2. It shares borders with two neighbouring countries, the Republic of Togo toward the East and La Cote d‘Ivoire toward the West. The black and white Volta are located within the zone. The weather condition of the area is generally dry and the rainfall trend is unimodal and starts in April/May and ends in October. The mean annual rainfall varies between 800mm and 1200mm. The dry season begins in November and ends in March /April with the highest temperature being observed towards the end of the dry season. The vegetation cover comprises of short, deciduous, usually spread out, trees that are drought resistant and shrubs which do not form close shade (Amankwah *et al.*, 2012).

The Semi-deciduous rainforest is situated in the middle belt of Ghana. It lies between longitudes 2.25^{0}W and 0.15^{0}W, and latitudes 7.46^{0}N and 5.50^{0}N. It is the second largest zone after Guinea Savanna and occupies a total land area of 6,600km^2. The mean annual rainfall varies between 1200mm to 1600mm. The zone has two rainy periods, the major season starts from March and ends in July and the minor season also begin September to November. The average daily temperature is about 27^{0}C.
(MoFA, 2005).

The Coastal Savannah zone is noted to cover land area of $4,500km^2$, stretched along the coastline. The area lies between the dry tropical and moist semi-equatorial zones. The mean yearly rainfall ranges from 600mm to 1200mm. It lies within latitudes 5.62^0 N and longitudes 0.10^0 W. The mean monthly temperature values for the zone ranges from 24^0C in the coolest month of August and around 30^0C in the hottest months of March to April (MoFA, 2005). The study was conducted over a period of 3 months from August to October, 2014.

3.2 Study design

A cross sectional study was carried out in the three ecological zones of Ghana, namely Guinea Savannah, Semi-deciduous Rain Forest and Coastal Savannah. Under Guinea Savannah zone, Kumbungu district, Sagnerigu district and Savelugu Municipal were sampled. Kumawu district, Sekyere Afram Plains district and Bekwai Municipal were selected for Semi-Deciduous Rain Forest and the sampled areas for the Coastal Savannah were Mfantsiman Municipal, Gomoa West and Komenda-Edina-Equafo-Abirim district.

3.3 Sampling and Sample Size for the survey

A stratified sampling procedure was used in selecting the three ecological zones. Three districts from each ecological zone were randomly selected. After the selection of the districts, multi-stage approach was used to take a reconnaissance studies at some villages in the selected districts. This helped the researcher to identify farmers who have been keeping the needed mutant birds. Lists of villages/towns within each district were prepared with the help of the District Livestock Officer. Five (5) villages were randomly selected from each district and nine (9) households per village for the study. A total of four hundred and five (405) households were contacted within the three ecological zones for the study.

3.4 Data Collection Technique for the survey

Informal and formal interviews were used to collect information from the local chicken keepers during the survey. The formal interviews were done using a structured questionnaire with both open- ended and pre- coded questions. Data were collected on flock dynamics, individual birds with phenotypic expression of nakedneck, frizzle feathers, polydactyl (5 toes), ptilopody (feathered shank), silky feathered, crest feathered or featherless genes within the chicken population and egg laying performance.

Participatory Rural Appraisal procedure was used to gather on-site information on linear body measurements as well as live body weight on birds. The parameters that were measured included live body weight, shank length, body length, wing length, body girth, keel length, and toe length. Top loader measuring scale (Camry) was used to measure the live body weight in kilograms. The shank length was measured from the hock joint of the tarso-metatarsus to the metatarsal pad. The body length was taken as the distance from the apex of the beak over the neck, through the body trunk to the tail. The wing length was measured as the distance between the scapula joint and the last digit of the wing. The toe length was recorded as the length of the third toe measured from the metatarsal fold to the last phalange on the toe. The body girth was measured as the perimeter of the breast area. The keel length was measured from the V- joint of the keel bone to the end of the sternum. All the linear body measurements were measured in centimeters using measuring tape. The counting of the local chickens took place early in the mornings or late in the evenings. The total chicken population used for the study was 3,264 excluding chicks.

3.5 Analysis of the data

The proportions of the various phenotypes were obtained by observing the birds individually for phenotypic expression of the traits. The number of birds showing each trait was then expressed as a percentage of the total number of birds enumerated. Hardy- Weinberg equation was used to calculate the occurrence of each gene for dominant alleles (*Na, F, Cr H, Po, Pti, Fl*) and the recessive alleles *(na, f, cr, h, po, pti, fl*) (Falconer and Mackay, 1996) as shown below:

$$q = \sqrt{\mathrm{m/t}}$$

Where; q= frequency of the recessive genes *(na, f, cr, h, po, pti, fl*) m = observed number of fowls with recessive gene under consideration t = sum total number of fowls examined

The frequency of the dominant alleles *(Na, F, Cr, H, Po, Pti, Fl*) were calculated using the formula below; p=1-q

Where p = the frequency of the dominant allele

The observed gene frequencies after the counting were tested against the estimated Mendelian values of 0.75 for the dominant allele and 0.25 for the recessive allele using the chi-square test.

The chi-square value (X^2) was calculated as shown below;

$$\frac{X^2 = \Sigma\,(observed - expected)^2}{expected}$$

The demographic data were analyzed by descriptive statistics using SPSS (2011) version 16.0 and the results presented in tables, frequencies, and percentages.

Data on live body weight, egg laying performance and linear body measurements were analyzed using the linear model below:

$Y_{ijk} = \mu + G_i + Z_j + (G\times Z)_{ij} + E_{ijk}$

Y_{ijk} = performance of the k^{th} checking of the i^{th} genotypic group μ

= overall general mean common to all observations

G_i = fixed effect due to i^{th} genotype (I = 1, 2, 3, 4, 5, 6) Z_j

= random effect due to j^{th} ecological zone (j= 1, 2, 3)

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

The data were subjected to analysis of variance using the 12th edition of Genstat statistical software (Lawes, 2009). Least significant difference (LSD) was used to separate the treatment means at $P<0.05$.

CHAPTERFOUR

4.0 RESULTS AND DISCUSSION

4.1 Gender and age of the respondents

Table 4.1 represents the demographic characteristics of farmers within the area of study. In terms of gender, there were more males than females in this study, the males constituted 72.6% of the total respondents and the females recorded 27.4%. The survey results indicated that males dominate the ownership of local chickens within the study area while the women take charge of the household activities. The current result was in agreement with the findings of Dankwa *et al.*, (2000) who recorded

83.3% of poultry keepers at West Mamprusi District for males and 16.7% for females. According to a survey conducted by Otchere *et al*., (1997), males were predominantly into livestock and poultry production at the Saboba Chereponi District in Ghana.

It was realized from the respondents interviewed that most of the males were food crop growers. They grow crops like maize, millet, cassava, tomatoes, pepper, okra etc. hence, they use the droppings of their fowls as organic fertilizer instead of using extra money to purchase inorganic fertilizer to be used on their farm. On the other hand, women were mostly allowed to stay at home to prepare meals for their husbands and children. The results from this study disagree with the findings of Hassan *et al.,* (1990) who observed that women normally stay at home to look after the birds while the men go to farm. Again, Gueye (1998) reported that more than 70% of chicken owners in rural sub-Saharan Africa are females and Badubi *et al.,* (2006) stated that apart from being owners of birds, the females are also, sole agents in the sale of the birds which contradicts the findings of the current study.

The age structure of the respondents as in Table 4.1 showed that a large proportion of the farmers interviewed were 21 years and above. Very few of them were between 620 years of age. The results suggest that most of the farmers were in their productive stage where the rate of dependency is very high. These group of people raised birds as part time job to earn additional income for a living. The present results agrees with findings of Dankwa *et al.,*(2000) who observed that farmers within the middle-aged group (30-49) play an active role in keeping local chickens in Ga Rural and Mamprusi district in Ghana.

4.2 Marital status and educational background of the respondents

The data obtained from the survey indicates that a large proportion of the respondents were married only few were not married (Table 4.1). The percentage obtained from this study is similar to Fisseha (2009) who observed 88.9% chicken keepers been married in North West Amhara. The results from the study showed that, the whole family could be used as an additional labour on the farm. This can reduce cost of production on crops and livestock which is very beneficial on the part of farmers. Again, the rearing of local chickens is recognized and accepted as a legitimate income generation activity within the study area.

The majority of the respondents had not had any formal education (ie. 72.8% being illiterates) and 27.2 percent of them have had formal education as indicated in Table 4.1. The current study agrees with Helima (2007) who observed 82.1% for NorthWest Ethiopia local chicken care takers been illiterate. The results suggested that proper record keeping on flock could be very low in terms of management practices such as disease vaccination programmes and feed formulation.

Table 4.1: Demographic characteristics of the respondents

Variables	Frequency of Respondents	Respondents percentage	Cumulative (%)
Age			
6-12yrs	9	2.2	2.2
13-20yrs	9	2.2	4.4
21yrs and above	387	95.6	100
Marital status			
Single	33	8.1	8.1
Married	372	91.9	100
Sex			
Male	294	72.6	72.6
Female	111	27.4	100

Educational background			
Nil	295	72.8	72.8
MSLC	74	18.3	91.1
JHS	22	5.4	96.5
Tertiary	14	3.5	100

4.3 Housing

The survey revealed that 78.0% of the households provided housing for their chickens overnight. The birds were kept in a complete enclosure and the structures were made up of mud walls and thatched grass roof. The remaining 22.0% left their birds to roost on walls and perched in treetops at night (Table 4.2). The current study agrees with the findings of Kugonza *et al.,* (2008), who observed that, 77% of the local chicken keepers in Eastern Uganda provide complete enclosure for their birds. Riise *et al.,* (2004) reported that poultry pen is important to safeguard birds against predators, thieves, rough weather (rain, sun, very cold winds, and dropping night temperatures) and to provide shelter for egg laying and broody hens. Smith (1992) however, reported that the provision of good housing serves as a prerequisite for any viable and sustainable chicken project. A suitable poultry house enhanced efficient productivity of local chicken rearing. From the survey, it was realized that almost all the respondents were crop farmers, early morning they clean their hen coop and use the chicken droppings as source of manure for their crops farms.

4.4 Feed supplementation

All the 405 farmers interviewed provided feed supplement to their birds. From Table 4.2, 87.4% provided whole maize grain, 4.4% fed with millet only and 8.2% offered household leftovers, insects and green vegetables. All the respondents gave supplementary feed to their birds every day before releasing them for scavenging. Feed supplementation was done early in the morning (88.4%), noon (5.7%) and evenings (5.7%) when these chickens returned to the housing unit (Table 4.2). The present finding was higher in terms of feed supplementation and the type of feed given to the birds. Adomako (2009) reported 66.6% feed supplementation to local chickens in Ghana and 60% of the farmers offered whole maize as feed supplement. Riise *et al.,* (2004) reported that egg production and growth of local birds easily increased by giving supplementary feeds. However, local chickens living in the rural areas are generally the best converters of feed to eggs under unstable environmental conditions as reported by Riise *et al.,* (2004).

The types of feed the respondents were giving to their birds in the present study confirms the findings of Adomako *et al.,* (2010) and Badubi *et al.*, (2006) where majority of the farmers offered whole maize as feed resource base to their birds. It was revealed that, almost all the respondents were crop farmers and maize is a dominant crop. However, they used most of the leftovers after harvesting to feed their birds. According to Clarke (2004), supplementary feeding can greatly improve the poultry‘s performance, but care must be taken to ensure that feed is affordable and locally available. A report submitted by Wilson (2010) states that, regular supplies of some supplementary feeding would greatly increase the survival rate of chicken and chicks and thus reduce economic losses. During the survey, it was observed that birds were always around the compound of the poultry keepers. This confirms the findings of Adomako (2009) that daily feed supplement to birds enticed the birds to stay inside or around the house instead of going far away or into the bushes.

4.5 Reasons for keeping local chickens

A large proportions of the respondents (91.1%) dispose of their birds for home consumption and to settle financial obligations in the house. Few farmers interviewed (8.9%) disposed of their local birds for rituals and gift (Table 4.2). The current study agrees with the report of Aganga e*t al.*, (2000) that farmers kept chickens mainly for home consumption and occasional sales. Adomako e*t al.*, (2009) similarly reported that rural poultry production provides animal protein in the form of meat and eggs as well as being a reliable source of income for the farmers' family. Moreover, this present work is also in agreement with Aini (1990), Gueye (1998), Moreki (2000) and Badubi *et al.*, (2006) who observed home consumption and income generation as the main reason for keeping local chickens at household level in the rural areas.

4.6 Laying nest

Hens usually prefer to lay eggs in a protected nest than simply on the floor of the house. Most of the respondents (90.9%) prepared laying nest for their birds as indicated in Table 4.2. Only 9.1% allowed their birds to lay on the floor, bushes and outside the houses. The nests used by the chicken keepers include: clay pots, baskets, cardboard, wooden boxes and calabashes. It was realized from the survey that the eggs laid outside the houses were exposed to predators, breakages and thieves.

Table 4.2: Management characteristics of mutant traits within the three ecological zones.

Parameter	Frequency	Percentage	Cumulative (%)
Housing			
Treetops	46	11.4	11.4
Walls	9	2.2	13.6
Hen coop	282	69.6	83.2
Kitchen	34	8.4	91.6

Both trees and hen coop	43	8.4	100
Feed supplementation			
Whole maize	354	87.4	87.4
Millet	18	4.4	91.9
Leftovers, insects, green vegetables	33	8.2	100
Time of feed supplementation			
Morning	358	88.4	88.4
Noon	24	5.7	94.3
Evening	23	5.7	100
Reasons for keeping birds			
Petty cash and food	283	69.9	69.9
Home consumption only	86	21.2	91.1
Hobby	36	8.9	100
Provision of laying nest			
Yes	368	90.9	90.9
No	37	9.1	100

4.7 Health care and disease incidence of local chickens

According to the respondents, the following symptoms of diseases were common; twisted neck, greenish diarrhoea, nasal discharge, sneezing, coughing, respiratory noise, and lesions on comb, wattle and corner of beak. About 53.3% claimed that Newcastle disease was the most prevalent disease. This was followed by fowl pox (31.9%), and chronic respiratory (14.8%) (Table 4.3).

The result of the present study is similar to that of Yakubu (2010) who reported 74.4% of Newcastle disease being the most predominant and commonest poultry disease at Nasarawa agricultural zones of Nigeria. Chaheuf (1990) also reported that, the most obliterating infection of local birds in Cameroom is Newcastle disease. A report summited by Swai *et al.*, (2007) stated that, Newcastle disease is a predominant disease in Tanga, Tanzania. Many exploration work done in other African nations such as Burkina Faso (Bourzat and Saunders, 1990), Benin (Chrysostome *et al.*, 1995), and the United Republic of Tanzania (Yongolo, 1996) bolsters the contention that Newcastle disease is the most devastating ailment of indigenous birds. Chaheuf (1990) and Olabode *et al.*, (1992) described some of the major factors associated with the transmission of Newcastle disease; exposure of the birds to the common habitat, comprising wild fauna, flocks of different ages and vulnerable new hatches. Again, through contact either give-and-take of live chickens and products or movement amongst families and towns.

Among the farmers interviewed, access to Veterinary services appeared limited within the three ecological zones in Ghana. According to the data obtained, 90.1% had no access to any veterinary services. Only 9.9% of the respondents consulted Veterinary Officers for advice and proper medication. Bogale (2008) reported that limited access to veterinary services by farmers could negatively impact the development of poultry production. Kryger *et al*., (2010) reported that when animal health services are not available to farmers and bird mortality rate is high, awareness and interest in improved husbandry practices does not generally exist. The limited access to Veterinary services within the study area could be due to the following reasons; high cost of treatment, unaware of the benefits of disease control, small flock sizes, difficulty in accessing the Veterinary services and the uncertainty of cure on the side of farmers.

During the survey it was noted that, most of the respondents normally resorted to selfmedication where most of their drugs were obtained from mobile drug sellers or herbalist concoctions. The drugs used by the majority of farmers to treat all kinds of diseases within the study area were amoxicillin, fragile, paracetamol, vitamin-B complex and local herbs. Amoxicillin recorded 33.8% and 12.3% of the respondents interviewed did not give any medication to their sick birds. About 43.2% resorted to local herbs, and 10.7% used fragile, vitamin-B complex and paracetamol. According to the data obtained, the local chicken keepers in the study area resort to traditional method of treating poultry diseases hence, few farmers who bought drugs from veterinary shops were those who either lived close to towns or kept poultry in relatively larger numbers. It was realized that some of the local oils used by the farmers within the study area include palm oil, palm kennel oil and sheanut oil which was smeared on scabs for the treatment of fowl pox. Others also prepared traditional herbal concoctions for example; mango, mahogany, jatropha, and cashew tree barks together with ‗prekese' (*Tetrapleura tetraptera*) in water solution for treatment of Newcastle disease.

The current study was in agreement with the findings of other researchers, Dankwa *et al*., (2000) in West Mamprusi and Ga Rural Distrct of Ghana and Yakubu (2010) in Nasarawa state of Nigeria that indigenous poultry farmers treat diseases with traditional medicines or modern drugs and a few consult Veterinary Officers. According to Chavunduka (1976), the leaves of *Aloe excelsa* are doused and the separated liquid is added to drinking water in Zimbabwe to treat fowl pox disease. Again, *Lageneria vulgaris* or the bark of *Parkia filicoidea* are given to the birds in water solution to treat Newcastle disease as reported by Nwude and Ibrahim (1980) in

Nigeria. The leaves of *Cassia didymobotrya* or the latex of *Euphorbia matabelensis* are given in drinking water to treat Newcastle disease in Zimbabwe (Chavunduka,

1976). Minja *et al*., (1989) also reported that, the stem of *Euphorbia candelabrum, Kotschy var. candelabrum* or the fruitlet of *Capsicum annuum* together with the leaves of *Iboza multiflora* are offered to birds for the treatment of Newcastle disease in the United Republic of Tanzania, especially in the areas of Arusha and

Kilimanjaro.

About 59.0% of the mortalities of local chickens were recorded during dry season while 17.8% and 23.2% of the farmers reported wet season and both wet and dry seasons respectively within the three zones (Table 4.3). A healthy bird eats and drinks frequently and defecates quite frequently and displays no signs of respiratory distress. Kingori *et al.*, (2010) reported that, the most recognized constraint in smallholder poultry production in extensive system of keeping birds are noted to be at a high risk of disease infections.

Table 4.3: Health care of local birds

Parameter	Frequency	Percentage	Cumulative (%)
Common diseases			
Newcastle	216	53.3	53.3
Fowl pox	129	31.9	85.2
Chronic respiratory	60	14.8	100
Veterinary services			
Yes	40	9.9	9.9
No	365	90.1	100
Type of medication			
None	50	12.3	12.3
Local herbs	175	43.2	55.6
Amoxicillin only	137	33.8	89.4
Amoxicillin and paracetamol	16	4.0	93.3
B-vitamins	17	4.2	97.5
Fragile	10	2.5	100
Source of drugs			
None	50	12.3	12.3
Farmers farm	171	42.2	54.6
Drug store	181	44.7	99.3
Veterinary office	3	.7	100

Season birds are lost			
Wet	72	17.8	17.8
Dry	239	59.0	76.8
Both wet and dry	94	23.2	100

4.8 Identification of mutant chickens within the indigenous chicken population in three ecological zones of Ghana.

The following mutant chickens were found within the local chicken population during the survey; naked neck, frizzle, silky, crest feathered, polydactyl, ptilopody and flightless. The current study support the findings of Naazie *et al*., (2007) who found the following mutant genes among the indigenous chicken population in Ghana; naked neck, frizzle, silky, crest feathered, and dwarfism and other genes like polydactyl, ptilopody and rose comb. During the on-site interviews, the respondents came out with the following names for the various mutant traits based on their phenotypic characteristics in their local language.

Local name		**Phenotypic description**
Akan	***Dagbane***	
Akokɔdwane	*Bimbihim*	Silky
Asensɛ	*Gbungbun*	Frizzle
Kɔntwa	*Kpavien*	Naked neck
Akokɔchew	*Guutusa*	Crest (feather cap on head)
Nanduro	*Napontari*	Polydactyl (five toes)
Nan ho nwi	*Naponwura*	Ptilopody (feather on shank)

Plate 4.1. Naked neck chicken

Plate 4.2. Frizzle feathered chicken

Plate 4.3. Silky chicken

Plate 4.4. Crest feathered chicken

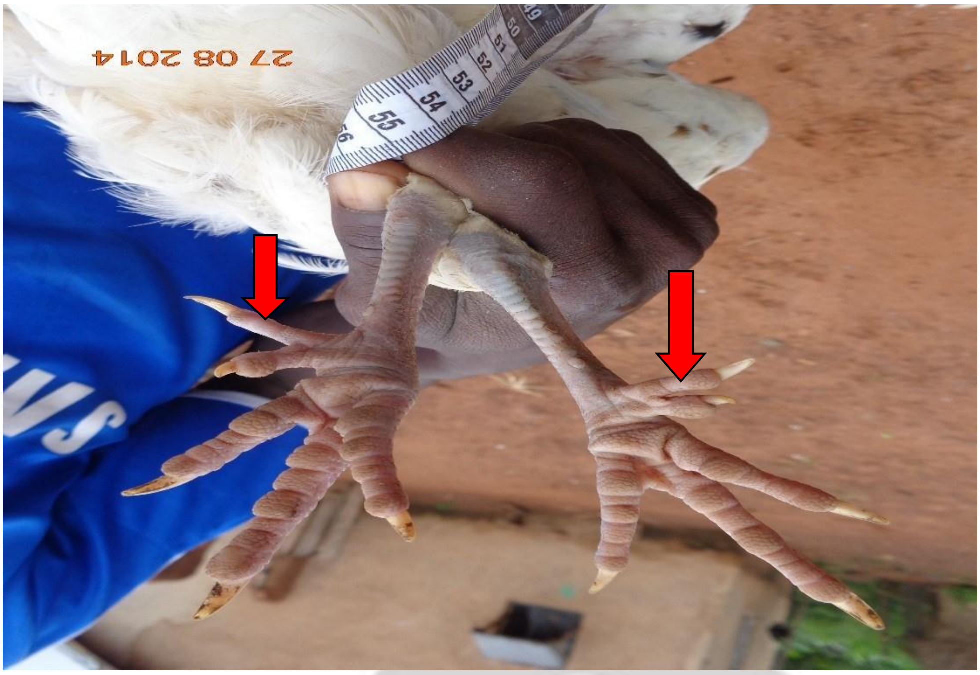

Plate 4.5. Polydactyl chicken (five toes)

Plate 4.6. Ptilopody chicken (feathered shank)

Plate 4.7. Flightless chicken

4.9 Frequencies of mutant genes

The results from Table 4.4 show the genotypic frequencies and gene frequencies of mutant birds existing in the local chicken population. The calculated gene frequencies for the dominant characters and the recessive characters ranged from 0.01 to 0.05 and 0.95 to 0.99 respectively as shown in Table 4.4. The percentage incidence of birds showing the dominant and recessive traits ranged from 0.06% to 9.52% and 90.47% to 99.93% respectively. The gene frequencies for the traits observed differed significantly ($p<0.05$) from the estimated Mendelian values.

The present data from Table 4.4 recorded low gene frequencies for the various mutant birds within the study area. The current data were in agreement with the findings of Sonaiya and Olori (1990) in South-Western Nigeria who observed low gene frequencies for naked neck and frizzle genes. The low gene frequencies for these dominant traits in the current study means that, these mutant birds are at the brink of extinction especially silky, polydactyl, ptilopody and flightless birds. It however agrees with the work done by Fayeye *et al*., (2006) who concluded that the low frequencies for the dominant alleles could be attributed to the negative selection process these birds probably found themselves in. He further stated that, social predisposition has led to the eradication of chickens with ptilopody mutation in Nigeria.

During the survey, the farmers indicated that several traditional beliefs are placed on most of the mutant birds because of the relevant part they play in rituals and sacrifices. For example, silky birds are used in place of sheep to perform rituals to lesser gods (‗*Bonfum*' and ‗*Naroow'* at Bodomasi in Sekyere Kumawu district of Ghana). The reason being that the silky gene is an autosomal recessive gene which causes the barbs of the feathers to be highly modified resulting the silky and a woolly appearance like that of sheep. Similar findings were reported in Nigeria by Sonaiya and Olori (1990) who observed that chicken keepers perceive frizzled and naked neck birds as unpleasant and frustrating. They further noted that naked neck chickens are to be kept by aged and for occultic reasons and when these birds are sold as live birds for meat, they normally attract lower price in the market.

Interactions with some of the local chicken farmers in Northern part of Ghana (Guinea Savannah) specifically Kunbugu District revealed that it is a taboo to raise ptilopody bird on that land due to their religious beliefs. This bias has led to total removal of indigenous chicken with the ptilopody mutations. The present study agreed with the submission of Ikeobi *et al.*, (1997) who observed low frequency of ptilopody birds because of the combined effect of social inclination, natural selection as well as adaptation. Moreover, the farmers interviewed at Guinea savannah zone reported that, silky birds were mostly given guinea fowl eggs to incubate and raise them instead of hatching their own eggs. This study confirms the findings of Ekarius (2007) who reported that the silky feathered birds are mostly used to incubate and raise the offspring of other chickens and waterfowls like ducks, and geese, and game birds such as quail and pheasants.

Table 4.4: Mutant traits and their gene frequencies found within the local chicken population

Trait	Allele	Observed	% incidence	Gene frequency
Naked neck	Na	200	6.12	0.04*
Normal	na	3064	93.87	0.96
Frizzle	F	215	6.58	0.04*
Normal	F	3049	93.41	0.96
Silky	H	118	3.61	0.02*
Normal	H	3146	96.38	0.98
Crest	Cr	311	9.52	0.05*
Normal	Cr	2953	90.47	0.95
Polydactyl	Po	33	1.01	0.01*
Normal	Po	3231	98.98	0.99
Ptilopody	Pti	45	1.37	0.01*
Normal	Pti	3219	98.62	0.99
Flightless	Fl	2	0.06	0.01*
Normal	Fl	3262	99.93	0.99

*Significantly different (p<0.05) from the estimated Mendelian values (3:1)

4. 10 Production performance

4.10.1 Effect of zone on egg performance of adult female local chicken.

The data for egg production performance of the various indigenous chickens within the three ecological areas are presented in the Table 4.5.1. Average clutch size per year, number of eggs set and chicks hatched per natural incubation were relatively the same in all the three ecological zones. The mean eggs per clutch per bird and eggs per bird per year were similar in Coastal Savannah and Semi-Deciduous Rain Forest but significantly better than Guinea Savannah. There was no significant difference in percentage hatchability between the Coastal and Guinea Savannah zone (p>0.05) but the two zones had higher values for the hatchability than Semi-Deciduous Rain Forest

(Table 4.5.1). The data for average clutch size per year and average number of eggs laid per clutch per bird respectively were similar to the findings of other researchers who recorded 2.5 and 9-13 in Ashanti Region of Ghana (Adomako *et al.*, 2010), 3.8 and 9.8 in the Ga West, East and Damgbe West of Ghana (Blackie, 2014), 3.7 and 10.1 in the West Mamprusi district of Ghana (Dankwa *et al.*, 2000), 4.5 and 10.87 in Sudan as reported by Wilson (1979) as well as Kitalyi (1998) in Gambia who recorded 3.2 and 11.

The percentage hatchability recorded in this study were in agreement with the findings of Hagan *et al.*, (2013) and Osei Amponsah *et al.*, (2009) who observed 84.5% and 87.8% respectively in Ghana. Similar percentages have been observed in other African nations such as 82% (Kusina and Mhlanga, 2000) in Zimbabwe, 90% in Sudan by Wilson (1979), 60-90% in Burkina Faso (Bourzat and Sounders, 1990). Only Shanawany and Banerjee (1991) in Ethiopia recorded lower hatchability (3942%) than the current study. It was realized from the data that the hatchability figures obtained were higher than the FAO (2000) set value 80% for hatchability from natural incubation as normal, and satisfactory with the range of 75-80%.

The low clutch size and egg number per clutch may be attributed to the long pauses between laying of clutches by the local chickens and a predominant inclination to broodiness. Again the local hens are known to be excellent brooders and are also good mothers. However, the information given by the respondents during the survey revealed that, some of the farmers normally give guinea fowl or turkey eggs to replace chicken eggs to hatch and raise the offspring especially in Guinea Savannah zone. This agrees with Ekarius (2007) who observed that silky feathered hens are mostly used to incubate and raise the offspring of other birds and waterfowls such as ducks, geese and game birds like quail and pheasants.

Table 4.5.1: Effect of zone on egg characteristics of indigenous chickens within the study area

Variable	Coastal Savannah	Guinea Savannah	Semi-Deciduous Rain Forest	LSD
Av clutch size/year	3.39±0.07	3.61±0.04	3.55±0.05	0.15
Av.Eggs/clutch/bird	12.56±0.24[a]	10.64±0.13[b]	12.14±0.18[a]	0.53
Av.Eggs/bird/year	43.46±1.21[a]	38.47±0.66[b]	42.75±0.89[a]	2.61
Av.Number of egg set	10.72±0.26	10.60±0.14	11.28±0.19	0.57
Av. chicks hatched	9.18±0.26	9.23±0.14	9.28±0.19	0.56
% Hatchability	86.19±1.35[a]	87.08±0.74[a]	82.56±0.99[b]	2.93

Means with different superscripts along the same row are significantly different (p<0.05). LSD: Least significant difference, ±: standard error of means. Av: Average, %: percentage

4.10.2 Effect of mutant trait on egg performance of local chickens

The effect of mutant trait on egg production characteristics of the various phenotypes within the three ecological zones are presented in the Table 4.5.2. Average clutch size per year, and percentage hatchability were relatively the same across the various treatments (p>0.05). The average number of eggs set for the mother hen and number of chicks hatched for polydactyl phenotypes were better (p<0.05) than their recessive counterparts. There was no significant difference in average eggs per clutch per bird between the frizzle, silky, naked neck, polydactyl and normal feathered but there existed a significant difference between these five genotypes and the crest feathered birds. There were no differences between the various phenotypes for average eggs per bird per year.

From Table 4.5.2, polydactyl birds were better than their respective recessive gene carriers in terms of average eggs per clutch per bird, average eggs per bird per year, number of eggs set for natural incubation as well as average number of chicks hatched. The outstanding egg performance characteristics could be due to the ability of the polydactyl birds to convert feed into valuable egg and meat products. According to Crawford (1990) and Huang *et al.*, (2006) polydactyl traits are controlled by incomplete autosomal dominant genes and its manifestation is influenced by more than one gene. However the current study was in agreement with the findings of Columella (1977) who considered chickens with five toes as the most fertile and prolific breeders. Again, this study agrees with findings of Shoffner *et al.,* (1993) who stated that polydactyl and ptilopody chickens are associated with better egg production and body weight as compared with their normal counterparts. Comparatively naked neck and silky phenotypes are next to polydactyl phenotype in terms of number of eggs per clutch and number of eggs per bird per year according to the data obtained from the survey.

Lack of significant differences in clutch size per year for all the phenotypes in this current study can be attributed to common physiological characteristics of local chickens in developing countries including Ghana. These include; late maturity of hens, small body size and long pauses between lying of clutches which is associated with broodiness. Broodiness is a phylogenic trait controlled by a number of autosomal genes as a result of an increase level of prolactin hormone which is an important candidate hormone for broodiness and it plays a significant role in incubation behaviour of hens (El Halawani *et al*., 1993). However, it was known that, naked neck, frizzle, polydactyl, ptilopody, and crest feathered traits are controlled by dominant autosomal genes except silky feathered trait which is controlled by a recessive autosomal gene.

Table 4.5.2: Effect of mutant trait on egg production performance in three ecological zones in Ghana

Variable	Crest	Frizzle	Silky	Naked neck	Polydactyl	Normal	LSD
Av clutch size/year	3.55±0.05	3.51±0.07	3.70±0.14	3.49±0.07	3.65±0.18	3.56±0.04	0.29
Av. Eggs/clutch/bird	11.70±0.20 [b]	11.16±0.25[b]	11.72±0.49 [b]	11.53±0.26 [b]	13.49±0.62[a]	11.17±0.14 [b]	0.98
Av. Eggs/bird/year	41.63±0.98[ab]	38.77±1.27[b]	43.70±2.42 [a]	40.28±1.28[ab]	47.41±3.05[a]	39.85±0.71[ab]	4.8
Av. Number of eggs set for mother hen	11.06±0.21[b]	10.44±0.28 [b]	11.45±0.53 [b]	11.18±0.28 [b]	13.13±0.67[a]	10.45±0.15 [b]	1.06
Av. Chicks hatched	9.61±0.21 [b]	9.11±0.27 [b]	8.80±0.52 [b]	9.74±0.27 [b]	11.17±0.65[a]	8.83±0.15[b]	1.03
% Hatchability	87.61±1.09	87.02±1.42	78.66±2.72	86.10±1.44	87.40±3.42	84.53±0.79	5.38

Means with different superscripts along the same row are significantly different ($p<0.05$). LSD: Least significant difference, ±: standard error of means, %: percentage, Av: Average

4.10.3 Effect of ecological zone and mutant trait interaction on egg production performance characteristics

The effect of ecological zone and mutant trait interaction on egg production performance are presented in Table 4.5.3. The results on average clutch size showed a similar trend for all phenotypes across all the ecological zones. The results indicate that all the phenotypes across the various ecological zones had a similar genetic background. This present study were in line with the findings of Adomako *et al.*,(2013) who also reported no significant difference on clutch size per year among frizzle, naked neck and normal feathered phenotypes in Ashanti Region of Ghana as a result of long pause in egg laying of local chickens initiated by broodiness. From Table 4.5.3 it could be seen that average number of eggs per clutch per bird for crest feathered and naked neck was relatively the same for Semi-deciduous rain forest and Coastal savannah while Guinea savannah recorded lower number of eggs per clutch per bird for birds having the two traits. The average number of eggs per clutch per bird for frizzle feathered birds were the same ($p>0.05$) for all the zones. Birds with silky and polydactyl genes for Semi-deciduous rain forest were superior ($p<0.05$) than Coastal savannah followed by Guinea savannah in terms of the number of eggs per clutch per bird. However, the number of eggs per clutch per bird for normal feathered phenotypes were not significantly different between all the ecological zones.

The average eggs per bird per year for crest, frizzle and silky birds were not significantly ($p>0.05$) different from each other with respect to the three ecological zones. Again, naked neck and normal feathered birds recorded no significant difference across the three zones. Polydactyl birds for Guinea savannah and Coastal savannah were similar while Semi-deciduous rain forest recorded the highest number in terms of eggs per bird per year.

All the three ecological zones had no effect on number of eggs set for natural incubation for crest feathered birds. However, frizzle, naked neck and normal feathered were not significantly influenced by the ecological zones in terms of number of eggs set (Table 4.5.3). Silky and polydactyl birds for Guinea Savannah and Coastal Savannah were the same while Semi-deciduous rain forest had superior number of eggs set.

Crest feathered, frizzle, silky, and naked neck birds were not significantly different ($p>0.05$) from each other with respect to the three ecological zones about the number of eggs hatched per natural incubation. However, polydactyl birds found within the Semi-deciduous rain forest recorded higher ($p<0.05$) number of chicks hatched by the mother hen than Guinea savannah and Coastal savannah. There was no significant difference ($p>0.05$) for normal feathered birds in terms of number of chicks hatched by the mother hen between Guinea savannah and Coastal savannah but there existed a significant difference ($p<0.05$) between these two zones and the Semi-deciduous rain forest.

There were no significant difference in percentage hatchability for crest, frizzle, naked neck, and normal feathered counterpart across the three ecological zones. The average hatchability recorded for the various phenotypes across the three ecological zones were in line with the results of Hagan *et al.,* (2013) who observed similar values for Coastal Savannah (83.6%), Guinea Savannah (87.6%) and Forest zone (80.2%) in Ghana. Osei-Amponsah *et al.*, (2009), also recorded 87.8% hatchability for local chicken ecotypes for Forest and Savannah zones in Ghana. However, silky and polydactyl birds within Guinea Savannah and Coastal Savannah had higher ($p<0.05$) average hatchability values than Semi-deciduous rain forest (Table 4.5.3). The differences recorded by the silky and polydactyl birds could be attributed to similar climatic conditions related to the various ecological zones for example Coastal and Guinea Savannah zone. The average temperature for Coastal and Guinea Savannah ranges from 30^{0}C to 35^{0}C and average daily temperature for Forest zone is 27^{0}C. Hence, adaptability on the part of birds to withstand stressful environment to brood over their eggs enhance hatchability. Decuypere *et al.,* (2001) reported that in a control environment, the incubation temperature for the highest hatchability lies within the range of 37-38^{0}C where embryos can withstand deviations of temperature during developmental stage.

Table 4.5.3: Effect of zone and mutant trait interaction on egg production performance of indigenous chickens.

	Av. Clutch size (LSD=0.48)					
	Cr	**F**	**H**	**Na**	**Po**	**nf**
Coastal	3.31±0.16	3.45±0.19	3.33±0.26	3.28±0.17	3.27±0.19	3.48±0.12
Guinea Savannah	3.61±0.09	3.45±0.08	3.59±0.09	3.65±0.13	4.25±0.32	3.60±0.06
Semi-deciduous Rain Forest	3.57±0.08	3.62±0.16	4.00±0.36	3.36±0.09	3.00±0.26	3.53±0.06
	Av. Eggs/clutch/bird (LSD=1.61)					
	Cr	**F**	**H**	**Na**	**Po**	**nf**
Coastal	12.19±0.53	12.73±0.64^{a}	12.17±0.87^{b} a	13.29±0.57^{a}	12.73±0.64^{b}	12.52±0.42^{a}
Guinea Savannah	10.43±0.30^{b}	10.22±0.28^{ab}	9.89±0.32^{c}	10.96±0.44^{b}	10.00±1.07^{c}	11.03±0.20^{a}
Semi-deciduous Rain Forest	13.22±0.29^{a}	11.81±0.53^{a}	14.00±1.24^{a}	11.61±0.32^{b}	18.50±0.87^{a}	10.83±0.22^{ab}
	Av. Eggs/bird/year (LSD=7.[illegible]9)					
	Cr	**F**	**H**	**Na**	**Po**	**nf**
Coastal	41.25±2.62^{a}	44.09±3.17^{a}	40.17±4.29^{a}	43.21±2.81	41.91±3.17^{b}	45.44±2.10
Guinea Savannah	37.43±1.50^{ab}	35.78±1.41^{ab}	35.59±1.58^{ab}	39.87±2.19	43.00±5.25^{b}	39.76±1.00
Semi-deciduous Rain Forest	47.43±1.43^{a}	40.69±2.62^{a}	56.00±6.07^{a}	39.68±1.58	55.50±4.29^{a}	37.77±1.12
	Av. Eggs set (LSD=1.74)					
	Cr	**F**	**H**	**Na**	**Po**	**nf**
Coastal	10.25±0.58^{ab}	11.27±0.70	10.33±0.95^{b}	11.43±0.62	10.18±0.70^{b}	10.64±0.46
Guinea Savannah	10.39±0.33^{a}	10.15±0.31	9.89±0.35^{b}	10.96±0.48	10.00±1.16^{b}	10.97±0.22
Semi-decidous Rain Forest	12.28±0.31^{a}	10.50±0.58	4.00±1.34^{a}	11.39±0.35	18.50±0.95^{a}	9.67±0.24
	Av. chicks hatched (LSD=1.[illegible]0)					
	Cr	**F**	**H**	**Na**	**Po**	**nf**
Coastal	9.56±0.56	9.27±0.68	9.50±0.92	9.27±0.60	9.27±0.68^{b}	8.80±0.45^{a}

Guinea Savannah	8.98±0.32	8.74±0.30	8.45±0.34	9.25±0.47	9.25±1.13[b]	9.60±0.21 [a]
Semi-deciduous Rain Forest	10.48±0.30	9.56±0.56	9.00±1.30	10.13±0.34	14.50±0.92[a]	7.81±0.24[b]
		ercentage hatc (LSD=8.84)				
	Cr	**F**	**H**	**Na**	**Po**	**nf**
Coastal	93.31±2.94	82.45±3.55	91.67±4.81 [a]	82.57±3.14	91.05±3.55[a]	83.31±2.35
Guinea savannah	86.34±1.68	86.74±1.58	85.76±1.77 [a]	86.46±2.45	92.95±5.89[a]	87.59±1.12
Semi-deciduous Rain forest	87.07±1.60	89.19±2.94	64.00±6.80[b]	87.00±1.77	78.50±4.81[b]	80.89±1.25

Means within the same column with different superscript letters are significantly different (p<0.05). LSD: Least significant difference, Cr: crest, F: frizzle, H: silky, Na: naked neck, Po: polydactyl, na: normal feathered, ±: standard error of the means

4.11 Evaluation of body weight and linear body measurements of indigenous chicken

4.11.1 Effects of ecological zone on body weight and linear body measurements of indigenous male and female chickens.

The effect of zone on body weight and linear body measurements of adult male and female chickens are shown on Table 4.5.4. Average body weight for adult cocks were not significantly different (p>0.05) between Guinea Savannah (1.35kg) and Coastal Savannah (1.26kg) but significantly heavier in Semi-deciduous Rain Forest (1.86kg) compared to the two other zones. Similarly the mean body weights for hens were also significantly higher in Semi-Deciduous Rain Forest than the values recorded for other two zones. However, Guinea savannah and Coastal Savannah had no significant difference in terms of body weight for local hens. The present work supported an earlier findings by Osei- Amponsah *et al.*, (2007) that significant differences in performance between indigenous chickens in the Forest and Savannah Zones in Ghana. The values obtained from this study is again similar to those reported by

Hagan *et al.*, (2013) who observed 1.8kg (cocks) for Coastal Savannah and 1.7kg (cocks) for both Forest and Guinea Savannah zone while 1.3kg for hens was noticed for all three zones in Ghana for mean live body weight. However, the body weight recorded in the present study for Semi-Deciduous Rain Forest fell within the weight range of 1.52kg to 1.59kg and 1.03kg to 1.30kg for cock and hen respectively as reported by Adomako *et al.*, (2013) in Ashanti Region of Ghana. The shank length, wing length, and the keel length were significantly influenced by the zone interaction for adult males ($p<0.05$). The average body length and toe length for Guinea savannah and Coastal Savannah did not differ significantly ($p>0.05$) from each other while the highest average body length (46.82cm) and average toe length (5.61cm) were recorded in Semi-Deciduous Rain Forest for male chickens within the study area

(Table 4.5.4). The average body girth for Guinea Savannah and Semi-Deciduous Rain Forest did not vary significantly ($p>0.05$) from each other but Coastal Savannah recorded the lowest average body girth for males.

In terms of female, Semi-Deciduous Rain Forest was significantly superior ($p<0.05$) in shank length and body girth followed by the Guinea Savannah and the Coastal Savannah zones respectively (Table4.5.4). The wing length, body length and keel length data obtained were significantly different from each other among the three ecological zones in Ghana.

The significant superiority in body weight and linear body measurements of SemiDeciduous Rain Forest when compared with other Savannah Zones could be due to the favorable environmental conditions the chickens found themselves. The forest zone also experience two rainy periods which indirectly influence the availability of feed for the birds. Hence, indigenous chickens in the forest areas might be able to get richer scavenging feed resources and have a better growth than those in the other zones.

Clarke (2004) stated that chickens performance are improved when supplementary feed are always available. The chickens within the Semi-Deciduous Rain Forest may also have inherent adaptive features like hardiness to intense rainfall, resistance to most of the local chicken diseases and heat dissipation characters that could have been contributed to higher body weight and appreciable linear body measurements. Addison *et al.*, (2014) made a submission that local birds with better heat dissipation are able to conserve more energy thereby directing it into productive functions such as egg production and body weight gain.

The body weight, shank length and body length of adult males in this study were higher than their female counterparts and this could be due to sexual dimorphism exhibited by local chickens which normally favours the males than the females. The present results were in agreement with earlier reports by Fayeye and Oketoyin (2006) and Osei-Amponsah *et al.*, (2007) who stated that indigenous male chickens were heavier than their female chicken counterparts. The present work agrees with the work of Okpeku *et al.*, (2003) in local chicken from Edo State in Nigeria who observed longer shank length in males than in female adult chickens. Comparatively, the present report is in agreement with Badubi *et al.*, (2006) who stated that males are superior to females in most of the linear body measurements.

Table 4.5.4: Effect of zone on male and female body weight and linear body measurement of local chickens in three ecological zones in Ghana

	MALE				FEMALE			
Variable	**Guinea Savannah**	**SemiDeciduous Rain Forest**	**Coastal Savannah**	**LSD**	**Guinea Savannah**	**SemiDeciduous Rain Forest**	**Coastal Savannah**	**LSD**
Body weight, kg	1.35±0.06[b]	1.86±0.04[a]	1.26±0.07[b]	0.17	1.07±0.02[b]	1.38±0.03[a]	1.11±0.02[b]	0.07

shank length, cm	8.44±0.18[b]	9.85±0.12[a]	7.13±0.21[c]	0.49	6.83±0.05[b]	7.72±0.06[a]	5.97±0.06[c]	0.17
Body length, cm	42.24±0.74[b]	46.82±0.48[a]	40.83±0.88[b]	2.00	37.14±0.26[c]	40.78±0.31[a]	38.30±0.28[b]	0.79
Wing length, cm	18.92±0.42[b]	21.74±0.27[a]	16.50±0.49[c]	1.13	16.04±0.16[c]	18.58±0.18[a]	16.88±0.17[b]	0.48
Body girth, cm	32.33±0.76[a]	30.50±0.50[a]	27.35±0.90[b]	2.05	29.29±0.25[b]	31.01±0.29[a]	28.19±0.26[c]	0.74
Keel length, cm	10.30±0.21[b]	11.28±0.14[a]	7.96±0.25[c]	0.57	9.03±0.06[c]	9.80±0.07[a]	9.37±0.06[b]	0.18
Toe length, cm	5.13±0.10[b]	5.61±0.06[a]	5.29±0.12[b]	0.27	4.42±0.10[b]	4.83±0.12[a]	4.35±0.11[b]	0.32

[abc] *Means in the same row with different letters are significantly different at the 5%level for male and female respectively. LSD: least significant difference, ±: standard error of means.*

4.11.2 Effects of mutant traits on live body weight and linear body measurements of adult male indigenous chicken

The average body weight were not different among the frizzle, silky, polydactyl, ptilopody and the normal feathered birds but performed better than naked neck within the chicken population observed. The present results obtained from this study however disagrees with earlier findings by Njenga (2005) who compared naked neck with other local chicken phenotypes and reported that the naked neck chickens were superior in terms of body weight than the other local chicken genotypes. The average body weight for adult male chickens in this study (Table 4.5.5) therefore contradicts the report made by Adomako *et al.*,(2013) who recorded significantly higher body weight for the naked necks compared to the frizzles and normal feathered birds. The average shank length recorded in all the phenotypes were similar.

The average body length was relatively the same in all the treatments ($p>0.05$). However, Normal feathered and ptilopody birds had better shank length than other phenotypes. The body girth for frizzle, silky, naked neck, polydactyl and normal feathered counterparts were not significantly ($p>0.05$) different from each other while the lowest body girth was recorded in ptilopody. The wing length for all the phenotypes was similar but Ptilopody and normal feathered birds had better length than the rest of the phenotypes. Again, ptilopody birds had superior keel length ($P<0.05$) while the rest of the phenotypes were similar in keel length. Silky birds also recorded shorter keel length as compared with other phenotypes. The exceptional performance of the ptilopody phenotypes in terms of shank length, body length and kneel length from Table 4.5.5 might be influenced by genetic and environmental dynamics which is highly related to faster growth rate and skeletal development.

Moreover the trait could be selected for subsequent poultry genetic improvement programme. The present result on shank length of adult male local chickens were similar to the findings of Msoffe *et al.*,(2002) who reported 12.7cm (8.5cm to 15cm) as the mean shank length of free range local chickens in Tanzania. Earlier researchers made a submission that shank length is used as a prerequisite tool for determining the fertility, body weight, estimates of frame size as well as examining the growth and development of pullets (Salahi *et al.*, 2013). The keel length and shank length are considered as good markers of skeletal development which is highly related to the amount of meat a bird can carry. According to Gao *et al.*, (2010) adult males with a good balance of shank length, keel length and breast width had a high fertility rate.

The mean toe length for ptilopody and normal feathered birds were better ($p<0.05$) but there was no significant difference ($p>0.05$) existed among all the genotypes.

Again, ptilopody and normal feathered birds had longer toe length than silky birds (Table 4.5.5). The longer toe length for the ptilopody and normal feathered phenotypes indicate how far the birds are able to scratch the surface of the soil for food in order to expose some of the organisms in the soil such as earth worms, insects and other feed items for nourishment to improve growth. Another reason could be due to inherent characteristics of the birds that help them to balance their center of gravity during standing and ability of the birds to run away quickly from their predators in terms of danger than their recessive counterparts. According to Fournier *et al.*, (2015) the nature of the toe length of turkey birds determines the active behaviours of the birds in terms of feeding, standing, walking and running.

Table 4.5.5: Effect of mutant trait on male body weight and linear body measurement of local chickens in three ecological zones in Ghana

MALE	Frizzle	Silky	Naked neck	Polydactyl	Ptilopody	Normal	LSD
Body weight, kg	1.58 ± 0.16^{a}	1.49 ± 0.13^{a}	1.33 ± 0.08^{b}	1.76 ± 0.21^{a}	1.79 ± 0.11^{a}	1.64 ± 0.04^{a}	0.37
shank length, cm	8.36 ± 0.44^{ab}	7.72 ± 0.38^{abc}	8.05 ± 0.23^{abc}	9.38 ± 0.45^{a}	10.17 ± 0.27^{a}	9.09 ± 0.11^{ab}	0.92
Body length, cm	42.23 ± 1.80^{ab}	41.35 ± 1.54^{abc}	40.27 ± 0.95^{abc}	43.95 ± 1.84^{ab}	48.42 ± 1.09^{a}	45.16 ± 0.45^{a}	3.75
Wing length, cm	18.34 ± 1.02^{ab}	18.03 ± 0.87^{ab}	19.06 ± 0.54^{ab}	19.30 ± 1.04^{ab}	21.76 ± 0.62^{a}	20.35 ± 0.25^{a}	2.12
Body girth, cm	31.99 ± 1.85^{a}	30.61 ± 1.58^{a}	31.06 ± 0.98^{a}	28.01 ± 1.89^{a}	26.47 ± 1.12^{b}	31.34 ± 0.46^{a}	3.84
Keel length, cm	10.32 ± 0.5^{b}	9.13 ± 0.44^{bc}	9.58 ± 0.27^{b}	10.56 ± 0.53^{b}	11.75 ± 0.31^{a}	10.41 ± 0.12^{b}	1.07
Toe length, cm	5.19 ± 0.24^{ab}	4.73 ± 0.21^{abc}	5.28 ± 0.13^{ab}	5.08 ± 0.25^{ab}	5.90 ± 0.15^{a}	5.46 ± 0.06^{a}	0.51

Means within a row with no common superscript differ significantly at the 5%level.

LSD: least significant difference, ±: standard error of the means.

4.11.3 Effects of mutant trait on physical characteristics of adult female local chickens

From table 4.5.6, the body weight and the toe length for adult female chickens were not influenced by the genotypes ($p>0.05$). Hence, no significant difference might be due to common ecological adaptations of the birds which enhanced their ability to scratch their immediate environment for invertebrates to be used as a source of food in order to increase their growth. The mean body weight of adult female chickens for the various phenotypes in this present work were in accordance with other researches that local chickens are relatively small in body weight (Fayeye and Oketoyin, 2006; Nwosu and Asuquo, 1985; Nwosu and Omeje, 1985). The silky birds recorded a higher shank length followed by ptilopody and naked neck while the shank length for frizzle, polydactyl, crest feathered and their normal counterparts were similar ($p>0.05$). It could be seen that an increase in shank length also corresponds with an increase in body weight especially the silky birds. Shank length is closely connected with body weight. Since shank length is considered as a good tool for checking growth and development. Again, frizzle, polydactyl, crest feathered and normal feathered birds recorded similar values for shank length. The current data on shank length for the various phenotypes were in line with the discoveries of Msoffe *et al.*, (2002) who indicated shank length 9.7cm with a range of 7.0cm to 12.0cm for adult female local chickens in Tanzania.

The body length for all the treatments were not significantly different ($p>0.05$) from each other. The wing length for silky, ptilopody, crest feathered and normal feathered was longer than frizzle, naked neck, and polydactyl (Table 4.5.6). Polydactyl birds recorded a better body girth but no difference existed between frizzle, silky, naked neck, crest feathered and normal feathered birds. Again, the body girth for polydactyl was significantly better than ptilopody ($p<0.05$).

The average keel length was relatively similar across the treatments ($p>0.05$). There was no significant difference in keel length between frizzle, naked neck, crest feathered and normal feathered counterparts while the lowest keel length was recorded in frizzle. The toe length of female birds recorded no significant difference among all the phenotypes ($p>0.05$).

The average body weight, keel length, body length, toe length and shank length of female birds recorded in this current study agrees with Badubi *et al.*, (2006) who reported that when chickens are taken as one group their mean values tend to overshadow the effect of individual region.

Table 4.5.6: Effect of mutant trait on female body weight and linear body measurement of local chickens in three ecological zones in Ghana

FEMALE	Frizzle	Silky	Naked neck	Polydactyl	Ptilopody	Crest	Normal	LSD
Body weight, kg	1.17±0.03	1.22±0.09	1.15±0.03	1.31±0.10	1.22±0.09	1.18±0.03	1.17±0.02	0.18
shank length, cm	6.78±0.08^{bc}	8.30±0.23^{a}	7.04±0.08^{b}	6.96±0.27^{bc}	7.40±0.22^{b}	6.69±0.07^{bc}	6.60±0.05^{bcd}	0.44
Body length, cm	37.43±0.39^{ab}	40.18±1.03^{a}	38.83±0.40^{a}	38.62±1.21^{a}	40.37±1.00^{a}	38.91±0.33^{a}	38.50±0.24^{a}	1.98
Wing length, cm	16.75±0.24^{b}	18.37±0.63^{a}	16.98±0.24^{b}	16.74±0.74^{b}	18.61±0.60^{a}	16.96±0.20^{a}	17.07±0.15^{a}	1.21
Body girth, cm	28.61±0.37^{b}	30.22±0.97^{b}	29.13±0.37^{b}	32.28±1.14^{a}	26.72±0.93^{c}	30.31±0.31^{b}	29.58±0.23^{b}	1.86
Keel length, cm	8.99±0.09^{abc}	9.74±0.24^{a}	9.38±0.09^{ab}	10.08±0.28^{a}	9.85±0.23^{a}	9.39±0.07^{ab}	9.37±0.05^{ab}	0.46
Toe length, cm	4.37±0.16	4.80±0.42	4.46±0.16	4.78±0.49	4.97±0.40	4.46±0.13	4.57±0.10	0.8

Means within a row with no common superscript differ significantly at the 5%level.
LSD: least significant difference, ±: standard error of the means.

4.11.4 Effects of mutant trait and zone interactions for adult male live body weight and linear body measurements

Table 4.5.7 shows the effects of zone and mutant trait interactions on body weight and linear body measurements for adult male chickens within the three ecological zones in Ghana. There were no significant difference (p>0.05) in body weight with respect to the distribution of the various phenotypes within the three ecological zones. The toe length and keel length for the various phenotypes were also not significantly (p>0.05) influenced by zones interaction (Table 4.5.7). In terms of shank length, the naked neck, silky and frizzle feathered birds within the three ecological zones recorded no significant differences.

The body length for frizzle, silky, naked neck and polydactyl was relatively the same in all ecological zones within the study area. Ptilopody birds recorded a higher body length in Semi-deciduous rain forest and Guinea Savannah than Coastal Savannah (Table 4.5.7).

The wing length for frizzle, polydactyl, ptilopody and their normal feathered counterparts was significantly (p<0.05) longer in Semi-deciduous rain forest and Guinea Savannah than Coastal Savannah zone while silky and naked neck birds were not significantly different from each other with respect to the zones within the area of study (Table 4.5.7).

The body girth for frizzle, naked neck and normal feathered was not significantly different from each other with respect to the three ecological zones. Again the body girth for silky and polydactyl birds were not significantly different from each other in Semi-deciduous rain forest and Guinea Savannah but significantly better than Coastal savannah zone. However, the body girth for polydactyl birds in Semi-deciduous rain forest, Guinea Savannah and Coastal savannah zone were similar ($p>0.05$).

The variation observed between the various zones could be attributed to differences in genetic characteristics of the individual birds and the availability of feed resources found within the zone. The results obtained in this present study were similar to finding of an earlier study by Tadelle *et al.,* (2003a) who assessed the genetic distance between and within ecotypes in Ethiopia local birds and observed genetic variation in both, but was higher within ecotype than between ecotypes. Moreover, Leroy *et al.,* (2012) reported higher resemblance of hereditary structure between chicken populaces living in a similar major farming systems through West African countries than between farming systems inside countries. The result on body weight (Table 4.5.7) indicates that birds in Semi-deciduous Rain Forest ecotypes were heavier than those in the other two ecotypes which disagree the earlier report by Youssao *et al.,* (2012) that body weights of indigenous chickens in Savannah ecotype were heavier than that of Forest ecotype in Benin. Similar conflicting observation was made by Fotsa (2008) in Cameroon where the Savannah-West/West indigenous chickens were found to be heavier than chickens from the Forest and Central regions.

Table 4.5.7: Effect of zone and mutant trait interactions on adult male body weight and linear body measurement of local chickens in three ecological zones in Ghana

	Mean body weight (kg) (LSD=0.59)					
	F	H	Na	Po	Pti	nf

	F	H	Na	Po	Pti	nf
Coastal Savannah	1.30±0.16	1.40±0.28	1.30±0.19	1.27±0.24	1.10±0.28	1.27±0.10
Guinea savannah	1.25±0.17	1.58±0.19	1.11±0.19	1.85±0.34	1.66±0.28	1.32±0.07
Semi-deciduous Rain forest	1.86±0.28	1.48±0.21	1.45±0.10	1.90±0.34	2.11±0.11	1.95±0.05
	Mean shank length (cm) (.SD=1.54)					
	F	**H**	**Na**	**Po**	**Pti**	**nf**
Coastal	6.72±0.4[ab]	8.00±0.75	6.66±0.53[ab]	6.50±0.6[b]	7.33±0.7[b]	7.20±0.29 [b]
Guinea savannah	8.11±0.4[a]	8.66±0.53	7.33±0.53 [a]	10.00±0.92[a]	10.66±0.75[a]	7.98±0.20 [b]
Semi-deciduous Rain forest	9.00±0.7[a]	7.20±0.14	8.82±0.29 [a]	10.00±0.65[a]	10.82±0.22[a]	10.20±0.14 [a]
	Mean body length (cm) (LSD=6.23)					
	F	**H**	**Na**	**Po**	**Pti**	**nf**
Coastal	40.89±1.77	40.00±3.06	40.83±2.16	39.00±2.65	42.33±3.06	40.60±1.18
Guinea savannah	40.78±1.77	43.83±2.16	38.50±2.16	45.00±3.75	49.33±3.06	40.93±0.82
Semi-deciduous Rain forest	43.33±3.06	40.60±2.37	40.93±1.18	45.00±2.65	49.88±0.91	48.88±0.91
	Mean wing length (cm) (LSD=3.52)					
	F	**H**	**Na**	**Po**	**Pti**	**nf**
Coastal	16.11±1.00[b]	17.67±1.73	17.17±1.22	16.00±1.50[b]	15.33±1.73[b]	16.65±0.67 [b]
Guinea savannah	17.00±1.00[a]	18.33±1.22	18.33±1.22	20.00±2.12[a]	23.00±1.73[a]	18.17±0.46 [a]
Semi-deciduous Rain forest	19.67±1.73[a]	18.00±1.34	20.00±0.67	20.00±1.50[a]	23.18±0.51[a]	22.53±0.34 [a]
	Mean body girth (cm) (LSD=6.39)					
	F	**H**	**Na**	**Po**	**Pti**	**nf**
Coastal	27.33±1.81	26.67±3.14[b]	28.67±2.22	27.00±2.72[b]	27.67±3.14[a]	27.05±1.21
Guinea savannah	32.22±1.81	33.67±2.22[a]	30.00±2.22	34.00±3.85[a]	33.33±3.14[a]	32.33±0.84
Semi-deciduous Rain forest	33.33±3.14	30.40±2.43[a]	32.30±1.21	25.50±2.72[b]	22.85±0.93[ab]	32.22±0.61
	Mean keel length (cm) (LSD=1.79)					
	F	**H**	**Na**	**Po**	**Pti**	**nf**
Coastal	7.88±0.50	8.00±0.88	8.50±0.62	8.50±0.76	8.33±0.88	7.70±0.34
Guinea savannah	9.77±0.50	10.16±0.62	9.00±0.62	11.00±1.07	12.50±0.88	10.02±0.23
Semi-deciduous Rain forest	11.33±0.88	9.00±0.68	10.20±0.34	11.00±0.76	12.47±0.26	111.43±0.17
	Mean toe length (cm) (LSD=0.85)					
	F	**H**	**Na**	**Po**	**Pti**	**nf**
Coastal	5.22±0.24	5.00±0.42	5.33±0.29	5.50±0.36	5.00±0.42	5.40±0.16
Guinea savannah	4.88±0.24	4.83±0.29	5.00±0.29	5.00±0.51	6.16±0.42	4.94±0.11

Semi-deciduous Rain forest	5.33±0.42	4.60±0.32	5.40±0.16	5.00±0.36	6.05±0.12	5.72±0.08

Means within columns with different superscripts along the same row are significantly different (p<0.05), LSD: least significant difference, ±: standard error of the means, Cr: crest, F: frizzle, H: silky, Na: naked neck, Po: polydactyl, Pti: ptilopody, nf: normal feathered

4.11.5 Effect of mutant trait and zone interactions on body weight and linear body measurement of adult females.

The effect of mutant trait and zone interactions on body weight and other body parameters on adult female chickens are presented on Table 4.5.8. Body weight, shank length and toe length were not significantly (p>0.05) different from each other across the birds within the three ecological zones (Table 4.5.8). Mean body length for silky birds with respect to Semi-deciduous rain forest was significantly higher (p<0.05) than that of the Coastal Savannah which was also significantly higher than that of the Guinea Savannah zone. Body length of crest feathered birds in Semideciduous rain forest was significantly higher (p<0.05) than that of the Coastal Savannah and Guinea Savannah zone. The body length for naked neck in Coastal Savannah, Guinea Savannah and Semi-deciduous rain forest were relatively the same (p>0.05). However, Semi-deciduous rain forest and Coastal Savannah were better in body length for naked neck than Guinea Savannah zone. Mean body lengths for ptilopody were the same in all the zones but Coastal Savannah recorded lower body length as compared with other zones.

The mean wing length for crest feathered and polydactyl in Semi-deciduous rain forest was significantly longer (p<0.05) compared to Coastal and Guinea Savannah zone (Table 4.5.8). Mean wing length for frizzle and ptilopody birds were not significantly different (p>0.05) among the three ecological zones. Wing length for silky birds was significantly longer in Semi-deciduous rain forest than Coastal Savannah and Guinea Savannah zone, whereas relative wing length for naked neck and normal feathered birds were not significantly different within the three zones.

The crest feathered and frizzle recorded no significance for body girth for all three zones. The body girth for silky birds was highly significant ($p<0.05$) with respect to Semi-deciduous rain forest while Coastal Savannah and Guinea Savannah zones were relatively similar. Body girth for polydactyl birds was significantly longer in Semideciduous rain forest than Coastal Savannah and Guinea Savannah zone. The mean body girth for naked neck, ptilopody and normal feathered counterparts did not differ significantly ($p>0.05$) between all the three ecological zones.

Semi-deciduous rain forest recorded better toe length for silky, polydactyl and ptilopody birds than Coastal Savannah and Guinea Savannah. Hence, the toe length for crest, frizzle, naked neck and normal feathered birds were not significantly influenced by the ecological zones within the study area.

Table 4.5.8: Effect of ecological zone and mutant trait interactions on body weight and linear body measurement of adult female indigenous chickens.

	Mean body weight (LSD=0.29)						
	Cr	**F**	**H**	**Na**	**Po**	**Pti**	**Nf**
Coastal	1.13±0.05	1.10±0.06	0.91±0.15	1.17±0.05	1.34±0.09	1.15±0.12	1.08±0.04
Guinea Savannah	1.04±0.05	1.11±0.04	0.98±0.05	1.03±0.07	1.06±0.21	1.13±0.21	1.09±0.03
Semideciduous Rain forest	1.40±0.04	1.30±0.08	1.80±0.26	1.27±0.05	1.60±0.15	1.40±0.09	1.35±0.04
	Mean shank length (LSD=0.70)						
	Cr	**F**	**H**	**Na**	**Po**	**Pti**	**Nf**
Coastal	5.83±0.13	6.12±0.15	7.25±0.35	6.28±0.12	5.85±0.23	6.16±0.29	5.58±0.10

	Cr	F	H	Na	Po	Pti	Nf
Guinea Savannah	6.75±0.13	6.72±0.11	6.81±0.13	7.06±0.18	6.50±0.61	7.66±0.50	6.77±0.08
Semideciduous Rain forest	7.38±0.10	7.45±0.19	11.00±0.61	7.69±0.12	8.50±0.35	8.20±0.22	7.30±0.09

Mean body length (LSD=3.15)

	Cr	F	H	Na	Po	Pti	Nf
Coastal	37.67±0.61^{b}	38.27±0.68	39.50±1.59^{b}	38.61±0.57^{a}	38.36±1.04	38.56±1.30^{ab}	38.27±0.48
Guinea Savannah	37.35±0.59^{b}	36.17±0.50	35.77±0.61^{c}	37.30±0.81^{ab}	38.50±2.76	40.00±2.25^{a}	37.21±0.37
Semideciduous Rain forest	41.88±0.48^{a}	38.15±0.87	46.00±2.76^{a}	40.85±0.57^{a}	39.00±1.59	42.47±1.01^{a}	40.24±0.43

Mean wing length (LSD=1.92)

	Cr	F	H	Na	Po	Pti	Nf
Coastal	15.92±0.37^{b}	17.42±0.41	18.00±0.97^{b}	16.43±0.35^{a}	16.50±0.63^{b}	18.22±0.79	17.09±0.29^{a}
Guinea Savannah	15.86±0.36^{b}	15.68±0.31	15.55±0.37^{c}	16.30±0.49^{ab}	15.00±1.68^{b}	18.00±1.37	16.17±0.23^{ab}
Semideciduous Rain forest	19.18±0.29^{a}	17.40±0.53	22.00±1.68^{a}	18.26±0.35^{a}	19.00±0.97^{a}	19.67±0.61	18.10±0.26^{a}

Mean body girth (LSD=2.96)

	Cr	F	H	Na	Po	Pti	Nf
Coastal	29.17±0.58	27.52±0.64	27.67±1.50^{b}	28.67±0.54^{a}	28.50±0.98^{c}	27.22±1.22^{a}	27.88±0.45^{a}
Guinea Savannah	30.84±0.58	28.53±0.47	28.95±0.58^{b}	27.91±0.76^{ab}	32.00±2.60^{b}	24.67±2.12^{ab}	29.66±0.35^{ab}
Semideciduous Rain forest	30.71±0.45	29.70±0.82	34.00±2.6^{a}	30.98±0.54^{a}	36.00±1.50^{a}	28.67±0.94^{a}	31.02±0.40^{a}

Mean keel length (LSD=0.74)

	Cr	F	H	Na	Po	Pti	Nf
Coastal	9.25±0.14	9.33±0.15	9.50±0.37^{b}	9.53±0.13	9.28±0.24^{b}	9.33±0.30^{b}	9.37±0.11
Guinea Savannah	9.18±0.14	8.59±0.11	8.85±0.14^{b}	9.13±0.19	9.50±0.64^{b}	9.66±0.52^{b}	9.01±0.08
Semideciduous Rain forest	9.75±0.11	9.17±0.20	11.00±0.64^{a}	9.54±0.13	11.50±0.37^{a}	10.53±0.23^{a}	9.78±0.10

Mean toe length (LSD=1.28)

	Cr	F	H	Na	Po	Pti	Nf
Coastal	4.33±0.25	4.34±0.27	4.33±0.64	4.38±0.23	4.35±0.42	4.50±0.52	4.35±0.19
Guinea Savannah	4.22±0.24	4.19±0.20	4.14±0.25	4.28±0.33	4.50±1.12	5.16±0.91	4.68±0.15
Semideciduous Rain forest	4.86±0.19	4.60±0.35	6.00±1.12	4.75±0.23	5.50±0.64	5.16±0.40	4.64±0.17

Means within columns with different superscripts along the same row are significantly different (p<0.05) LSD: least significant difference, ±: standard error of the means Cr: crest, F: frizzle, H: silky, Na: naked neck, Po: polydactyl, pti: ptilopody, nf: normal feathered.

4.12. Relationship between live body weight and linear body measurements of adult male indigenous chickens within the study area.

Correlation coefficient for adult male live body weight (kg) and linear body measurements (cm) are presented in Table 4.6. It could be realized from the correlation analysis that the correlation coefficient of the various body traits for almost all the genotypes were significant ($p<0.01$). The current study on correlation between body weight and linear measurements support the findings of Ibe and Nwakalor (1987) who recorded high and positive correlations between body weight and linear measurements in the Nigerian local chicken. Polydactyl and ptilopody phenotypes showed better correlation significance ($p<0.05$) for wing length, keel length and toe length respectively. No-significance were recorded between body weight and toe length (-0.574) in polydactyl phenotypes, body weight and body girth (0.009) in ptilopody phenotypes, body weight and toe length (0.520) in silky phenotypes. Again, body weight and body girth (-0.257), keel length (0.335) and toe length (0.062) in frizzle phenotypes were not significantly affected. It could be seen from Table 4.6 that the highest and positive correlation coefficient were recorded between body weight and body girth (0.978) as well as body weight and body length (0.905) in polydactyl phenotypes. It means that body girth and body length could best be used as indicators of body weight for polydactyl phenotypes. Yakubu and Salako (2009) reported that, the body length contribute 83.0% in body weight for indigenous chicken managed in extensive system in Nigeria. Lilja (1983) who observed strongest correlation between chest girth and body weight of 0.93. Raji *et al*., (2009) also reported very high association between body weight and chest girth in Muscovy ducks and further explained that, the strong relationship between chest girth and body weight could be attributed to the presence of important bones, muscles and viscera at the chest region. Meanwhile the toe length (-0.574) for polydactyl birds were negatively correlated with body weight. However, toe length is not an economic trait which is more important to the poultry farmer. Polydactyl and naked neck birds recorded appreciable correlation coefficient for all the linear body measurement as compared with their counterparts. This implies that polydactyl chickens and naked neck chickens had very strong relationship between linear body measurements and body weight. The present study was in line with the findings of Ukwu *at al.*, (2014) who reported similar values for correlation between body weight and shank length (0.896), body girth (0.816), wing length (0.812), thigh length (0.839) and back length (0.888) for Nigerian indigenous chicken. The current results also agrees with Alabi *et al.*, (2012), and Yahaya *et al*., (2012) who reported positive correlation between linear body measurements and body weight in naked neck/venda and broiler chickens in South Africa respectively. Missohou *et al*., (2003) also reported good relationship between shank length and body weight. The phenotypic correlation between body weight and body girth (-0.257) in frizzle as well as body weight and toe length (0.574) as in polydactyl birds were very low and negative which implied weak relationship between body weight and body measurements of these birds. In general, the correlation of linear body measurement with body weight in all the breeds were medium to high which conform to Ezzeldin *et al*.,(1994) who recorded medium to high correlation between body weight and linear body measurements in pure breed chickens and their crosses. The medium to high and positive phenotypic correlations between live body weight (kg) and shank length, body length, wing length, keel length shows that local chicken keepers can use tape measure to determine weight of a bird easily without carrying weighing scale to their farms. Correlation enhanced the level at which one body part affect the other and they could be useful in pricing chickens since there are mostly no weighing scale available to weigh the birds during sales.

Table 4.6. Correlation coefficient between live body weight (kg) and linear body measurements (cm) in adult male Ghanaian indigenous chicken population.

Breed	SL	BL	WL	BG	KL	TL
Polydactyl	0.846**	0.905**	0.749*	0.978**	0.711*	-0.574
Naked neck	0.804**	0.815**	0.855**	0.865**	0.858**	0.763**
Silky	0.698**	0.813**	0.731**	0.749**	0.727**	0.520
Ptilopody	0.653**	0.624**	0.683**	0.009	0.701**	0.450*
Frizzle	0.639**	0.278	0.601**	-0.257	0.335	0.062
Normal	0.662**	0.795**	0.355**	0.495**	0.686**	0.441**

** ($p<0.01$), * ($p<0.05$); SL= shank length; BL= Body length; WL= Wing length; BG= Body girth, KL= keel length TL= toe length

4.13 Correlation analysis for live body weight and linear body measurements in adult female indigenous chicken.

Coefficient of correlation between live body weight and linear body dimensions for adult female local chickens are presented in Table 4.7. The results showed that correlation between live body weight and linear body measurements for all the breeds were positive except frizzle phenotypes which gave negative for toe length. The values obtained for the frizzle birds were very low which indicates weak relationship between body weight and its linear body measurements. The correlation between body weight and body length, wing length and toe length in ptilopody phenotypes were positive and highly significant ($p<0.01$) than its recessive phenotypes. Polydactyl phenotypes recorded appreciable relationship between body weight and other linear measurements such as shank length, wing length, toe length, body girth and keel length. The correlation coefficient in polydactyl is low-medium. The current study was in agreement with the findings of Teguia *et al*., (2008) who recorded highest relationship between body weight and wing length in Muscovy duck. The relationship between body weight and linear body measurements recorded in this study are in accord with those reported by Ojedapo *et al.*, (2012) and Momoh and Kershima (2008) . However, high market price of every chicken is best determined by its live body weight which is more important to both consumer and the farmers. It is important to note that, traits with more economic value should be considered in selection programs for high body weight which is of interest to both the poultry farmer and the final consumer.

Table 4.7 Correlation between live body weight (kg) and linear body measurements (cm) in the Ghanaian local chicken population for adult females.

Breed	**SL**	**BL**	**WL**	**BG**	**KL**	**TL**
Polydactyl	0.669**	0.135	0.609**	0.599**	0.522*	0.667**
Naked neck	0.294**	0.618**	0.488**	0.36**	0.584**	0.459**
Silky	0.631**	0.257	0.447**	0.225	0.389**	0.633**
Ptilopody	0.627**	0.858**	0.882**	0.435*	0.666**	0.741**
Frizzle	0.104	0.019	0.044	0.13	0.154	-0.008
Crest	0.334**	0.488**	0.221**	0.178*	0.355**	0.479**

Normal	0.320**	0.516**	0.144*	0.237**	0.510**	0.046

** ($p<0.01$), * ($p<0.05$); SL= shank length; BL= Body length; WL= Wing length; BG= Body girth, KL= keel length, TL= toe length

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

It could be concluded that, naked neck, frizzle, silky, crest, ptilopody, polydactyl and flightless mutant birds were present within the local chicken population in Ghana. Despite the fact that, the gene frequencies for polydactyl, ptilopody, naked neck, frizzle and silky phenotypes were very low within indigenous chicken population, they had unique potential for faster growth and lay high number of eggs compared to their normal counterparts.

5.2 Recommendations

1. It is recommended that polydactyl, ptilopody, naked neck and silky phenotypes must be preserved for future breeding programs in order to prevent the total extinction of these important genes.
2. More public education should be organized at the village level and market centers by extension agents to eliminate the negative social bias against these mutant traits found within the local chicken population.
3. Further studies should be conducted on molecular analysis of these mutant birds to determine the genetic reasons for the high growth rate and better egg production performance of the mutant birds.
4. Local poultry farmers should incorporate these mutant genes into meat and egg type chickens for improved productivity and adaptability to the humid tropical conditions in Ghana.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE FOR THE SURVEY

TOPIC: IDENTIFICATION OF LOCAL CHICKEN WITH MUTANT GENES

Ecological Zone: Guinea savanna [ ] Semi-deciduous rainforest [ ] Coastal savanna [ ]

District: …………………………………… Town/ Village …………………

Name of Respondent ……………………………………………………………………

Sex: male [ ] female [ ]

Marital status: single [ ] married [ ]

Age: 6-12yrs [ ] 13-20yrs [ ] 21yrs and above [ ]

Main Occupation………………………………………………………………………

Educational Background: Nil [ ] MSLC [ ] JHS [ ] SHS [ ] Tertiary [ ]

1) When did you start keeping local chickens? [ ]

2) How did you get your first birds? ....

1) How many local chickens do you have? [ ]

2) How many of them are ;

a) Hens (at sexual maturity and above) [ ]

b) Cocks (at sexual maturity and above) [

c) Growers (below sexual maturity but not following the hen) [

d) Chicks (birds following the hen) [ ]

Do you have the following local chickens?

e) Naked neck (_ kontwa')	Yes [ ]	No [ ]
f) Frizzle (_ Asense')	Yes [ ]	No [ ]
g) Silky (_Akok dwan')	Yes [ ]	No [ ]
h) Polydactyl (_Akok a new nan nsoa ye nnum')	Yes [ ]	No [ ]
i) Ptilopody (_Akok a ewi afu ne nan ho')	Yes [ ]	No [ ]
j) Dwarfism (_Akok ntiatia')	Yes [ ]	No [ ]
k) Muffled/bearded (_Akok ab dwes ')	Yes [ ]	No [ ]
l) Crest feathered (_Akok kye)	Yes [ ]	No [ ]
m) Normal feathered	Yes [ ]	No [ ]

If yes in any at (5), then continue.

3) How many of them are;	**Hens**	**cocks**	**Growers**	**chicks**
a) Naked neck	[ ]	[ ]	[ ] [ ]	[ ]
b) Frizzle	[ ]	[ ]	[ ] [ ]	[ ]
c) Silky	[ ]	[ ]	[ ] [ ]	[ ]
d) Polydactyl	[ ]	[ ]	[ ] [ ]	[ ]
e) Ptilopody	[ ]	[ ]	[ ] [ ]	[ ]

f) Dwarfism	[ ]	[ ]	[ ]	[ ]	[ ]
g) Muffled/bearded	[ ]	[ ]	[ ]	[ ]	[ ]
h) Crest feathered	[ ]	[ ]	[ ]	[ ]	[ ]
i) Normal feathered	[ ]	[ ]	[ ]	[ ]	[ ]

Complete the table below;

Body measurement (cm)	**sex**	Naked neck	Crest feathered	Frizzle	Silky	Polydactyl	Ptilopody	Dwarfism	Muffle/ bearded	Normal feathered
Average Live body weight	**Male**									
	Female									
Average shank length	**Male**									
	Female									
Average body length	**Male**									
	Female									
Average wing length	**Male**									
	Female									
Average body girth	**Male**									
	Female									
Average keel length	**Male**									
	Female									
Average toe length	**Male**									

	Female									

4) What system of management do you use? Intensive [ ]semi-intensive [ ] extensive [ ] 5) Where do your birds sleep at night? Trees [ ] Walls [ ] Hen coop [ ]

Others ……………………………………………………………………………..…

6) Do you give any feed supplement to your birds? Yes [ ] No [ ]

If yes, how often do you give them? Everyday [ ] Once a week [ ]

At least two times a week [ ] occasionally [ ]

7) What kind of feed supplement do you give? ....

8) What is the average clutch size of your layers? ……………………………………………

9) What is the average eggs per clutch of your layers? ………………………………………

10) What is the average eggs per bird per year of your layers? ....

11) What is the average weight of an egg from your layers? ……………………………..………

12) What is the percentage hatchability of your layers? ………………………………………

13) What is the percentage of eggs set hatched? ……………………………………………… 14) What percentage of chicks normally survives to adulthood? ……………………………..

15) What are the symptoms of diseases that normally attack your birds? ……………………

16) What is the mortality rate among the various groups of birds per year?

a) Naked neck [ ]

b) Frizzle [ ]

c) Silky [ ]

d) Polydactyl [ ]

e) Ptilopody [ ]

f) Dwarfism [ ]

g) Muffled/bearded [ ]

h) Crest feathered [ ]

i) Normal feathered [ ]

17) Why do you keep local chickens?

……………………………………………………………………………………………
……………………………………………………………………………………………

18) Do you sell some of your chickens in (5) above? Yes [ ] No [ ]

If yes, how much do you sell ;

a) One hen		b) one cock		c) One grower
i) ¢1.00 - ¢10.00	[ ]	i) ¢1.00 - ¢10.00	[ ]	i) ¢1.00 - ¢10.00 [ ]
ii) ¢11.00 - ¢15.00	[ ]	ii) ¢11.00 - ¢15.00	[ ]	ii) ¢11.00 - ¢15.00[ ]
iii) ¢16.00 - ¢20.00	[ ]	iii) ¢16.00 - ¢20.00	[ ]	iii) ¢16.00 - ¢20.00[ ]
iv) 20.00 above	[ ]	iv) ¢20.00 above	[ ]	iv) ¢20.00 above [ ]

19) Where do you normally sell them?

……………………………………………………………………………………………
……………………………………………………………………………………………

20) For what purpose do people purchase these birds?

……………………………………………………………………………………………
……………………………………………………………………………………………

21) Is there any other use for these mutant birds apart from selling them for petty cash?

……………………………………………………………………………………………
……………………………………………………………………………………………

22) Do you give the sick birds drugs? Yes [ ] No [ ]

If yes, specify the type of drug…………………………………………………

where do you get the drugs? ……………………………………………………

23) Has there been any genetic improvement on your birds? Yes [ ] No [ ]

APPENDIX 2.0: ANOVA TABLES

SURVEY ON QUALITATIVE MUTANT GENES WITHIN THE INDIGENOUS CHICKEN POPULATION.

Appendix 2.1: Laying performance of local chickens

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	1.8604	0.3721	0.91	0.476
+ ZONES	2	2.4446	1.2223	2.98	0.052
+ BREED.ZONES	10	6.0324	0.6032	1.47	0.147
Residual	560	229.7198	0.4102		
Total	577	240.0571	0.4160		

Variate: Average Eggs per Clutch per Bird

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	264.738	52.948	11.46	<.001
+ ZONES	2	247.864	123.932	26.83	<.001
+ BREED.ZONES	10	407.237	40.724	8.82	<.001
Residual	560	2586.807	4.619		
Total	577	3506.646	6.077		

Variate: Average Eggs per Bird per Year

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	2302.1	460.4	4.16	0.001
+ ZONES	2	1617.5	808.7	7.32	<.001
+ BREED.ZONES	10	5049.5	505.0	4.57	<.001
Residual	560	61905.9	110.5		
Total	577	70875.0	122.8		

Variate: Average Number of Eggs set for natural incubation

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	169.717	33.943	6.26	<.001
+ ZONES	2	18.826	9.413	1.74	0.177
+ BREED.ZONES	10	538.124	53.812	9.92	<.001
Residual	560	3036.438	5.422		
Total	577	3763.105	6.522		

Variate: Average Number of Chicks Hatched

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	176.477	35.295	6.87	<.001
+ ZONES	2	5.214	2.607	0.51	0.602
+ BREED.ZONES	10	351.556	35.156	6.84	<.001

Residual	560	2877.604	5.139
Total	577	3410.851	5.911

Variate: Average Clutch size per year

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	962.0	192.4	1.39	0.228
+ ZONES	2	1229.2	614.6	4.43	0.012
+ BREED.ZONES	10	4475.6	447.6	3.22	<.001
Residual	560	77723.1	138.8		
Total	577	84389.9	146.3		

Appendix 2.2: Female body weight and linear body measurement

Variate: Body Weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	6	3.2619	0.5436	3.90	<.001
+ ZONE	2	10.1245	5.0623	36.27	<.001
+ BREED.ZONE	12	1.6870	0.1406	1.01	0.440
Residual	718	100.2104	0.1396		
Total	738	115.2838	0.1562		

Variate: Shank length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	6	27.8823	4.6471	6.11	<.001
+ ZONES	2	280.3510	140.1755	184.29	<.001
+ BREED.ZONES	12	43.2607	3.6051	4.74	<.001
Residual	704	535.4887	0.7606		
Total	724	886.9827	1.2251		

Variate: Body length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	6	706.44	117.74	7.70	<.001
+ ZONES	2	1479.30	739.65	48.36	<.001
+ BREED.ZONES	12	326.65	27.22	1.78	0.048
Residual	702	10736.82	15.29		
Total	722	13249.20	18.35		

Variate: Wing length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	6	191.998	32.000	5.64	<.001
+ ZONES	2	727.397	363.698	64.13	<.001
+ BREED.ZONES	12	177.198	14.766	2.60	0.002
Residual	704	3992.318	5.671		

Total	724	5088.910	7.029		

Variate: Body girth

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	6	372.64	62.11	4.59	<.001
+ ZONES	2	715.02	357.51	26.44	<.001
+ BREED.ZONES	12	306.57	25.55	1.89	0.033
Residual	704	9520.89	13.52		
Total	724	10915.13	15.08		

Variate: Hatchability (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	6	48.9529	8.1588	9.69	<.001
+ ZONES	2	62.2501	31.1251	36.95	<.001
+ BREED.ZONES	12	31.9257	2.6605	3.16	<.001
Residual	704	592.9600	0.8423		
Total	724	736.0887	1.0167		

Variate: Toe length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	6	15.045	2.507	1.00	0.427
+ ZONES	2	21.033	10.516	4.17	0.016
+ BREED.ZONES	12	18.737	1.561	0.62	0.827
Residual	704	1773.779	2.520		
Total	724	1828.593	2.526		

Appendix 2.3: Male body weight anlinear body size measurement

Variate: Body weight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	6.0580	1.2116	5.06	<.001
+ ZONE	2	16.1735	8.0868	33.78	<.001
+ BREED.ZONE	10	3.3512	0.3351	1.40	0.182
Residual	218	52.1882	0.2394		
Total	235	77.7710	0.3309		

Variate: Shank length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	175.660	35.132	20.31	<.001
+ ZONE	2	267.288	133.644	77.27	<.001
+ BREED.ZONE	10	62.197	6.220	3.60	<.001
Residual	239	413.369	1.730		
Total	256	918.515	3.588		

Variate: Body length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	1855.00	371.00	13.14	<.001
+ ZONE	2	1716.58	858.29	30.41	<.001
+ BREED.ZONE	10	690.10	69.01	2.44	0.009
Residual	239	6746.57	28.23		

Total	256	11008.25	43.00		

Variate: Wing length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	573.032	114.606	12.71	<.001
+ ZONE	2	935.690	467.845	51.88	<.001
+ BREED.ZONE	10	189.984	18.998	2.11	0.025
Residual	239	2155.407	9.018		
Total	256	3854.113	15.055		

Variate: Kneel length

Variate: Body girth

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	1870.02	374.00	12.59	<.001
+ ZONE	2	591.38	295.69	9.96	<.001
+ BREED.ZONE	10	633.22	63.32	2.13	0.023
Residual	239	7097.13	29.70		
Total	256	10191.75	39.81		

Variate: Kneel length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	191.882	38.376	16.49	<.001
+ ZONE	2	313.174	156.587	67.29	<.001
+ BREED.ZONE	10	42.058	4.206	1.81	0.060
Residual	239	556.168	2.327		
Total	256	1103.282	4.310		

Variate: Toe length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
+ BREED	5	21.5802	4.3160	8.12	<.001
+ ZONE	2	14.6426	7.3213	13.77	<.001
+ BREED.ZONE	10	7.9601	0.7960	1.50	0.141
Residual	239	127.0302	0.5315		
Total	256	171.2131	0.6688		