UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

PHENOTYPIC CHARACTERIZATION OF DOMESTIC PIGEON (*Columba livia domestica*) RESOURSES IN THE NORTHERN REGION OF GHANA

IS-HAQ NAJAT

2019

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BY

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(UDS/MAN/0017/14)

A THESIS PRESENTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF M.PHIL ANIMAL SCIENCE DEGREE

OCTOBER, 2019

DECLARATION

STUDENT

I hereby declare that this dissertation/thesis is the result of my own original work and that no part of it has been presented for another degree in this University or elsewhere:

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Candidate's Signature: ……………..……………. Date: …………………………

SUPERVISORS

I hereby declare that the preparation and presentation of the dissertation/thesis was supervised in accordance with the guidelines on supervision of dissertation/thesis laid down by the University for Development Studies.

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ABSTRACT

This study aimed at characterizing the phenotypic, morphology and production performance of the domestic pigeon resources of the Northern region and also, looking at the socio-economic characteristics of pigeon production systems in Northern region of Ghana. Ninety (90) pigeon farmers were sampled from nine (9) districts, ten (10) farmers from each of the districts using snowball sampling method. Pigeon farmers were interviewed using a semi-structured interview and questionnaire on social characteristics of pigeon farmers, pigeon management practices and production. The socio-economic analysis indicated that pigeons played an important role in the social lives of most of the farmers especially in rural areas. Pigeon farmers were predominantly males, about 94.4% with high level of illiteracy (83%). Pigeon farmers in Northern region described the birds as hardy and highly resistant to diseases with rate of mortality as low as (0-5%) throughout a year. Three hundred and sixty (360) pigeons were sampled for morphological measurements. The effects of variety, region and sex on body measurements were analyzed and phenotypic correlations among the various body and egg measurements were estimated. Regression equations were also fitted for body weight using body measurements. Four (4) eye colours were identified as orange/yellow, pearl/white, bull and cracked of which the orange eye colour had the largest presentation in the nine districts of the Northern region accounting for over 75% and cracked accounting for least 1.1% of the pigeons sampled. Ten plumage colour types were identified: blue bar, blue check, black spread, white, ash red, ash red bar, brown, brown check, pied, and tiger. Pied accounted for 25.8% which was the largest presentation and brown check accounted for least 1.9%. The effect of plumage colour variety was a significant ($p<0.05$) source of variation for body weight but pigeons recorded similar ($p > 0.05$) values for all the morphological parameters. Pigeons of the various districts were different in terms of body length

($p < 0.01$), wing span ($p<0.05$) and wing length ($p < 0.05$). Sex had profound influence ($p < 0.01$) on body weight and body length in pigeons. Also, both sexes were significantly different ($p < 0.05$) for wing length and wing span. In all male pigeons were superior to females. The highest correlation was between body weight and body length (0.467), body weight and wing length had the second highest correlation value of 0.299. With the stepwise multiple regression, body length (BL) was the best predictor of body weight with R^2 of 0.218. The R^2 increased a bit to 0.240 for body length (BL) together with wing length. The two equations obtained were: BWT = -117.481 + 13.512BL and BWT = -125.174 +12.033BL +4.828WL. Fifty (50) pigeons were raised over a period of five (5) months for performance traits measurement. The overall mean values for egg weight, egg length, egg width and egg shape index were; 26.350±0.257g, 3.681±0.018cm, 2.867±0.013cm and 78.090±0.432% respectively. The highest correlation was between egg weight and egg length (0.847) while the lowest correlation was between shape index and egg length (-0.154). For performance characteristics, fertility and hatchability percentages were 70.4% and 35.2% respectively. Adult mortality was 8% while squab mortality was 21.1%. The overall mean values for body weights of squab for day1, week1, week2, week3 and week4 were 22.655±1.119g, 157.321±6.230g, 224.107±8.227g, 267.381±3.827g and 271.667±3.321g. Squab had fast growth rate for both male and female but the rate slowed down with age from day one to week four. Data on carcass characteristics were collected from thirty (30) domestic pigeons (squab). The effect of sex was found to be a significant ($p<0.05$) source of variation for pre slaughter weight, dressed weight and heart weight. All carcass parameters were not influenced ($P > 0.05$) by colour variety, except for back, lung and gizzard weight on which colour varieties had little effect ($p > 0.05$). In conclusion, pigeon breeds in Northern Ghana were local with small body conformation, wide range of plumage colour varieties, males been superior to female, hardy and highly prolific coupled with high growth rate.

ACKNOWLEGMENTS

Eternal praises and glory be to the Almighty Allah for granting me success and bringing me this far. In life, one's design, whether great or small cannot succeed without the help, support and encouragement of others. Also, it is real that a person to lean on in times of difficulty and distress is not easy to come by. Thus, I should be grateful to all who in diverse ways contributed to the success of this study.

I would like to express my deepest gratefulness to my supervisors, Dr. Anthony Amison Agbolosu and Mr. Jakper Naandam for their enormous supervisory role and pursuit to seeing that the right thing was done. I am also much grateful to Mr. Husein Shuaib Mbelayim for his resourcefulness and immense contributions to the success of this study. I appreciate the efforts of the staff of the Department of Animal Science and Meat Unit of University for Development Studies for their wonderful contribution. Moreover, I appreciate the effort Yakubu Yussif and Feruza Sadiq and all those who assisted me in my data collection process.

DEDICATION

This work is dedicated to my dear husband Mudasir Tiamiu Mohammed, my noble mother Mariama Adams, my lovely children and all hardworking citizens of Ghana.

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CHAPTER ONE

1.0. INTRODUCTION

The term Animal Genetic Resources (AnGR) is used to include all animal species, breeds and strains that are of economic, scientific and cultural interest to humankind in terms of food and agricultural production for the present or the future (Rege and Okeyo., 2006). AnGR are of great importance to every nation since they serve as an important source of income, employment and food. An estimated 1.96 billion people rely on livestock to supply part or all their daily needs (Simon, 2013) and many of the world's rural poor, an estimated 70 percent keep livestock and rely on them as important components of their livelihoods. Domesticated animals also contribute to the ecosystems in which they exist, providing services such as seed dispersal and nutrient cycling (FAO, 2000). Some of Ghana's indigenous AnGR are cattle, small ruminants, grasscutters, pigs, equines and poultry (Mogre, 2009).

Poultry species help meet the protein needs of the poorest people in the world and can be produced in areas with insufficient land for other meat-producing animals (Ogunniyi *et al.*, 2015). Extensive small-scale, rural, family-based poultry systems continue to play a crucial role in sustaining livelihoods in developing countries, supplying poultry products not only in rural but also peri urban and urban areas, and providing important support to women farmers. Small-scale poultry production will continue to offer opportunities for income generation and quality human nutrition as long as there is rural poverty (FAO, 2014[a]). Also, the state of food insecurity crises in Sub-Saharan Africa has challenged the efforts to achieve the Sustainable Development Goal (SDG) of reducing the proportion of people who suffer from hunger to half by 2015. According to FAO (2011[a]), even if the SDG were to be achieved by 2015 some 600 million people in developing countries would still be undernourished in terms of consumption, the annual growth of total calories share from livestock products was 0.2% as compared to the world average of 11.8% in 1995 and 12.9% in 2005 (FAO, 2014[b]). The per capita consumption of livestock products in Ghana is 4.42kg/head/year which is very low not only compared to FAO recommended levels of 183kg/head/year but also among countries within the West African sub-region resulting in severe protein deficiency among the populace (MoFA, 2003). Thus, there should be a focus on other neglected, aspects of animal production. The Ghanaian domestic pigeon is one of the important AnGR of Ghana that requires attention and improvement for protein supplement and poverty reduction. The Ghanaian local pigeon is distributed throughout the country (FAO, 2014[b]) in low input Systems.

Domestic pigeons (*Columba livia domestica*) are seen in many regions of the world, they live side by side with humans and they are bred as source of food, hobby and for experimental purposes and they have adapted to the life in urban, suburban and rural environment and have close communication with humans (Amal *et al*., 2014; Mohammad *et al* 2014; Mushi *et al*., 2000; Naem *et al*., 2013). Pigeons (*Columba livia* domestica) are durable birds that can be raised with little effort. Farmed pigeons are particularly promising as urban micro livestock because they require little space and thrive in cities. Domestic pigeons, like other domestic poultry, are also part of subsistence farming done by most poor families. Pigeons are kept as pet and reared for food in several countries in Africa like Nigeria, Botswana, Egypt (Adang *et al*., 2008; Mushi *et al* 2000), including Ghana. Raising pigeons for food is not as widespread as it could be; indeed, in modern times its potential has hardly been touched. Their meat is finely textured, has an attractive flavor, and is often used in place of game fowl. Tender and easily digested, it commands good market prices. In many areas, the continuing demand is unfilled and when given much attention, it would serve as a raw material for foreign exchange (Diane, 1997).

In addition, these birds grow quickly and mature rapidly. For instance, a squab, the young pigeon reaches the stage of consumption from 25-30 days (Mohammed, 2014; Sales *et al*., 2003[b]). They adapt readily to being fenced or penned much, or all, of the time. And, compared with the major farm livestock, their life cycles are short and their production of offspring is high (Branson *et al.*, 1994)

Pigeon breeds differ in body shape, structure, colour and markings of the plumage, but few studies from morphological characters in pigeon breeds have been performed (Pares-Casanova, 2013). Estimates of genetic correlations between pigeons body weights and morphometric traits are limited in scientific literature (Momoh *et al.*, 2013). Data on production systems, phenotypes and molecular markers should be used together in an integrated approach to characterization. Phenotypic characterization is useful in obtaining a better understanding of the composition and developmental patterns of the breed and such understanding can aid a breeding programme and can also be used to divide animals into species since it can reveal great diversity across species. Morphological characters can provide very useful information to complete other investigations about genetic relationships of domestic and all other breeds in general as well as being extremely important anthropologically (Pares-Casanova, 2013).

The need to characterize the specific traits of local populations is quite urgent. A more accurate characterization of these populations will support their development and could lead to monitored cross-breeding strategies – avoiding uncontrolled absorption which might result in the loss of the local resource. It is noted that the utilization of local genetic resources first requires characterization of the population existing in the country (FAO, 2014[b]; Husein *et al*, 2016 and Kristensen *et al* 2015).

The available pigeon population in Ghana is genetically uncharacterized and unimproved and no known genetic improvement program for this poultry type has been ever started. There is therefore a compelling need for the complete phenotypic, genetic, and molecular characterization of Ghanaian pigeon resources. This study seeks to lay a foundation for the eventual characterization of the Ghanaian pigeon by starting with phenotypic and morphological characterization.

1.1 Main objective of the study

To phenotypically characterize the domestic pigeon resources in the Northern region of Ghana.

1.2 The specific objectives are:

1. To investigate the socio-economic importance of pigeons in the study area.
2. To characterize production systems of pigeons
3. To describe the morphological features of pigeons.
4. To investigate the effects of plumage colour variety, location (districts) and sex on body measurements.
5. To estimate phenotypic correlations among the various body measurements.
6. To find the best morphological trait predictor of body weight.
7. To characterize the production and carcass traits of the pigeons.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin, History and Distribution of the Domestic Pigeon

According to the Pigeon Control Research Centre, PCRC (2009), the word 'pigeon' is derived from the Latin word 'pipio' meaning 'young cheeping bird'. The word 'dove' is of Norse origin and first appeared in the 14th century as 'dova' or 'douve'. Both words are used interchangeably. Domestic pigeons (*Columba livia domestica*) are all descended from the wild Blue Rock Pigeon (*Columba livia*) of the Old World (Branson *et al*., 1994). The taxonomy of pigeons is found in (Table 2.1).

They have been domesticated for thousands of years in several quarters of the world; the earliest known record of pigeons is in the fifth Egyptian dynasty, about 3000 B.C. Images of pigeons were first found on the reconstructed facade of an excavated temple and during excavations of sites in Iraq and Crete dating back to 3000 BC (Darwin, 186; PCRC, 2009). They have been raised for centuries, especially in North Africa and the Middle East. At various times in their history, they have been used for food, game, religious purposes, navigation and even medicine (Ashraful, 2014[d]; Branson *et al*., 1994; Levi, 1977; Mushi *et al* 2000; NRC, 1997; PCRC, 2009).

In 1100 BC, King Rameses III sacrificed pigeons to the god Ammon at Thebes, confirming that the pigeon were domesticated not only for food but also for religious purposes. In the time of the Romans, immense prices were given for pigeons (Goodwin, 1967). About this same period the Dutch were as eager about pigeons as the old Romans. Pigeons also appear as religions icons in

Christianity, Paganism and Judaism. Pigeons or doves are prized as symbols of peace, love and grace (Branson *et al*., 1994; Darwin, 1868; PCRC., 2009).

The pigeon is probably best known for its ability to return 'home' from long distances and has been used extensively by man for this purpose. The Romans and ancient Greeks used the pigeon extensively for carrying messages and the first sophisticated messaging service was established in Syria and Persia in the 12th century AD, with messages being carried by pigeons from city to city (PCRC, 2009) Later, in the 19th century, the pigeon was used for commercial purposes, carrying messages for financial institutions and news agencies in Europe and even providing an airmail service in New Zealand. In the 20th century, pigeons were used extensively in both Great Wars to carry messages, and as a result of their bravery and heroism, tens of thousands of human lives were saved (Hendrik, 2015; Mukesh *et al.*, 2011; PCRC, 2009).

Pigeons can be termed cosmopolitan bird because, with the exception of the northern and southern Polar Regions, they are found in the entire continent and in all the countries in the world (Branson *et al*., 1994). More than half of the species are native to the Asia and Australia; the second largest number occurs in the tropics of Americas (Branson *et al.*, 1994; Mohammad *et al* 2014, Levi, 1977)

Table 2.1. Taxonomy of Pigeon

Phylum	Vertebrates
Class	Aves
Order	Columbiformes
Sub Order	Columbae
Family	Columbidae
Sub Family	Columbinae
Genus	*Columba*
Species	*Livia*

2.2. General Description of Domestic Pigeon

Pigeons have small heads, plump, full-breasted bodies, and soft dense plumage. They weigh from about 0.5 to nearly 1kg. A few large breeds (Runts, for instance, which commonly weigh 1.4 kg) are the size of small domestic chickens (NRC, 1991). The prevailing colour is a dull, checkered blue, varying in shade from a very light blue to nearly black. The blue is sometimes replaced by red with similar variations in shade (Branson *et al*., 1994). There are also white pigeons, black pigeons, and many birds in which all the colours that have been named are irregularly mixed (Branson *et al*., 1994; Johnston, 1999). The natural voice of the pigeon is a soft, gurgling coo repeated over and over with monotonous effect (Branson *et al*., 1994)

2.3. Distinguished Groups of Pigeons

The great diversity of pigeon breeds that exists in the world and attempts at systematic classification of these breeds into closely related groups are widely known (Pares-Casanova, 2013). Below are descriptions of some breed (Branson *et al*., 1994). See Plate 1-12.

- Medium-sized pigeons are varieties with body mass of 500-700g.
- Heavy sized pigeons are varieties with a length of up to 55cm, a wing length of up to 105cm and a body weight of over 700g.
- Pigeons with characteristics of vocal expressions, example trumpeters.
- Pigeons with a particular feather structures and design, example, frill backs, fantails, jacobin, monks, dewlaps and swifts.
- Pigeons for good flights mainly breed for sports. Example; tumblers
- Wattled pigeons have a characterized bulged, distended or wart-like cere, as well as more or less prominently developed naked or wart-like rings around the eyes.
- Pouters are pigeons with singular developed round or sack-like crop area which varies with breeds.
- Hen pigeon are varieties with fowl-like body morphology and body posture.
- Coloured pigeons are selected breed for coloration and plumage morphology.

2.4. Distinctive Behavior of Domestic Pigeon

Knowledge of normal behaviour of a species is of great value in interpreting results of experimental studies. Nevertheless, it is useful in other cases to acquaint a worker quickly with the units of behaviour for any particular species so that he may go on to more advanced studies.

- Domestic pigeons are monogamous and exhibit biparental care in that both parents are participating in feeding of the young with their crop gland secretion known as crop milk. Both male and female pigeons (*Colomba livia*) possess the ability to produce a complete nutrient substance, termed crop milk, for the nourishment of their young (Mohammed, 2014; Meleg *et al*., 1999; Sales *et al.*, 2003[b]). The monogamous nature of the pigeon makes the population to be structured with full-sib families. Pigeons are non-seasonal breeders. (Branson *et al*., 1994; Momoh *et al.*, 2013).
- The domestic pigeon is highly territorial and will defend roosting spaces and nesting areas. In nest building, either sex, but more often the male, may walk around the ground picking up "suitable" (small, irregular shaped) sticks with its bill. The female predominates in arranging the sticks. However, a reversal of the roles occurs to some extent. In pigeons, both male and female parents are responsible for brooding the eggs and caring for the squabs (Johnston, 1990).
- Pigeons and doves are unique amongst birds in not imbibing by repeatedly scooping water up into their beaks and elevating their heads to help them in the act of swallowing. All Columbidae drink by submerging their beaks to the nostrils and sucking in continuous drafts (Branson *et al*., 1994).

2.5. Phenotypic and Morphological Characterization of the Domestic Pigeon

There are several strains of domesticated pigeon globally. These can be differentiated from the rock pigeon by body morphology, size and weight, deviation of the skeleton, musculature, beak and cere; coloration and design of plumage (a particular feather structure) and feather morphology and breed specific behaviour (Branson *et al.,* 1994). There is an enormous dynamic range of phenotypic variation but it is all contained within one species pigeon and like other domesticates, have been selectively bred for a range of morphological and behavioural characteristics (Darwin, 1868). The varieties of the pigeon are so numerous that it is practically impossible to make a complete list of them. They have wonderful differences in their beaks, entailing corresponding differences in their skulls. Charles Darwin in 'Origin of Species' described some strains of domestic pigeons as follows;

- The carrier- more especially the male bird, is also remarkable from the wonderful development of the carunculated skin about the head, and this is accompanied by greatly elongated eyelids, very large external orifices to the nostrils, and a wide gap of mouth.
- The "short-faced" tumbler has a beak in outline almost like that of a finch; and has the singular strictly inherited
- Common tumbler has a habit of flying at a great height in a compact flock, and tumbling in the air head over heels.
- The runt is a bird of great size, with long, massive beak and large feet; some of the sub-breeds of runts have very long necks, others very long wings and tails, others singularly short tails.

- The barb is allied to the carrier, but, instead of a very long beak, has a very short and very broad one.
- The pouter has a much elongated body, wings, and legs; and its enormously developed crop, which it glories in inflating, may well excite astonishment and even laughter.
- The turbit has a very short and conical beak, with a line of reversed feathers down the breast; and it has the habit of continually expanding slightly the upper part of the oesophagus.
- The jacobin has the feathers so much reversed along the back of the neck that they form a hood, and it has, proportionally to its size, much elongated wing and tail feathers.
- The trumpeter and laughter, as their names express, utter a very different coo from the other breeds.
- The fantail has thirty or even forty tail-feathers, instead of twelve or fourteen, the normal number in all members of the great pigeon family; and these feathers are kept expanded, and are carried so erect that in good birds the head and tail touch. Pictures of some pigeon strains are showed in (Table 2.2) below.

2.6. Pictures of Some Strain of Domestic Pigeons




Plate 1. Mondain Plate 2. King Plate 3. Dragoon Plate 4. Nun




Plate 5.Trumpeter Plate 6. JocobinPlate 7. English Pouter Plate 8. Rock Pigeon




Plate9. Oriental frills Plate 10. Swallow Plate 11.Fantail Plate 12. Short FaceTumbler

Source: PCRC (2009)

2.7. Plumage of Domestic pigeons

According to the Genetic Science Learning Center (2014), colour and pattern variation in pigeons is a great example that shows how genes work together to generate diversity. For example pigeons can have 4 different wing patterns. When we multiply this by the 3 colors, we get birds with 12 different color/pattern combinations. Dilute doubles the diversity to 24: each color/pattern combination can be either dilute or non-dilute. With spread and recessive red in the mix, the number of possible combinations increases to 32. Appendix 7 shows some plumage colour types of pigeons.

2.8. Eye Colour of Domestic Pigeons

Pigeon colour genetics, be it for fearther colour or eye colour cannot be completely discussed, without first acknowledging the work of Dr. W.F. Hollander. In his book "Origins and Excursions in Pigeon Genetics," Dr. Hollander points out that the most significant genetic differences of eye colors are orange, pearl, and bull (Plate: 13-15). Thus, there are only two known pigment types (orange and pearl) possible on the outer iris and only one pigment type possible on the inner surface. The inner surface when visible has a dark almost black look similar to the effect seen on cattle, thus, the name bull eye which result when the orange or pearl pigment has been turned off; thus allowing light to pass through the outer iris pigment, deeper into the eye reflecting the darker pigment of the inner surfaces of the eye. Genetically, a bull eye is still an orange or pearl eye, however; the pigment production (orange or pearl) on the outer surface of the iris has been simply switched off by the pied white gene. Some eyes are much lighter and brighter than others and some have far greater amounts of red color in the iris due to the amount of blood found in the different variations of these two eye colors. Cracked eyes (partly colored or partly bull) or eyes which are mismatched one side colored and the other dark bull are always the result of no pigment present in the dark areas (Plate 16).




Plate:13 orange Plate:14 Pearl Plate:15 Bull Plate: 16 Cracked

2.9. Importance and Uses of Domestic Pigeon

Initially pigeons were used for all sorts religious purposes (Bhowmik *et al*., 2014), medicinal purposes (Diane, 1997) and utility (meat, fertilizer and feather), only later man began to use the birds as carrier of information or messengers. Pigeons were used to carry messages, and were mostly released singly, documenting that each individual bird in principle has the ability to find its way home alone (Schiffner *et al*., 2018). Domestic pigeons have also been used for sports and in a variety of different ceremonies (Jerolmack., 2007). White pigeons (doves) in particular are released at different events. Weddings and funeral are common places to release white pigeons. They are regarded internationally as peace symbol. More recently, they are used as

- Laboratory animals - Pigeons have been used for experimental purposes to determine nutritive requirements for maintenance and reproduction as well as experimental animals in behavioural analyses and studies for the improvement of human health. The pigeon has proved to be an excellent laboratory animal for genetic, endocrinology, physiology, parasitology, psychology and behavioural study (Ashraful, 2013; NRC., 1991; Oriol *et al*., 2013; Sales *et al*., 2003; Wright., 2013).

- Meat production - Young pigeons bred for meat are called squab. Squabs are harvested just prior to leaving the nest, typically around 26 to 30 days of age (Mohammed *et al*., 2017). Each squab weighs about 500 g. Pigeons that are used for squab are referred to as Utility Breeds. They are heavier in body than non-utility breeds, the squabs grow quickly, and the parents are highly productive. They have been bred to produce many young over a short period of time, and to be able to reliably raise them to table size (Ashraful., 2014[b]; Bolla, 2007, Mohammed *et al*., 2017). Pigeon meat has a gamy bird taste. Squab is highly nutritious with greater dressing percentage, larger portion of soluble proteins, rich in minerals and vitamins and a smaller proportion of connective tissue compare to most meats. In addition, it is very delicate, lean (low cholesterol), easily digested and considered as fancy meat because of its taste and delicacy (Aliza, 2005; Jane, 2005; Kristensen *et al* 2015; Mohammed *et al*., 2017; Pomianowski *et al*., 2009)
- Sports and exhibition - Pigeon racing offered not only the thrills and excitement of racing but also the more sedate and intellectual rewards of breeding and rearing the birds (Martin Johnes, 2007). Currently homing pigeons are mainly used in racing competitions, Europe remains the world centre of pigeon racing, which is extremely popular not only in Belgium, but also in the Netherlands, England, Germany and Poland. Pigeon racing enthusiasts are also numerous in China, Japan, Thailand, and South Africa (Danuta *et al*., 2016; Rahman *et al*.,1999). There are several breeds of pigeons, which come in many sizes, shapes, and colors, which are used for shows.

2.10.0. Potential of Domestic Pigeons

2.10.1. Research Model

Pigeons have been used as a research model in numerous disciplines, and in many respects have become the workhorses of the avian Order (Vaughan *et al*., 1984). But upon closer inspection, the pigeon could be a subject worthy of study for both ecological and social science purposes and highlights the importance of urban species in ecology (Stella *et al*., 2008). They are easy-going, reliable breeders, and live for up to 20 years as opposed to the very short lifespan of most laboratory animals. In comparison to other animals, these pigeons have a short gestation period and have minimal requirements for breeding space and become sexually mature within 6 months (Helms *et al*., 2007; Sari *et al*. 2008).

2.10.2. Market and Export Commodity

Young pigeon (squab) has gained popularity in European countries, Australia and Indian subcontinents. Squab meat is very lean, easily digestible, and rich in protein, mineral and vitamin (Aliza, 2005; Ashraful, 2013; Jane, 2005). See (Table 2.3) for nutritional composition of squab meat. Squab is often sold as much higher prices than other poultry species and other game birds (Diane, 1997). Squab is a high value, specialized product purchased by wholesale and restaurant sectors and considered as luxury food in Chinese, European and North American restaurant and retail markets. Squab is the fourth biggest poultry source in China (Hsiung *et al*., 2005; Peng Xie *et al*., 2013). Pigeon is a traditional part of the Middle Eastern diets, whilst buyers in Japan, Thailand and Singapore have expressed interest when regular supplies can be granted (Diane., 1997; World Poultry, 2006).

Table 2.2. Nutritional Composition Squab Meat

Nutritional value per 100 g (3.5 oz)	
Energy	594Kj (142kcal)
Carbohydrate	0.00
Dietary Fiber	0.0
Fat	7.5
Saturated	1.960
Monounsaturated	2.660
Polyunsaturated	1.660
Protein	17.50
Vitamins	
Vitamin A equi	28 µg
Vitamin A	94 IU
Thiamine B1	0.283 mg
Riboflavin B2	0.285 mg
Pantothenic Acid B5	0.787 mg
Vitamin B6	0.530 mg
Folate B9	7 µg
Vitamin B12	0.47 µg
Vitamin C	7.2 mg
Minerals	
Calcium	13 mg
Iron	4.51 mg
Magnesium	25 mg
Manganese	0.019 mg
Phosphorus	307 mg
Potassium	237 mg
Sodium	51 mg
Zinc	2.70 mg
Other constituents	
Water	72.80
Ash	1.17

Units: µg=micrograms; mg=milligrams and IU=International units

Source: USDA Nutritional Database, 2016

2.11.0. Husbandry or Production Systems of Domestic Pigeon

2.11.1. Extensive system

Pigeons are traditionally raised in dovecotes or coops. This system allows free-ranging flight and requires almost no human intervention and this is a low maintenance way of keeping pigeons. Dovecotes system is usually constructed of mud conical structure in shape. Pots and pipes are cemented together in horizontal layers with some of them opening outside of the tower and others inside. Inside the tower there is either a ladder or a stairway by means of which the owner can climb up to harvest his squabs. The pigeon tower (Plate: 20-22) maintains the characteristics of a simple local traditional method for rearing (NRC, 1991; Amal *et al*., 2014).

2.11.2. Semi-intensive system

In this system, pigeons are house in dovecote, coops or wooden or woven loft in different shapes and sizes containing nests for incubation (Plate: 19). They are normally located on the rooftops of the house and secured from predators (Ashraful, 2013). The farmer feeds the pigeons some number of times in a day, the birds tend to remain in the neighborhood, but they are able to find their feed within a radius of 15 km, that way making use of the different vegetation cycles of local plants (Amal *et al*.,2014)

2.11.3. Intensive system

On the other hand, pigeons can also be raised in confinement - usually in enclosed yards - with all their needs supplied by the farmer (Plate 17-18). There are, for example, pigeon farms in the

United States with up to 35,000 pairs of breeding birds unlike chickens, pigeons do not prefer communal roosts. Instead, they prefer nesting shelves, of which there should be two for each breeding pair. The shelves are usually placed in dark corners and are fitted with low walls to keep eggs from rolling out. This system protects the birds from the elements of weather and from predators. (NRC, 1991, Parvez *et al.,* 2016).

2.12. Types of Pigeon Houses

Plate 17. And 18. Modern Large Intensive pigeon lofts

Plate19.Wall mounted pigeon loft

Plate 20. Ancient Egyptian Dovecote 44AD


Plate 21. Traditional dovecote Plate 22. Interior of dovecote

Source: (PCRC, 2009)

2.13. Nutritional Requirement and Feed Consumption

According to the Research Animals Department of Royal Society for the Prevention of Cruelty to Animals**,** RSPCA (2011), domestic pigeons are primarily seed eaters but will take a wide range of grains, fruits, berries and vegetation and invertebrates such as small snails. Among the feeds, pigeon like grains such as corn, soya bean, peanut and wheat grain (Ashraful, 2013). However, very little information is available on the nutrient requirements and metabolism of nutrients in this species. This could partly be attributed to the complexity of studies to evaluate the nutrient requirements of pigeons, caused by the fact that young growing pigeons (squabs) continuously stay in the nest and are fed by the parents, initially with a special feed , crop milk (Sales *et al*., 2003[b]).

There is no pigeon feed available in poultry shop that is produced commercially. A mixed feed and broiler diet can be given to the pigeon during production on different phases. Those feeds are expected to be able to meet the nutrient requirements for the pigeons in semi intensive rearing

(Ashraful, 2013). The use of a compound pellet in pigeon feeding is still marginal. Pigeon feeds mainly consist of whole grains and seeds while minerals, vitamins and some other nutrients are provided as separate supplements (Sales *et al*., 2003[b]). Asaduzzaman (2009) stated that the quantity of feed supplied range from 32-37g/day, with an average of 34.5g/day. Food consumption is about one-tenth of the pigeon's body weight and will range from 20-100g/daily, depending on the strain. Sales *et al*. (2003[b]) indicated that squab reaches mature body weight at 28 days of age and the increase in weight after that is very low. The highest dietary ME level of pigeon (3200 ME Kcal /kg of diet) gave the best performance compared with other ME levels. The diet containing (2600 ME Kcal /kg of diet) levels were suggested to be suitable requirement and no adverse effects on productive and reproductive performance of Baladi squabs and pigeons under Egyptian conditions (Abou-Khashaba *et al*., 2009)

2.14. Crop Milk

It is a white, slimy, caseous material formed by the desquamation of the epithelial cell structure in the parent for nutrition of the young. Its formation is controlled by prolactin. As a food of young pigeon (squab), crop milk is high in protein and lipid (Peng Xie *et al*., 2013). According to Branson *et al*. (1994), the crop milk consists of 75% water, 12.5% protein, 2.5% non-protein, 8.5% lipid and 1.5% minerals. In addition, it contains all the essential amino acids, fatty acids and gamma globulins, vitamins, mineral and trace minerals. Carbohydrates are present only in small amount, if at all. Crop milk is essential for squab and cannot be replaced by other material, at least not during the first six days of life. Both male and female pigeons (*Columba livia*) possess the ability to produce a complete nutrient substance, termed pigeon milk, for the nourishment of their young (Mohammed *et al*., 2014)

2.15. Production Performance of Domestic Pigeon

The success of avian reproduction depends also on several factors including nutrition, age of birds, conditions under which eggs are incubated, year season. Females usually lay two eggs at a session within an interval of 40-44 hours and more frequent laying can be induced by removing the eggs from the nest (Helms *et al*., 2007; Branson *et el*., 1994). Danuta and Tomasz (2016) stated in their study that, during the breeding season, the females of Warsaw Butterfly Tumbler and Polish Owl laid one or two eggs per lay and Warsaw Butterfly Tumblers demonstrated a better laying performance (10.3 eggs per female) compared to Polish Owls (6.72 eggs per female) in a period of 4 months. Both breeds laid eggs of similar weight, 14.82–14.85 g on average. Pigeons managed under farm conditions with controlled environment are able to lay as many as 22 eggs in a year, since they breed throughout the year. The size of an egg is an important factor of hatchability indices and chick body weight on hatching (Danuta *et al*., 2016). It was reported by Khargharia *et al.*, (2003) that the hatchability percentage in Assam breed was higher (84.98) in monsoon season than (80.01) in pre monsoon season with average hatchability of 82.86%. Also, the average for the clutch interval was 47.44±0.11days. It was found to be significantly ($p<0.01$) shorter in monsoon season as compared to premonsoon season. According to Danuta and Tomasz (2016), the body weight daily gains were 8.83 to 12.61 g between day 7 and day 14 of rearing, and next decreased to reach 0.47 to 1.77 g between days 21 and 28. Pawlina *et al*, (2011) found a similar pattern. Pawlina and Borys (2009) who studied a meat pigeon breed noticed a drop in daily gains at the end of 4 weeks of age. The age 4 weeks is therefore the optimum when meat pigeons should be slaughtered, as keeping them further would be economically inefficient. The level of production can be increased by providing a second nest for each pair. After eggs have hatched, the female pigeon will lay two more eggs in the second nest and incubate them while the male tends to the needs of the two squabs in the first nest. Table 2.4 below shows reproductive performance of jalali pigeon breed.

Table. 2.3: Mean ± SE of Reproductive Characteristics of Jalali Pigeon

Parameters	**Overall**
Egg weight (g)	16.18±0.08 (30)
Egg length (cm)	3.75±0.006 (30)
Egg width (cm)	2.81±0.005 (30)
Hatching period (days)	18.00±0.09 (15)
Fledgling period (days)	35.80±0.22 (15)
Interclutch period (days)	25.20±0.763 (15)

Figures in the parentheses indicate number of observations.

Source*:* Bhowmik *et al.* (2014)

2.16. Growth and Body Weight Characteristics of Domestic Pigeons

The growth performance and development of pigeon squabs are of crucial importance for meat production as well as racing pigeons. Squabs have an extraordinarily high rate of maturing (0.1466 to 0.1945 g/d) in comparison to other domesticated avian species such as chicken (0.0450g/d) and quail (0.077 to 0.097 g/d) presented in table 2.4. This growth rate is achieved by regurgitation of a holocrine substance (crop milk) by both parents, formed in response to prolactin secretion and triggered by brooding (Sales et al., 2003). According to Bolla (2007), the live weights of squab were about 679.5-736.1 g and 450-700 g respectively. Also, the male pigeon is larger, aggressive, and heavier and consume more feed than female. Ashraful (2013) in his study stated that, Squabs grow quickly during the third week and slow in fourth week, squab is weaned at 21 days old (Table 2.5). The averages of body weight at 1, 2, 3, 4, 30 weeks of age of racing pigeons were recorded as 79.10, 173.90, 233.55, 283.85 and 379.25g, respectively. The increment that occurred in the body weights at different age was logical and normal (Mohammed, 2014). Sales *et al.*, (2003[a]) indicated that pigeon reach to mature body weight at 28 days of age and the increase in weight after that is very low. Squabs are harvested just prior to leaving the nest, typically around 26 to 30 days of age. Each squab weighs about 500 g (Jacquie, 2015). Mean body weight of Jalali pigeon at 3-day, 15- day, 1-month and 5-month of age were 31.68±1.08g, 225.53±3.89g, 275.59±1.48g and 324.79±3.41g, respectively shown in table 2.6 below.

Table 2.4. Rate of maturing (growth constant) derived from the Gompertz equation for different avian species.

Species	Rate of Maturing (g)
Broiler Chicken	0.0450
Guinea Fowl	0.029-0.031
Ostrich	0.0085-0.0091
Pigeon	0.1466-0.1045
Quill	0.077-0.097

Gompertz equation: $C = C_m \times exp(-exp(-B \times (t-t^*)))$ *where C, is the final mature weight (g), B is the growth constant (g/d), and t* is the age (days) of maximum gain.*
Source: Sales et al., (2003).

Table 2. 5: Body weight and growth rate of squab

Week	Body Weight g/bird (Mean ±SD)	Growth rate (%)
1	39.43±19.88	57
2	99.29±20.08	76.92
3	146.43±10.59	91.25
4	175.14±15.40	87.5

Source: Ashraful .,(2013)

Table 2.6: Mean ± SE of Productive Characteristics of Jalali Pigeon

Parameters	Male	Female	Overall	Level of Significant
Body weight at 3-day (g)	37.19±0.37 (15)	26.16±0.60 (15)	31.68±1.08 (30)	**
Body weight at 15-day (g)	244.10±1.45 (15)	206.96±3.37 (15)	225.53±3.89 (30)	**
Body weight at 1-month(g)	282.15±1.12 (15)	269.04±1.33 (15)	275.59±1.48 (30)	**
Mature weight (g)	339.40±3.33 (15)	310.19±2.59 (15)	324.79±3.41 (30)	**

***, $p<0.01$; Figures in the parentheses indicate number of observations*. Source: Bhowmik *et al.*, (2014)

2.17. Carcass Characteristics

In the study of Khargharia *et al.*, (2002), overall least squares means combined over the sexes, for prefasting body weight, preslaughter body weight, defeathered weight, dressing weight and dressing percentage were 231.88±4.13g, 215.88±3.83g, 194.63±3.85g, 166.03±3.54g and 71.48±0.59g respectively. Also, the least square averages for the whole sale cut i.e. weight of neck, breast, back, thighs, drumstick and wings were 10.35±0.21g, 48.25±1.30g, 39.03±1.01g, 10.30±0.37g,10.45±0,20gand 32.90±0.64g respectively. Except for drumstick, the weights of all other part were significantly affected by sex being heavier for males. According to Gao *et al* (2016) in their carcass study, the correlation coefficients of organ to body weight ranged from 0.6337 to 0.9783. All these organ weight was positive correlated with body weight (correlation coefficient >0.6, *P* <0.0001). Table 2.7 shows the carcass characteristics of domestic pigeons at different age. A comparative assessment of the weights of the heart, liver and lungs in both pigeon and quill are shown in table 2.8 and 2.9 respectively.

Table 2.7: Carcass Characteristics at Different Days of Age of Domestic Pigeons

Age (d)	BW (g)	D% (%)	BMY (%)	LMY (%)	AFY (%)
1	18.7 ± 0.9[e]	95.91±0.36[a]	3.24 ±0.13[f]	5.04± 0.13[d]	−3
3	39.4 ±3.0[e]	95.73±0.36[a]	4.01±0.21[f]	5.47± 0.18[c,d]	–
7	115.8± 6.7[d]	94.84±0.45[a]	6.71± 0.33[e]	6.23± 0.20[a,b]	–
14	280.7 ±7.8[c]	84.92 ±0.41[c]	9.33 ±0.30[d]	6.50± 0.11[a]	0.59±0.06[c]
21	393.3±11.4[b]	84.17± 0.31[c]	14.04±0.37[c]	5.87± 0.17[a–c]	1.64±0.15[b]
28	487.5± 5.5[a]	85.46 ±0.20b[c]	18.11 ±0.32[b]	5.57 ±0.10[c,d]	2.33±0.11[a]
35	507.1±14.4[a]	87.00±0.45[b]	20.56 ±0.51[a]	5.78 ±0.08[b,c]	2.11±0.11[a]

Data are shown as means SE ± n = 12.Different superscript letters within a column indicate a statistically significant difference (P <0.05). BW: body weight, D%: dressing Percentage, BMY: breast meat yield, LMY: leg meat yield, AFY: abdominal fat yield. Source: Bhowmik *et al.*, (2014)

Table 2.8: Mean organ weights of Pigeon (±SEM) No = 10

Parameter(g)	Minimum value	Maximum value	Average value	Relative weight
Heart	1.8	4.2	2.95±0.22	1.08
Liver	3.0	7.0	5.96±0.44	2.20
Lungs	0.9	6.8	3.80±0.52	1.14
Body weight	240.2	285.0	270.88±4.08	100

Source: Hena *et al., (2012)*

Table 2.9: Mean organ weights of Quil (±SEM) No= 10

Parameter (g)	Minimum value	Maximum value	Average value	Relative weight
Heart	1.4	4.0	2.380.25	1.48
Liver	3.1	6.1	4.53±0.29	2.28
Lungs	1.0	2.0	1.89±0.30	1.40
Body weight	135.5	202.3	160.57±7.79	100

Source: Hena *et al.*, (2012)

2.18. Phenotypic and Morphometric Measurement in Birds.

Phenotypic traits are the external features of living organisms which could be metric or non-metric. Non metric traits are measured subjectively i.e by visual appraisal while metric traits involve objective measurements of heights, length and width. The ultimate aim in most animal breeding programme is improvement in the productivity. This can be determined using some phenotypic measurements. Research has shown that the measure of a body part may relate significantly to body weight. Linear body measurements, therefore, have been used to predict live weight in poultry (Ashraful *et al.*, 2006).Using body measurement can be useful in defining performance in many cases (Husein *et al.*, 2016). Several studies have shown relationship between body weight and body measurements in birds. In the pigeon, the juvenile body weight at weaning is positively correlated with adult body weight in both sexes. Males have been shown to have significantly higher ($p<0.01$) than their female counterparts in all body measurement parameters (Bhowmik *et al*, 2014) as shown in the table below. A study in pigeon by Momoh *et al* (2013) shows Phenotypic correlations between body parameters and those among the egg traits were positive and significant and hence demonstrate their importance in determining the size of selection differentials in selection practices.

Table 2.10: Mean ±SE of Morphological Characteristics of Jalali Pigeon

Parameters	Male	Female	Overall	Level of Significant
Body length (cm)	34.18±0.10 (15)	32.38±0.14 (15)	33.28±0.18 (30)	**
Wing span (cm)	65.24±0.22 (15)	63.50±0.15 (15)	64.37±0.20 (30)	**
Shank length (cm)	3.16±0.02 (15)	2.99±0.02 (15)	3.08±0.02 (30)	**
Bill length (cm)	2.07±0.01 (15)	2.00±0.01 (15)	2.04±0.01 (30)	**
Head length (cm)	3.74±0.02 (15)	3.58±0.01 (15)	3.66±0.02 (30)	**

***, p<0.01; Figures in the parentheses indicate number of observations.*

Source: Bhowmik *et al., (2014)*

2.19. Selection for Improvement of Economic Trait in Domestic Pigeon

Plant and animal breeders have been able to dramatically change the appearance of various lineages of organisms in a relatively short period of time. Charles Darwin noticed this and devoted the entire first chapter of *The Origin of Species* to the topic of artificial selection by humans. He used many examples of selection by humans to help support his argument that the mechanism of evolution in populations was natural selection (Baptista *et al*., 2009).

Studies on a variety of organisms have shown that many variable traits respond to artificial election. That is, it is usually possible to increase (or decrease) the frequency or average value of a trait in a lineage through careful selective breeding (Darwin 1868).

Many of the morphological features found in the domestic breeds used by Darwin to provide evidence of the efficiency of selection can be seen in pigeon species in diverse genera, e.g. giantism and dwarfism, elongated and shortened bills, feathered tarsi, supernumerary tail feathers, hypertrophied nose and eye ceres, frontal and occipital crests, colors of irises and orbital rings, sexual dichromatism as well as various plumage patterns (Baptista *et al*., 2009). Buyers brought these pigeons depending on some characteristics and sometimes they collect them by observing the flying capability (Ashraful, 2015). Within species, plumage colour variation is also an interesting example to study selective mechanisms for maintaining polymorphism in natural populations. Feral pigeons show extreme plumage variation, which originated from artificial selection of domestic stock (Richard, 1998).

2.20.0. Sex Determination

Sex is a set of structural and functional features that allow classifying organisms into male or female category. Sexual differences in birds can be observed on phenotypic, genetic and behavioural levels (Miąsko *et al*., 2017). In birds that are sexually dimorphic it is very easy to distinguish between males and females (Anna *et al*., 2006). Pigeons have no sexual dimorphism (Ashraful, 2014[a]). Males and females of many species have very similar phenotypic traits (sexual monomorphism) such that even experienced ornithologists may have problems with unambiguous sex identification (Anna *et al*., 2006). Several methods may be used, though none is particularly easy. In squab there are no points for its sex determination but in adult a lot of points for its gender with huge sexual behaviours. Observation of slight quantitative differences in coloration of the head, neck and breast, slight differences in the contour of the head and neck, differences in behaviour and others (Ashraful, 2014[b]).

2.20.1. Sexing by the Cloacal Characters

This method involves distinguishing between the single left oviduct opening of the female and the two sperm ducts of the male. Briefly, the method involves insertion of modified nasal speculum into the vent to allow identification of cloacal features. This method can only be used on mature birds and requires the use of a disposable, clear plastic nasal speculum. Details of procedure can be found in 'Sexing of Mature Columbiformes by Cloacal Characters' by Hollander.

2.20.2. Gonadal Sex

Gonadal sex in pigeons can only be determined with laparoscopy or vent (cloaca) endoscopy (Lumeij *et al*., 1985). On opening the vent of a female the opening of oviduct is seen and the left side, whereas in males two conical papillae appear on both sides. Depending on the bird size, these papillae can be 1 to 3 mms long (Wilmer *et al*., 1978). According to Wilmer (1976), direct visualization of either the single left ovary or the two testes may be accomplished under anesthesia by laparotomy, an operation penetrating the body cavity so that one can look at the internal gonads (primary sex organs) directly. "I have performed a very few hundred (perhaps 200+) such operations on ringnecks and domestic pigeons" If it is necessary to sex an immature animal. This is a slow procedure and not without some risk, though the identification should be sure.

2.20.3. Phenotypic Method

Phenotypic sex is a set of external features typical of each sex. In pigeons gonads cannot be seen without specialized inspection while phenotypic sex can be recognized by differences in shape and appearance (Miąsko *et al*., 2017). Phenotypic methods of sexing may be used on some, but not all, breeds. This will be based on colour, feather pattern differences and other phenotypic features, involving sex linkage and/or auto sexing (Ashraful, A2014[a]).

Table 2.11: Sexing of Pigeons by Phenotypic Features.

Features	**Male**	**Female**
Down feather at born	short	long
Aggressiveness	High	Low
On palm then pull	Tail Upwards	Tail downwards
Grasping then pulling beak	push backwards	silent
Beak	large	small
Forehead	rounded	flat
Head	big	small
Eye	small and locate lower the face	big and locate front or middle of face
Neck	long and thick	short and compact
Wing	large	small

Table 2.12: Sexing of Pigeons by Phenotypic Features Cont'd.

Body	Slim and large	Bulky and small
Vent	Narrow (1-2)	Broad (above 2)
Cloacal lip	present	absent
Waddle	bigger	smaller
Middle toe	larger	smaller
Sound	cooing	squeak/peep
Nature	clever	silent
Body feather and crown	ornamental and bright, higher	casual feathers and less bright, lower
Tail dragging and turn	dragging with 360^0	not dragging and 180^0
Nesting tendency	high	later in the day
Pelvic girdle	narrow	broad
Incubation	09-10 am to sunset	whole night

Source: Ashraful., (2014[a]).

2.20.04. Behavioural Sex

According to Miąsko *et al.,* (2017), behavioural sex is shaped by development of hormonal system and production of the relevant male and female hormones. They further explained that, sex can be determined by careful observations of behaviours, especially during mating seasons. Males choose their females and begin tooting with cooing and driving the females away from other males. The male outstretches his tail and rubs it on the surface. The next sequence of sexual behaviour is reciprocal feeding and copulation which takes a short while, the female crouches, lifts her tail up and beats her wings slightly while he jumps onto her back, presses his vent to hers and beats wings vigorously to keep balance. Eventually the pair moves to the nest. Once copulation acts have been completed, eggs are laid and brooded by both parents, males at daytime and females at nights (Ashraful., 2014[b]).

2.20. Disease Prevalence in Pigeons

- Pigeons are subject to few diseases. However, worms, lice, diarrhea (coccidiosis), canker (trichomoniasis), salmonella (paratyphoid) and avian tuberculosis etc, occur at some time in most domestic breeds. Salmonella exists in low levels in most flocks and will flare up if birds are stressed. Treatments recommended for domestic chickens are usually suitable for pigeons (Adang *et al.*, 2008; Mushi *et al.*, 2000; Naem *et al*., 2013; Kriz *et al.*, 2010).Several health problems can affect pigeons but parasite infections play a major role. They constitute a major source of infection and transmission of diseases (Marques et al., 2007). *Haemoproteus columbae*, is a common haemoprotozoan infection in them. It is transmitted by *Pseudolinchia canariensis*, a Hippoboscid vector fly. In India a higher prevalence of *H. columbae* parasitaemia in pigeons has been reported form Uttar Pradesh and Mumbai (Jahan et al., 2011). A study by Hassan (2012) showed that *A.columbae*, *H. columbae* and *Columbicloa columbae* were prevalent in domestic pigeons of Mashhad area and probably in other region of country.

2.21. Constraints of Domestic Pigeon Keeping

- Kotresh *et al*., (2017) reported some constraints of pigeon owners in Bangladesh as; lack of scientific knowledge non-availability of vaccine, difficulty in identifying breeds, difficulty in feeding the birds, difficulty in sexing of young birds , disease outbreak, difficulty in breeding, difficulty in hatching eggs, lack of organised marketing system.
- In traditional system of production, every conceivable type of predator can be expected; therefore, precautions must be taken. The dovecote must be well protected against predators, which are the principal enemy of the eggs and the squabs (Naem *et al*., 2013).
- Squabs are fed by their parents (both male and female) with "crop milk" in the first days of life; therefore, the feeding system of pigeons differs markedly from of different poultry species (Meleg., 1999). Young pigeon are totally helpless and must be raised by the parent which complicates the feed management of squabbing pigeons (Gwenith., 1986).Nesting birds need a high-protein diet to raise squab at the high rates of gain that are possible which would make cost of production high (Sales *et al*., 2003[b])
- The birds can become nuisances. They leave droppings in annoying places, some people find them too noisy, and a few people are severely allergic to "pigeon dust (David *et al*.,1994) and by flying over a wide area and eating grains and other foods, pigeons can cause conflicts with farmers (NRC, 1991; Hassan *et al*., 2012)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of Study

The study took place in the Northern region and in three phases. The Northern region (Fig:3.1), which occupies an area of about 70,384 square kilometres is the largest region in Ghana in terms of land mass. The land is mostly low lying except in the north-eastern corner with the Gambaga escarpment and along the western corridor. The climate of the region is relatively dry, with a single rainy season that begins in May and ends in October. The amount of rainfall recorded annually varies between 750 millimetres and 1,050 millimetres. The dry season starts in November and ends in March/April with maximum temperatures occurring towards the end of the dry season (March-April) and minimum temperatures in December and January. The harmattan winds, which occur from December to early February, have a considerable effect on temperatures in the region, making them vary between 14^{o}C at night and 40^{o}C during the day. Humidity is very low, aggravating the effect of the daytime heat. The rather harsh climatic conditions adversely affect economic activity in the region. The main vegetation is grassland, interspersed with guinea savannah woodland, characterized by drought-resistant trees (Ghana Statistical Service, 2010).

Figure 3.2: Map of Northern Region showing the various districts
Source: Ghana Statistical Service (2013)

3.2.0 Study Population and Data Collection for the Three Study Phases

3.2.1 Phase One: Collection of Pigeon Management and production Data from Farmers

The firsts study was conducted across nine districts of the region; Tolon, Kumbungu, Sagnarigu, Tamale Metro, Gushegu, Karaga, West Manprusi, East Gonja and East Mamprusi. Districts were sampled purposively after a survey. Ninety (90) pigeon farmers were sampled from the nine districts, ten (10) farmers from each of the districts using snowball sampling method. Farmers were interviewed using a semi-structured questionnaire which contained questions covering the socio-economic characteristics, pigeon production and management practices. Four (4) adult pigeons with sex (2 males and 2 females) from each of the farmers from the nine districts were sampled for morphological measurements. In all, three hundred and sixty (360) pigeons, forty (40) from each of the nine districts were used. Morphological measurements were taking using a portable hand electronic LCD digital weight scale (capacity=5kg and calibration=1g), a tape measure, a 30cm ruler, a digital camera (Kodak EeayShare C series: C330) and vernier metric manual caliper with 0.6inch/1500m stainless steel. Measurements were recorded in grams (g) and centimetres (cm). Some pigeons were purchased from farmers who were willing to sell out their birds for further data collection in phase two (2) and three (3) of the data collection process in the study. (Measurements were defined by: Borras *et al* 1999, Kevin, 1998, Olav, 2011, Bhowmik, *et al*, 2014)

- **BW –Body weight:** Live adult birds were restrained and placed on a digital measuring scale and their weights recorded.
- **BL – Body length:** The length between the tip of the bill and the tip of the tail was measured using a tape measure (Plate 24).
- **WS – Wing span:** The length between wingtips was measured when the wings are held outstretched using a tape measure (Plate 25).
- **WL – Wing length:** This was measured from the bend of the wing to the tip of the longest primary feathers using a tape measure (Plate 26).
- **SL – Shank length:** The length between the *Genu* and the *Regiotarsalis* was taken on the right limb using a pair of calipers (Plate 27).
- **BLL – Bill length:** Bill length was measured from the tip to skull (i.e., total culmen) using a pair of calipers (Plate 28).
- **BFC – Body feather colour:** feathers were observed and colour recorded based on a colour chat from the Genetic Science Learning Center (2014).
- **EYC – Eye colour:** Eye was observed and colour recorded based on the definitions of Dr. Hollander (1954).

3.2.2 Phase Two: Housing of Pigeons for the Collection of Data on Production Traits

The second study was conducted at Nyankpala. Nyankpala is about 18km west of Tamale in the Tolon district**.** The district lies between latitude 8ºN, 11ºN and longitude 0ºE 3ºW (SARI, 2008). The vegetation consists of grassland dotted with small drought resistant trees. The area experiences one rainfall season annually, beginning in March and ending in September. The average temperature is 31ºC with a minimum of 28.2ºC and a maximum of 42ºC (SARI, 2008). Fifty (50) pigeons were raised over a period of five (5) months for performance traits measurement. In all, 25 males and 25 females were used. The birds were housed for five months in a deep litter house using the intensive system. Fifty (50) wall mounted localy woven lofts were provided for breeding pairs for nesting (appendix 2, plate 29-30). Feed and water were administered *ad libitum*. Eggs were collected daily and identified using pair number, dovecot number and date laid.

Data on the following performance traits were collected:

- Egg characteristics**:** egg weight, egg length, egg width and shape index (appendix 3, plate 31-32)[Egg shape index = (egg width/egg length)*100]
- Fertility of eggs: the fertility of the eggs was determined by candling
- Hatchability of eggs**:** This was estimated using the percentage of eggs from eggs set.
- Incubation period
- Squab body weight (at hatch –week4):
- Mortality of adult pigeons and squab over the five months period

3.2.2.1. Composition of Diets for Experimental Pigeons

There is no pigeon feed available in the country. Therefore a mixed feed and broiler diet were given to the pigeon during production on different phases. Those feeds are expected to be able to meet the nutrient requirements for the pigeons in semi intensive rearing (Ashraful, 2013). Based on this, broiler diet was used to feed pigeons in this study. But substituting 50% of usual maize in the diet with sorghum, rice, and millet. Table 3.1 shows composition of feedstuff.

Table 3.1. Percentage Composition of Feedstuff for Experimental Pigeons

Feed ingredients	Percentage composition (%)
Yellow maize	10
Millet	15
Sorghum (white)	10
Sorghum (red)	15
Broken Rice	10
Soya beans	15
Pigeon pea	5
Fish meal	10
Rice bran	3.2
Vitamin Premix	0.5
Di-calcium phosphate	2
Salt	0.3
Oyster shell	4
Total	100
Calculated nutrient analysis	
CP (%)	20.142
ME (Kcal/kg)	2776.43

CP = Crude protein, ME = Metabolizable Energy and % = percentage.

3.2.3. Phase Three: Collection of Data on Pigeon Carcass Characteristics

The third phase of the study was conducted at the Meat Unit of the Animal Science Department, Faculty of Agriculture, University for Development Studies, Nyankpala campus. Data on carcass characteristics were collected from thirty (30) domestic pigeons (squab) 3 each of males and females from six colour types (blue bar, blue check, white, black and pied). Feed was withdrawn 12 hours prior to slaughter. Slaughter of pigeons was done according to standard abattoir procedure (Grandin, 2009). Measurements were taken using an electronic scale (Tanita TLC-100). Parameters measured were;

- Pre slaughter weight(g): the weight of the live domestic pigeon before slaughter
- Deplumed weight (g): the weight of the bled carcass after the feathers has been removed.
- Dressed weight (g): the weight of the bird after the removal of viscera, shanks, and the head.
- Breast weight (g): the weight of both side of breasts, no wing, sternal and vertebra ribs attached.
- Thigh weight (g): weight of the upper portion of the whole leg that is separated at the knee and hip joints.
- Back weight (g): the weight of back of carcass beginning of the base of the neck and extending backward to the tail.
- Wing weight (g): weight of the entire wing muscle with all muscle, bone and skin attached.
- Drumstick weight (g): lower portion of the whole leg that is separated at the knee and hock joints.
- Giblets (g) : weights of whole heart, liver and gizzard

Carcass cuts were done according to standard procedures: (Australian Chicken Meat Federation, 2018)

3.3.0. Statistical Analyses

1. The frequencies of the various social characteristics of pigeon farmer, production and management practices and pigeon marketing system were calculated using descriptive statistics of SPSS 17.0 (SPSS 2008)
2. The frequencies of the various colour varieties were calculated using descriptive statistics of SPSS 17.0 (SPSS 2008). The top five colour varieties were used for the remaining analysis since they formed over 95% of the population sampled.
3. To investigate the effects of colour variety, location (districts) and sex on body measurements the data was subjected to least squares analysis of variance using the General Linear Model (GLM).

The model used was:

$$Y_{ijkl} = \mu + V_i + R_j + S_k + VR_{ij} + VS_{ik} + VRS_{ijk} + e_{ijkl}$$

Y_{ijkl} = body weight, body length, wing span, wing length, shank length, and bill length.

μ = the overall mean

V_i = the effect of the i^{th} colour variety of pigeon, i =1… 5 (1=Blue bar, 2=Blue check, 3=Black, 4=White and 5=Peid)

R_j = the effect of the j^{th} districts location, j = 1…9 (1=Tolon, 2=Kumbungu, 3=Sagnarigu, 4=Gushegu, 5=Karaga, 6=East Mamprusi, 7=West Mamprusi, 8=East Gonja and 9=Tamale Metro)

S_k = the effect of the k^{th} sex of pigeon, k= 1, 2 (1=male, 2=female)

VR_{ij} = is the interaction effect between i^{th} colour variety and the j^{th} district location

VS_{ik} = is the interaction effect between i^{th} colour variety and the k^{th} sex

e_{ijkl} = the random error term assumed normally and independently distributed, $(0, \sigma^2 e)$.

Means were separated using lsd under the Post Hoc Multiple Comparison.

4. Correlation coefficients among the various linear body measurements were estimated using the Pearson's Correlation of SPSS v 17 (SPSS 2008).
5. Stepwise Multiple Regression Procedure SPSS v 17 (SPSS, 2008) was used for the best prediction equation for body weight.

The model used was: $BWT = a + b_1X_1 + b_2X_2 + \ldots b_nX_n + e_i$ ……………(2)

Where,

BWT = body weight or dependent variable;

a = the intercept

b_1- b_n = regression coefficients

X_1- X_n = linear body measurements (independent variables) represented by BW, BL, WS, WL, SL, BLL

e_i = random error.

6. Multiple linear regressions in Curve Estimation of SPSS 17.0 for each morphological trait to determine the nature of response (linear, quadratic and cubic) in predicting body weight. The general simple linear regression equation was: $Y_i = \alpha + \beta X_i + e_i$ -------------(3)

Where Y_i is body weight or dependent variable; α is the intercept or the value of Y_i

Where $X_i = 0$; β is the coefficient of regression or slope defined as the change in Y_i resulting from a unit change in X_i ; X_i independent variable represented by BL, WS, WL, SL, BLL; and e_i is the random residual associated with Y_i.

7. The frequencies of the various performance characteristics were calculated using descriptive statistics of SPSS 17.0 (SPSS 2008).
8. Correlation coefficients between the various external egg measurements were estimated using the Pearson's Correlation of SPSS v 17 (SPSS 2008).
9. The effect of colour variety and sex on the carcass characteristics were investigated using the GLM procedure in SPSS version 17. The model use was:

$Y_{ijk} = \mu + V_i + S_j + VS_{ij} + e_{ijk}$ ---------------- (4)

Y_{ijk} = pre-slaughter weight, defeathered weight, dressed weight, carcass weight.

μ = the overall mean

V_i = the effect of the i^{th} colour variety of pigeon, i =1…5 (1=Blue bar, 2=Blue check, 3=Black, 4=White and 5=Pied)

S_j = the effect of the j^{th} sex, j = 1,2 (1=male, 2= female)

VS_{ij} = is the interaction effect between i^{th} colour variety and the j^{th} sex

e_{ijk} = the random error term assumed normally and independently distributed, (0, σ^2e).

CHAPTER FOUR

4.0. RESULTS

4.1 Description of Pigeon Production in Northern Region

Pigeon farmers were predominantly males, about 94.4% with high level of illiteracy. Over eighty three (83%) of the pigeon farmers were not educated and 67.8% of them had farming as their main occupation (Table 4.1).

Over eighty seven percent (87.8%) of the farmers practiced the semi-intensive system where pigeons were given only cereals (millet, sorghum, rice, broken maize, sesame etc) once or twice a day with no additional feed supplement or concentrate. Most pigeon farmers, (84%) had pigeon population size up to fifty (50) and about 9% with over hundred birds at their disposal. The main method of incubation practiced by all the farmers (100%) was natural incubation where the females were allowed to sit on the eggs to hatch (Table 4.2).

In terms of health wise, most pigeon farmers in northern region describe the birds as hardy and highly resistant to diseases with rate of mortality as low as (0-5%) throughout a year according to 94.5% of pigeon farmers with 57.8% of the mortality being predators and 28.9% caused by diseases. None of the pigeon farmers had ever vaccinated their birds against any disease. About 4.4% farmers dewormed their pigeons while 13.3% normally provided their pigeons medication (Table 4.2).

Table 4.1: Social Characteristics of Pigeon owners and their Purpose of Keeping Pigeon in Northern Region

Variable	Frequency	Percentage (%)
Gender		
Male	85	94.4
Female	5	5.6
Education		
Not educated	75	83.3
Primary	1	1.1
JHS	5	5.6
SHS	4	4.4
Tertiary	5	5.6
Profession		
Farming	61	67.8
Farming & other	3	3.3
No occupation	5	5.5
Others	21	23.3
Purpose of keeping pigeons		
Fun/hobby	8	8.9
Home consumption	14	15.6
Home consumption and sale	58	64.4
Home consumption and religious purpose	6	6.7
Religious	1	1.1
Fun and sale	3	3.3

Table 4.2: Management Practices and Systems of Pigeon Production and Farm Population Size in Northern Region

Variable	Frequency	Percentage (%)
System of rearing		
Semi-intensive	79	87.8
Extensive	11	12.2
Type of reproduction		
Natural incubation	90	100
Artificial incubation	0	0.0
Flock size (adult+young)		
0-50	75	83.3
51-100	7	7.8
>100	8	8.9
Number of breeding pairs		
0-10	52	57.8
10-30	28	31.3
30-50	7	7.8
>50	3	3.3
Flock Size determination		
Counting	37	41.1
Estimation	53	58.9
Feeding		
Cereals only	90	100
Concentrate/feed supplement	0	0

Table 4.2: Management Practices and Systems of Pigeon Production and Farm Population Size in Northern Region Cont'd.

Health		
Provision of vaccination	0	0
No provision of vaccination	90	100
Deworming		
Povision of dewormer	4	
No provision of dewormer	86	4.4
Medication		85.6
Provision of	12	
medication provided		13.3
No provision of	78	
medication		86.7
Specific medication provided		
Antibiotic	10.0	
Multi vitamin	1.1	10
Back of mahogany	1.1	1.1
Shear butter for pox	1.1	1.1
		1.1
Mortality rate		
Low (0-5%)	85	
Medium (6-10 %)	2	94.5
High (>10 %)	3	2.2
		3.3
Course of mortality		
Disease	26	
Predators	52	28.9
Pest	8	57.8
Diseases & predators	2	8.9
		2.2

4.2. Marketing of Pigeons in Northern Ghana

In northern region, pigeon are priced base on their colour morphology unlike other poultry birds due to their religious, medicinal and sacrificial use. They are priced based on colour white, colour red the uncommon and most expensive and black or any other colour aside white and red been the cheapest (Table 4.3)

Table 4.3: Prices of Pigeons in Northern Region

Variable	Frequency	Percentage (%)
Pricing based on colour	26	28.9
Not pricing based on colour	48	53.3
Price for red colour		
>500 Ghana cedis	1	1.1
Price for white colour		
15-20 Ghana cedis	18	20
21-25 Ghana cedis	5	5.8
>25 Ghana cedis	4	4.4
Price for any other colour		
5-10 Ghana cedis	42	46.7
11-15 Ghana cedis	24	26.7
16-20 Ghana Cedis	2	2.2

4.3. Morphological Description

From a sample of 360 domestic Pigeons from nine districts of the northern region of Ghana, their plumage varied considerably, from blue-grey, double black wing bars and a white rump through various "blues", "browns", "white" and chequered types, to almost pure black. There were no visible differences in plumage colour between the sexes. Ten (10) plumage colour variants were identified as

well as four (4) eye colour. The plumage colour variants identified were Blue Bar, Blue Check, Black Spread, White, Ash Red, Ash Red Bar, Brown, Brown Check, Pied, and Tiger (appendix 6). No cases of frill and muffed feathers were noted. Also, neither fancy foot nor tail feathers were noted. All pigeons had close fitting or normal smooth plumage. There were no wattling around the beak and eye. The four (4) eye colours identified were Orange or Yellow, Pearl or White, Bull and Cracked.

4.4.0. Descriptions of the Various Colour Varieties Encountered Across the Nine Districts

4.4.1. Blue bar

This pigeons has two black or dark gray trips or bars on each light-gray wing, with a dark-gray body and shiny, rainbow-like neck feathers as shown in Appendix 7.

4.4.2. Red bar

This bird has two red trips or bars on each light-gray wing. Also, with rusty red or brown shade to its body.

4.4.3. Black spread

This pigeon has one dark colour spread all over its body.

4.4.4. White

This bird has a solid white.

4.4.5. Pied

These pigeons have white as well as other feather colours on its body. Thus, pied comes in many forms, black pied, brown pied, pied splash having one or more spots of white and many more. Black and brown paid (Appendix 7)

4.4.6. Checker

These birds have checkered wing feathers in the form of light and dark which comes in different colours. Black and brown checker (Appendix 7)

4.5. Frequencies of Eye Colour

The orange/yellow eye colour constituted the highest percentage of the sample size having 75.8% and the least being cracked which constituted 1.1%.

Table 4.4: Frequencies of the Eye Colour of Domestic Pigeon

Eye Colour	Frequency	Percentage
Orange/Yellow	273	75.8
Pearl/White	36	10.0
Bull	47	13.1
Cracked	4	1.1
Total	360	100

4.6. Frequencies of Plumage Colour Varieties

The pied, black, blue bar, blue check and white variety had the largest representation in the nine districts of northern regions constituting 25.8%, 16.9%, 16.6%, 15.3% and 13.3% of the sample respectively. The least represented was the tiger which constituted only 0.3 % of the birds sampled. The frequencies of the various colour varieties encountered are presented in Table 4.5. Pied, black, blue bar, blue check and white variety are the top five colour variety which formed 87.9% of the entire population size (Table 4.5). Pied colour had high presentation in all the districts except for Gushegu and Karaga while white colour had least presentation across all districts except for East Gonja (Table 4.6).

Table 4.5: Frequencies of the Ten Plumage Colour Variants of Domestic Pigeon

Variety	Frequency	Percentage (%)
Blue Bar	59	16.4
Blue Check	55	15.3
Black	65	16.9
White	48	13.3
Ash Red	11	3.1
Ash Red Bar	16	4.4
Brown	9	2.5
Brown Check	7	1.9
Pied	93	25.8
Tiger	1	0.3
Total	360	100

Table 4.6: Colour Variants among Pigeons in the nine districts

Variety	TL	KM	SG	GSH	KR	EM	WM	EG	TM	Variety Total
Blue bar	10	6	12	10	3	3	9	3	3	59
Blue check	4	12	7	5	3	7	6	3	8	55
Black	5	7	2	7	14	6	10	6	4	61
White	7	2	3	4	8	6	6	9	3	48
Pied	13	13	16	6	4	10	9	11	11	93
District Total	39	40	40	32	32	32	40	32	29	

TL = Tolon, KM =Kumbungu, SG = Sagnarigu , GS = Gushegu, KR = Karaga , EM = East Mamprusi, WM = West Mamprusi, EG = East Gonja, TM = Tamale Metropolis.

4.7.0. Least Square Means of Traits of Domestic Pigeon in Northern Region

4.7.1. Body Weight and Linear Body Measurement base on Sex

Mean body measurements for domestic pigeon based on sex are presented in Table 4.7.

Sex had significant influence ($p < 0.01$) on body weight and body length in pigeons. Also, sexes differed significantly ($p < 0.05$) n terms of wing length and wing span. In all male pigeons were superior to females in the below traits however there were no significant deferences in shank and bill length ($p > 0.05$)

Table 4.7: Effect of sex on body weight and linear body measurements of domestic pigeon in northern region

Variable	Sex			
	Male (180)	**Female (180)**	**Mean**	**P-Value**
BW (g)	316.26±2.48	285.82±2.48	301.04	**< 0.01**
BL (cm)	31.28±0.09	30.68±0.09	30.95	**< 0.01**
WS (cm)	61.30±0.27	60.10±0.28	60.70	**0.002**
WL (cm)	11.33±0.10	10.92±0.11	11.12	**0.005**
SL (cm)	3.33±0.01	3.03±0.20	3.18	**0.292**
BLL (cm)	1.86±0.01	1.83±0.01	1.84	**0.11**

P-Value = probability value, BW= body weight, BL= body length, WS = wing span, WL = wing length, SL = shank length, BL =bill length.

4.7.2. Body Weight and Linear Body Measurement base on Location

Mean body measurements for domestic pigeon based on location (districts) are presented in Table 20. Pigeons of the various districts were different in terms of body length ($p < 0.01$), wing span ($p < 0.05$) and wing length ($p < 0.05$). The pigeons recorded similar values ($p > 0.05$) for the rest of the morphological parameters.

Table 4 ... ect of location on body weight and linear body measurements of pigeons in northern region

Variable	Districts									
	TL	KM (n=40)	SG (n=40)	GS (n=40)	KR (n=40)	EM (n=40)	WM (n=40)	EG (n=40)	TM (n=40)	P-Value
BW	305. ... 5	305.59±4.76	296.35±5.51	292.49±5.17	298.63±5.42	310.21±4.74	295.64±4.46	306.82±5.08	297.13±5.13	**0.137**
BL	31.2	30.30±0.17[b]	30.45±0.20[b]	31.34±0.18[a]	31.02±0.18[a]	31.37±0.17[a]	30.80±0.16[a]	30.80±0.19[a]	31.12±0.18[a]	**0.000**
WS	61.0	58.65±0.54[b]	60.28±0.62[a]	60.48±0.59[a]	60.99±0.61[a]	61.47±0.54[a]	60.72±0.51[a]	60.88±0.58[a]	61.09±0.58[a]	**0.024**
WL	10.8	10.91±0.21[a]	10.94±0.24[a]	11.05±0.22[a]	11.50±0.23[a]	11.73±0.21[b]	10.57±0.19[a]	10.95±0.22[a]	11.28±0.22[a]	**0.004**
SL	3.01	3.47±0.39	3.08±0.45	3.13±0.42	3.04±0.44	3.08±0.39	3.03±0.37	2.98±0.42	1.83±0.20	**0.899**
BLL	1.83	1.86±0.01	1.87±0.02	1.84±0.02	1.84±0.01	1.86±0.001	1.84±0.01	1.83±0.01	1.83±0.02	**0.419**

BW= ... veight, BL= body length, WS = wing span, WL = wing length, SL = shank length, BLL =bill length; TL = Tolon, KM =Kuml ... SG = Sagnarigu , GS = Gushegu, KR = Karaga , EM = East Mamprusi, WM = West Mamprusi, EG = East Gonja, TM = Tamale Metropolis

4.7.3. Body Weight and Linear Body Measurement based on Colour Varieties

Mean body measurements for domestic pigeon based on colour variety are presented in Table 21. The various colour varieties did not have influences on body measurements of pigeons. The pigeons recorded similar values ($p > 0.05$) for all the morphological parameters except for body weight which had some differences ($p < 0.05$).

Table 4.9: Effect of colour variety on body weight and linear body measurements of domestic pigeon

Variable	Colour Variety					
	BB	**BCHK**	**BLK**	**W**	**P**	**P-*Value***
BW (g)	304.84±3.99[a]	309.11±4.20[a]	304.37±3.95[a]	291.92±4.46[b]	296.55±3.03[b]	**0.014**
BL (cm)	31.67±0.15	31.01±0.15	30.85±0.14	30.84±0.16	30.91±0.11	**0.392**
WS (cm)	59.45±0.45	61.08±0.48	61.04±0.45	60.14±0.51	60.85±0.34	**0.234**
WL (cm)	10.92±0.17	11.15±0.18	11.31±.17	10.92±0.19	10.19±0.13	**0.418**
SL (cm)	3.01±0.33	3.25±0.35	3.06±0.33	3.10±0.37	3.02±0.25	**0.874**
BLL (cm)	1.83±0.01	1.84±0.01	1.86±0.01	1.86±0.01	1.84±0.01	**0.783**

NB: P-Value = probability value, BW= body weight, BL= body length, WS = wing span, WL = wing length, SL = shank length, BLL =bill length, BB = blue bar, BCHK= blue checkered, BLK = black, W = white, P = peid.

4.8. Interaction effects of fixed factors on morphometric traits

Interaction effects of fixed factors on morphometric traits are presented in Table 10.

Table 4.10: Interaction effects of fixed factors on morphometric traits

Type of interaction	BW	BL	WS	WL	SL	BLL
District*colour	ns	ns	ns	ns	ns	ns
District*sex	ns	ns	*	ns	ns	ns
Colour*sex	ns	ns	ns	ns	ns	ns
District*colour*sex	ns	ns	ns	ns	ns	ns

*NB: *= P<0.05; not significant (ns), BWT= body weight, BL= body length, EL= Ear length, HG = heart girth, STD= shoulder to tail drop, TL= tail length, HPL= head to pubic length, LL= leg length and THL= thigh length.*

4.9. Correlations between body measurements

Correlation coefficients among the various body measurements are shown in Table 11. The highest correlation was between body weight and body length (0.467), body weight and wing length had the second highest correlation value of (0.299) followed by (0.279) and (0.232) for body length and wing length and body length and wing span respectively. The least was a correlation between body length and shank length (0.026). There was no negative correlation between body measurements.

Table 4.11: Correlations matrix of body measurements

	BW	BL	WS	WL	SL	BLL
BW	1.00					
BL	0.467**	1.00				
WS	0.166**	0.232**	1.00			
WL	0.299**	0.279**	0.157**	1.00		
SL	0.063	0.047	0.044	0.105*	1.00	
BL	0.117*	0.175	0.143	0.180**	0.026	1.00

*NB: **significant (p<0.01), * significant (P <0.05), BW= body weight, BL= body length, WS = wing span, WL = wing length, SL = shank length, BLL=bill length*

4.10.0. Prediction of body weight of domestic pigeon

4.10.1 Prediction of body weight from linear body measurements using stepwise multiple regression

With the stepwise multiple regression, body length (BL) was the best predictor of body weight with R^2 of 0.218. The R^2 increased a bit to 0.240 for body length (BL) together with wing length (WL). The two equations obtained were:

BWT = -117.481 + 13.512BL…………………… (a)

BWT = -125.174 +12.033BL +4.828WL ……….. (b)

4.10.2 Prediction of body weight from linear body measurements using linear multiple regression

The prediction equations (linear, quadratic and cubic) comprising the intercepts and the slopes of the regression line for various body measurements are presented in (Table 4.12) below. Body length showed good level of predicting body weight, the coefficients of determination (r^2) of all the three equations for body length was high.

Table 4.12: Prediction of body weight from linear body measurements

Nature	onds	Equation	R^2	Model	α	β_1	β_2	β_3
				P-value				
		Body length(BL)						
Linear		-117.48+13.51BL	0.218	<0.01	0.005	<0.01		
Quadra		$338.19+16.057BL+0.48BL^2$	0.219	<0.01	0.662	0.555	0.749	
Cubic		$133.96113.87BL+0.82BL^2+0.003BL^3$	0.218	<0.01	0.515	<0.01	0.920	0.867
		Wing span (WS)						
Linear		200.87+1.64WS	0.280	0.002	<0.01	0.002		
Quadra		$378.18-9.05S+0.128WS^2$	0.111	<0.01	<0.01	<0.01	<0.01	
Cubic		$-130.24+63.36WS1.87WS^2+0.02WS^3$	0.145	<0.01	0.353	0.001	<0.01	<0.01
		Wing length (WL)						
Linear		213.09-7.89WL	0.890	<0.01	<0.01	<0.01		
Quadra		$331.44-17.24WL+1.29WL^2$	0.135	<0.01	<0.01	<0.05	<0.01	
Cubic		$461.15-97.30WL+12.43WL^2-0.45WL^3$	0.155	<0.01	<0.01	0.001	0.001	<0.05
		Shank length(SL)						
Linear		297.49+48.50SL	0.004	0.233	<0.01	0.233		
Quadra		$226.91+26.40SL-0.73SL^2$	0.018	0.041	<0.01	0.021	0.026	
Cubic		$175.49+51.28SL-3.53SL^2+0.07SL^3$	0.031	0.011	<0.01	0.001	0.007	0.028
		Bill length(BLL)						
Linear		211.19+48.50BLL	0.014	0.026	<0.01	0.026		
Quadra		$-65.17+348.13BLL-81.07BLL^2$	0.014	0.074	0.904	0.553	0.609	
Cubic		$5.63+215.60BLL+92.22BLL^2-16.27BLL^3$	0.015	0.072	0.988	0.464	<0.01	0.569

Dependent variables (BL, WS, WL, SL, BLL); Co-efficient of multiple determinations (R2); Intercept (α); Slope of regression line (β1, β2, β3)

4.11.0 Egg characteristics

4.11.1. Means and Standard Deviations of Egg Measurements

The external egg measurements are presented in Table 13. The mean egg weight, length and width was 26.35g, 3.68cm and 2.87cm respectively with shape index of 78.095.

Table 4.13: Egg measurements (± SD)

Measurement	No	Mean	± SD	Range	
Egg weight (g)	54	26.35	1.89	23	30
Egg length (cm)	54	3.68	0.18	3.4	4.0
Egg width (cm)	54	2.87	0.13	2.6	3.1
Egg shape index (%)	54	78.09	3.18	74.4	96.6

SD = standard deviation and No = number.

4.11.2. Correlation between Egg External Measurements

The correlation matrix of external egg characteristics are presented in Table 4.14**.** The highest correlation was between egg weight and egg length (0.847). The lowest correlation was between shape index and egg length (-0.154).

Table 4.14: Egg measurements

	EW	EL	EWTH	ESI
EW	1.00			
EL	0.847**	1.00		
EWTH	0.684**	0.702**	1.00	
ESI	-0.121	-0.154	0.080	1.00

***significant (p<0.01), * significant (P <0.05), EW = egg weight, EL= egg length, EWTH = egg width and ESI = egg shape index.*

4.12. Performance of Pigeon Studied over Five Months Period

Pigeons laid two (2) eggs in every session of their incubation. Fertility and hatchability percentages recorded were 70.4 and 35.2 respectively. Table 4.15.

Table 4.15: Performance Characteristics

Performance characteristics	Flock mean
Number of egg laid at a session	2
Fertility (%)	70.4
Hatchability (%)	35.2
Adult mortality (%)	8
Squab mortality (%)	21.1

4.13. Body Weight of Squab

The mean weight at hatch of pigeons was 22.655g and week four was 271.66. Table 4.16 shows the weekly mean body weight.

Table 4.16: Pigeon Squab Weekly Mean Body Weight (±SD)

AGE	Mean (N=19)	± SD
Weight at hatch (g)	22.40	±4.806
Weight at week1(g)	157.75	±25.623
Weight at week2(g)	227.63	±36.147
Weight at week3(g)	267.25	±17.953
Weight at week4(g)	272.25	±15.600

4.14. Squab Growth Rate

Young domestic pigeon had faster growth rate for both male and female but the rate slows down with age from day one to week four. In all, over all weight gains of male squab was higher than female squab. Overall weight gains for male pigeons were 255.16 and female were 242.86. Table 29 and figure 2 shows the weekly body weight gains of young male and female pigeons.

Table 4.17. Squab Weekly Body Weight Gain base on Sex

	Sex	
Age	**Male**	**Female**
Weight at hatch	23.17	22.14
Weight at week1	139.33	130
Weight at week2	75	58.57
Weight at week3	35.83	50.72
Weight at week4	5	3.57
Over All Gains	**255.16**	**242.86**

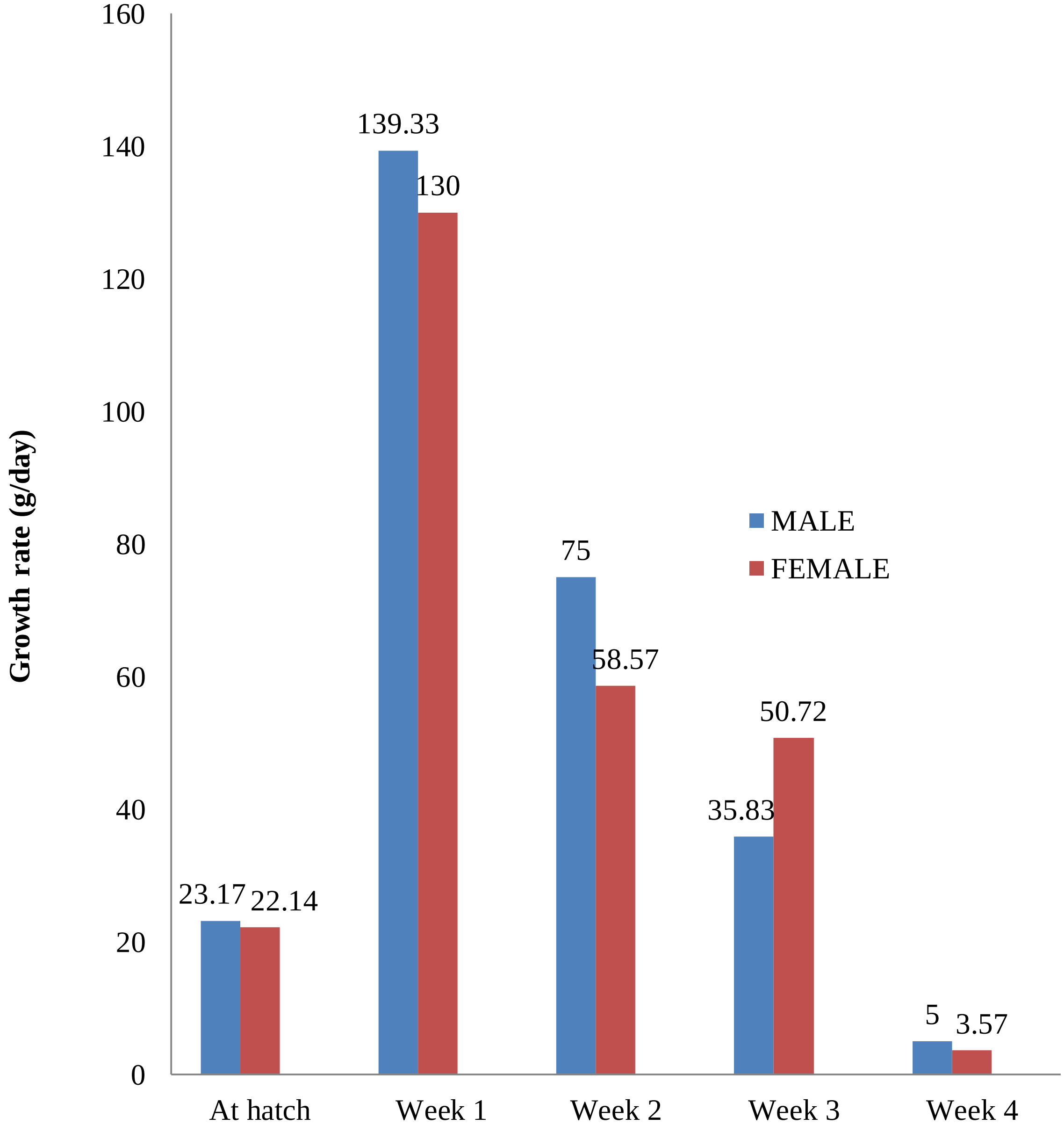

Figure 4.1: A bar graph showing the growth rate of squabs of different sexes against their ages (g/week)

4.15.0 Carcass Characteristics of Pigeons

4.15.1 Means and Standard Deviations of Carcass Measurements

Means weight of pigeon before slaughter, weight after defeathering, dressing weight and dressing percentage was 280.30g, 247.67g, 196.33g and 69.69% respectively. All other Means of carcass measurements are shown in (Table 4.18).

Table 4.18: Carcass Parameters of Pigeons, their Means and ±SD

Parameter	Mean	±SD	Range	
PSW (g)	280.30	34.71	267.77	292.83
DFW(g)	247.67	31.01	236.20	259.13
DW(g)	196.33	24.14	187.54	205.13
DP (%)	69.69	4.97	67.92	71.46
BW(g)	66.00	13.25	61.18	70.82
BCKW(g)	34.70	4.92	33.13	36.27
THW(g)	7.83	1.78	7.40	8.27
W(g)	28.30	5.00	26.33	30.27
DSTC(g)	5.47	0.90	5.13	5.81
H(g)	3.43	0.77	3.16	3.70
L(g)	6.27	1.26	5.93	6.61
G(g)	6.47	1.14	6.07	6.86

PSW= Pre-slaughter weight, DFW= defeathered, DW= dressed weight, BW= breast weight, BCKW= back weight, W= wing, DSTC= drumstick weight, H=hearth weight, L= lung weight, G= gizzard weight

4.15.2. Carcass characteristics expressed as a percentage of live weight

The pigeons lost 11.6% of their live weight after bleeding and defeathering and lost 30% of it body live weight after dressing. The edible internal organs (heart, liver and gizzard) constituted 6% of pigeon body live weight. Table 4.19.

Table 4.19: Carcass characteristics expressed as a percentage of live weight

Carcass Characteristics	Percentage Live Weight (%)
Defeathered weight	88.4
Dressed weight	70.0
Breast weight	23.5
Back weight	12.8
Thigh weight	2.8
Wing weight	10.1
Drumstick weight	2.0
Heart weight	1.2
Liver weight	2.5
Gizzard weight	2.3

4.15.3. Effect of sex on carcass characteristics of Pigeon

An important carcass characteristic for animal production is the live weight and dressing weight**.** The effect of sex was found to be a significant ($p<0.05$) source of variation for preslaughter weight, dressed weight and heart weight. All other carcass parameters were not influenced ($P > 0.05$) by sex (Table 4.20)

Table 4.20: Effect of sex on carcass measurements of domestic pigeon

Parameter	Male (n=15)	Female (n=15)	P-Value
PSW (g)	293.60±8.49	267.00±8.49	**0.039**
DFW(g)	258.67±7.77	236.67±7.77	**0.059**
DW(g)	206.33±5.97	186.33±5.97	**0.028**
DP(%)	70.25±3.27	69.13±3.266	**0.520**
BW(g)	70.53±3.27	61.47±3.27	**0.064**
BCKW(g)	35.20±1.06	34.20±1.04	**0.514**
W(g)	27.87±1.34	28.73±1.34	**0.652**
DSTC(g)	5.73±0.23	5.20±0.23	**0.118**
H(g)	3.73±0.18	3.13±0.18	**0.031**
L(g)	6.00±0.23	6.53±0.23	**0.118**
G(g)	6.40±0.27	6.33±0.27	**0.272**

P-value = probability value, g = grams PSW= Pre-slaughter weight, DFW= defeathered, DW= dressed weight, BW= breast weight, BCKW= back weight, W= wing, DSTC= drumstick weight, H=hearth weight, L= lung weight, G= gizzard weight

4.15.4. Effect of Colour on carcass characteristics of Pigeon

Except for back, lung and gizzard weight on which colour varieties had some effect ($p < 0.05$), all other carcass parameters were not influenced by colour variety ($P > 0.05$) (Table 4.21).

Table 4.21: Effect of colour variety on carcass measurements of domestic pigeon

Parameters (g)	COLOUR					P-Value
	White (n=6)	Black (n=6)	Pied (n=6)	BlueBar (n=6)	BlueCheck (n=6)	
PSW	269.17±13.43	285.83±13.43	269.00±13.43	280.00±13.43	297.50±13.43	0.539
DFW	235.83±12.29	256.67±12.29	240.83±12.29	244.17±12.29	260.83±12.29	0.569
DW	198.17±9.43	199.83±9.43	189.67±9.43	196.83±9.43	2.6.17±9.43	0.683
DP	72.38±1.90	70.12±1.90	70.42±1.90	66.20±1.90	69.33±1.90	0.268
BW	63.00±5.16	61.00±5.16	59.67±5.16	71.67±5.16	74.67±5.16	0.190
BCKW	30.67±1.68[a]	39.50±1.68[b]	33.50±1.68[a]	34.17±1.68[a]	35.67±1.68[ab]	0.020
THW	7.00±0.47	8.17±0.47	7.67±0.47	8.00±0.47	8.33±0.47	0.310
W	28.17±2.12	28.67±2.12	27.33±2.12	26.00±2.12	31.33±2.12	0.499
DSTC	5.67±0.29	5.33±0.28	5.33±0.28	5.33±0.28	5.67±0.28	0.906
H	3.00±0.29	3.17±0.29	3.50±0.29	3.50±0.29	4.00±0.29	0.175
L	5.00±0.37[a]	7.67±0.37[b]	6.00±0.37[a]	6.00±0.37[a]	6.67±0.37[b]	0.001
G	6.67±0.42[ab]	6.00±0.42[a]	6.00±0.42[a]	6.00±0.42[a]	7.67±0.42[b]	0.043

P-value = probability value, g = grams PSW= pre slaughter weight, DFW= defeathered, DW= dressed weight, BW= breast weight, BCKW= back weight, W= wing, DSTC= drumstick weight, H=hearth weight, L= lung weight, G= gizzard weight

CHAPTER FIVE

5.0. DISCUSSION

5.1.0. Description of Pigeon Production in Northern Region

5.1.1. Social characteristics of pigeon farmers

Pigeon farmers were predominantly males about 94.4%. This finding implies that men are the owners of small pigeons in the household. This reason may be attributed to societal customs and norms in some African societies where males control household productive assets. The large proportion of male farmers is very crucial for transferring and adoptions of technology since men are mostly the decision-makers in most African societies (Turkson & Naandam, 2006). This study did not agree with other literature reporting that most small scale poultry production are managed and owned by women. According to Amal *et al* (2014) about 55% of pigeon farmers were female under the family system, whereas 91-100% were males under the commercial production systems in Egypt. The birds were managed mainly by women (88%) and kept under scavenging system with very little inputs (Seth, 2014). Similar pattern of chicken ownership has been reported by Kitalyi (1998).

Over eighty three percent (83%) of the pigeon farmers did not have formal education in this study. This finding agrees with other reports. Majority (67%) of guinea fowl keepers have no formal education. This result is not peculiar to guinea fowl keepers as illiteracy rate among smallholder farmers in Ghana is generally high (Balma *et al.*, 2016). Access to formal education is an important determinant of livestock production technology adoption (Zipora *et al*., 2011; Sezgin *et al*., 2011) to the extent that it has a positive influence on technology adoption. Given the high illiteracy rates in the study area, farmers are forced to rely heavily on traditional methods of livestock rearing. Therefore, the high rate of illiteracy among pigeon keepers is a potential drawback to large-scale commercialization of pigeon production.

All the households interviewed in this study had access to farm lands and over 70% of them had agriculture as their main occupation while over 23% of them were traders. Subsistent agriculture production remains the primary employer of labour force of which livestock assumed a critical role (Adams *et al.*, 2014). The system of village poultry production involving low input integrates well with crop farming and other livelihood activities of rural households as it enables farmers to diversify their resources. This result agrees with the findings of Amaza (2000) that it is common for some farm households to engage in other non-farming activities to complement their earnings from farming occupation for their livelihood. This shows that pigeon farming can be a part time job.

5.1.2. Production systems and management practices of pigeons

The pigeon production system in Northern region can be classified as family poultry production system. There was no commercial pigeon production in the Northern region. The main reason for keeping pigeon in this production system is for home consumption (meat source, sacrifice, medicine, and presents for visitors and during funeral) and the surplus is being sold to achieve a better livelihood level. Family poultry production is the prevailing system in nearly all the rural sector. The economic purpose of the poultry farmer is mainly to meet family needs (Gharib *et al.*, 2012). The main objective of the farmers under the family system was home consumption and gaining profit (Amal *et al.*, 2014; El-Wardani *et al.*, 2008). Family poultry production was defined as flocks of less than 100 birds (Sonaiya., 1990). This system involves two subsystems according to flock size; small-scale and medium-scale village poultry production systems. Family poultry system is the most predominant systems in rural areas (Amal *et al.*, 2014). Village poultry are the predominant livestock species in many rural areas (El-Wardani *et al*., 2008 and Ahlers *et al*., 2009).

Over eighty seven percent (87.8%) of system of rearing was semi-intensive where pigeons were given only cereals (millet, sorghum, rice, broken maize, pea nut, cowpea, sesame etc) once or twice a day with no additional feed supplement or concentrate while 12.2% was extensive system of rearing. According to RSPCA (2011), domestic pigeons are primarily seed eaters but will take a wide range of grains, fruits, berries and Ashraful (2013) stated in his study that among the feeds, pigeon like grains such as corn, soya bean, peanut and wheat grain which conforms the findings of present study.

In this study, 83.3% of farmers had pigeon population size ranging 0-50 while 8.9% of the farmer had pigeon population above 100. According to Amal *et al* (2014) family system represented about 45% of the studied farms versus 55% for the commercial system and average flock size was 32±2.8, 83±12.9 and 344±51.8 birds in the family, wooden lofts and mud dovecotes systems, respectively.

From the findings of this study, only local pigeon breeds were seen and all bred under traditional systems of management, which was family run and no labour employed from outside. This was similar in other poultry reports. Since the small scale system is a scavenging type of production with occasional and seasonal supplementary feeding of homegrown grains and household food refusals this led to using indigenous or native breeds (Ashraful K.M., 2014[c] ; Gharib *et al*, 2012). The system of management appears to have an influence on the breeds used. The free range systems uses almost exclusively local breeds as it has been found, from the fate of exotic cocks in the numerous cock exchange programmes, that exotic birds do not survive under this system. There are reports of local birds having the ability to use high fibre feeds (Amal *et al* 2014). Local birds are kept by rural smallholders, landless farmers and industrial labourers, because of their scavenging adaptability, production ability and low maintenance cost (Kitalyi, 1998).

In terms of health, most pigeon farmers in northern region describe the birds as hardy and highly resistant to diseases with rate of mortality as low as (0-5%) throughout the year. According to the farmers in this present study, 28.9% of the cause of pigeon mortality is caused by diseases while predators cause 57.8%. None of the pigeon farmers have ever vaccinated their birds against any disease. And about 4.4% farmers deworm their pigeons while 13.3% normally provide their pigeons medication. The rate of mortality in this study was lower compared to other studies, Amal *et al* (2014) observed mortality rate under the mud dovecotes system to be (12.66%) followed by that of the family system (10.7%). And according to them, the high mortality in dovecotes systems was due to predators attack. This present study also recorded lower rate than (14.58%) reported by Ghosh (2013) and Asaduzzaman *et al*. (2009) who found 5-15% and most of the mortality occurs from the attack of predators and disease. Other constraints to increasing poultry production in rural areas are losses due to predators and insufficient feeding (Jaiswal *et al* 2016). In some African countries, a large proportion of village poultry are lost due to nocturnal predators (Bell and Abdou 1995).

5.1.3. Marketing of pigeons

Unlike other livestock pigeons are not processed for sale. Pigeons are sold live in local markets. They may be bought from pigeon farmers or from middle men who buy the birds in the villages from farmers and sell them at the market to traders and final consumers. This is not a full time job but an extra activity besides farming . A neighbor of a pigeon farmer who may need a pigeon for any purpose may not buy but exchange cereals, millet or sorghum for pigeon. In Northern region, pigeons are priced based on their colour morphology unlike other poultry birds due to their religious, medicinal and sacrificial use. The most expensive and uncommon colour was red which is sold above five hundred (500) Ghana cedis. Colour white was next expensive pricing from twenty (20) to thirty (30) Ghana cedis while any other colour aside the two priced from five (5) to twenty (20) Ghana cedis. From the results, red and white pigeons have more value than others. This may be due to their uses for some socio-cultural and religious purposes. Among the Mamprusi in Northern Ghana (Van Veluw, 1987), chicken cocks are the most popular sacrificial animals. A red cock is sacrificed to ask for rain or a good harvest; a white cock is used when they are grateful; a black cock is for protection from evil like disease, war or quarrel.

5.2. Morphological Description of pigeons in northern region

The pigeons encountered in northern region of Ghana fell into the local pigeon category. There was no exotic/cross pigeon category. The local pigeons were generally small in size or body weight as compared to their exotic counterparts as well as their crosses. There were no visible differences between the sexes except that males appeared larger than females. Pigeons have no sexual dimorphism (Ashraful., 2014[a]). Males and females of many species have very similar phenotypic traits (sexual monomorphism) such that even experienced ornithologists may have problems with unambiguous sex identification (Anna *et al*., 2006; Jaiswal *et al*., 2016). But sexual dimorphism may be considered as responding to some traits since phenotypic means are higher in male pigeons. The existence of sexual dimorphism was reported in various avian species including doves and pigeons (Santiago-Alarcon *et al* 2007, Forshaw *et al*., 1991 and Özbaser *et al.,* 2016).

The colour varieties identified were Blue Bar, Blue Check, Black Spread, White, Ash Red, Ash Red Bar, Brown, Brown Check, Pied, and Tiger.

5.3 Body Measurements

Generally, the mean body weights of adult Ghanaian domestic pigeon found in the Northern region was 301.04g where the mean body weights for males and females were 316.26±2.48g and 285.82±2.48g respectively. Azad (2009) observed that live weight of Gola male and female pigeons were 304.10g and 257.50g, respectively in Bangladesh which partially agrees with present findings. The mean body weights for male and female pigeons were found to be 344.95 g and 338.41 g respectively (Faruk *et al*., 2018). Rose *et al*. (2016) and Bartyzel *et al*. (2003) have reported higher body weight means of 356-344 g and 484-474 g for male and female pigeons in *Columba livia* and *Columba palumbus*, respectively. Furthermore, body weights means ranging from 328-432 g for male and 314-425 g for female have been reported in Turkish native pigeon breeds (Atasoy *at al*., 2013 Özbaser *et al 2016* and Soysal *et al* 2011). According to Jane (2005) and Bolla (2007), the live weights of pigeons were about 679.5-736.1g and 450-700g respectively. According to NRC (1991), pigeons weighed from about 500g to nearly 1000g and that a few large breeds (Runts, for instance, which commonly weigh 1400g) are the size of small domestic chickens. The disparity might be due to differences in management systems and practices employed in raising birds. Also, the small size of the Ghanaian pigeons agrees with Bergmann's Rule as stated by Kendeigh (1969) who postulates that, geographic races of small size are generally found in the warmer parts and races of larger size in the cooler parts. Also, in the developed world, many breeds have been developed for meat production. They produce squab that grow quicker and have larger breasts than unselected birds (NRC, 1991).

Mean body length, wing span, wing length, shank length and bill length in this study were 30.95cm, 60.70, 11.12cm, 3.18cm, 1.84cm respectively. The results of mature Jalali pigeon for same parameters observed in the study of Bhowmik *et al* (2014) were 33.28±0.18cm, 64.37±0.20cm, 3.08±0.02cm and 2.04±0.01cm, respectively which are all higher than the results from the present study. Faruk *et al.* (2018) recorded 26.70cm, 2.6cm, 59.07cm and 8 .42cm for body length, bill length, wing span and shank length respectively which is lower than present study except for shank length. These differences between this study and previous study may be due to genetic effect and selective breeding in the developed world.

Sex had profound influence ($p < 0.01$) on body weights and body lengths in pigeons and both sexes had similar ($p < 0.05$) wing length and wing span. In this study, male pigeons had higher body measurements than their female counterparts; the males were slightly heavier (316.26±2.48g) than the females (285.82±2.48g). In all, male pigeons were superior to females though there were no significant differences in shank and bill length ($p > 0.05$). In literature, the means for body weight of male pigeons have been reported to be higher compared to females (Gayathri *at al*., 200; Johnston., 1990; Rose *et al.*, 2016). In this respect, sexual dimorphism may be considered as responding to some traits since their phenotypic means were higher in male pigeons. The existence of sexual dimorphism was reported in various avian species including doves and pigeons (Santiago-Alarcon *et al* 2007, Forshaw *et al*., 1991 and Özbaser *et al.*, 2016).

The various districts locations of pigeons were different in terms of body length ($p < 0.01$) and ($p < 0.05$) wing span and wing length. Birds in east Mamprusi recorded the longest body length, wing span and wing length (31.37±0.17cm, 61.47±0.54cm and 11.73±0.21cm respectively) while those at Tolon recorded the least 31.21±0.19cm for body length, Kumbungu recorded the least (58.65±0.54) for wing span and West Mamprusi recording the least (10.57±0.19) for wing length. The pigeons recorded similar ($p > 0.05$) values for the rest of the morphological parameters. Pigeons from the East Mamprusi were the heaviest (310.21±4.74g) and those from Gushegu recording the lightest (292.49±5.17g) among the nine districts. These differences may be due to differences in non-genetic factors such as feeding, housing, climate and management as stated by Kabuga and Agyemang (1983); Osei and Effa-Baah (1989); Osei *et al.* (1991); Ahunu *et al.* (1993); Darko and Buadu (1998); Baffour-Awuah *et al.* (2005); Beffa *et al.* (2009). Animals in different herds perform differently because they are given different treatment or management. Differences might also be due to differences in genetic makeup since they are not from the same lineage.

The various colour varieties did not have an influence on body measurements of pigeons in this study. The values recorded were similar ($p > 0.05$) for all the morphological parameters except for body weight which had some significant differences ($p < 0.05$). Blue checked pigeons recorded the highest body weight (309.11±4.20g) while white pigeons recorded the lowest body weight (291.92±4.46g). The difference in body weight may be due to environmental effects such as nutrition, housing and healthcare.

5.4. Correlations among morphometric traits and prediction of body weight using body measurements

Correlations among body traits are very important in the study of morphometric characters because they (the correlations) serve as indicators of the magnitude and direction of change in one trait as affected by another. In this study, the highest correlation was between body weight and body length (0.467), body weight and wing length had the second highest correlation value of (0.299). There was a relatively high correlation between body length and wing length (0.279) and body length and wing span (0.232) respectively. Similar results have been reported by Bhowmik. *et al* (2014) that, positive and significant correlations were between body weight and body length, wing span which suggests that selection for any of these body parameters will cause direct improvement in body weight. The least was a correlation between body length and shank length (0.026).

The best regression equation utilized body length and wing length to estimate body weight. Using additional body measurements showed negligible increases in the R square value. Since every additional measurement increases time and cost it was best to recommend the use of only two measurements (body length and wing length) for prediction of body weight. The live body weight of an animal is one of the single most important growth and economic trait that most producers and processors of animal products give special attention to. Accurate knowledge of live weight and ways of predicting it are therefore imperative for maximization of its benefits by farmers and livestock processors. Even though using conventional weighing scales is the best way of determining the live weight of an animal, the use of linear body measurements have become a laudable alternative (Fourie *et* al., 2002; Riva *et al*., 2004; Afolayan *et al*., 2006; Cam *et al*., 2010; Birteeb, 2011).

5.5. Egg production

For the duration of the study, egg laying never ceased. Eighteen (18) hens out of the 25 laid a total number of 54 eggs, Two (2) eggs at a session. Typically, there are two eggs per clutch (NRC, 1991) which is in agreement with present findings. From personal interaction with the farmers across the nine districts, it was obvious that pigeon are non-seasonal breeders, they produce all year round.

5.6. Egg characteristics

The mean egg weight, length and width in this study were recorded 26.350g, 3.681cm and 2.867cm respectively. Ibrahim *et al.* (2010) reported that mean egg weight of street pigeons (*Columba livia*) was 14.46±0.11g which is lower than those obtained in this present study. Darwati *et al.* (2010) found that egg weight ranged from 10.7 to 23.2g with a mean of 17.7±1.6g which is lower than the present study. Robinson (2005) noticed the mean egg weight of domestic pigeon was 18.9g which is lower than those obtained in this present study. Sales and Janssens (2003) reported the mean egg weight of domestic pigeon as 21.4g which is also lower but closer to results of present study. These differences could be due to genetic and/or non-genetic effects. Meat pigeons lay much heavier eggs, 22 g (Meleg *et al*. 1999, Mikulski Pudyszak 2002). Abou-Khashaba *et al*. (2009) demonstrated that the weight of eggs increased significantly with the diet metabolic energy content. Egg length and width of pigeon (*Columba livia*) were 3.68cm and

2.85cm in the study of Bhowmik *et al* (2014) in Bangladesh strongly agrees with the present study. The hatching period of Jalali pigeon obtained in the study of Bhowmik *et al* (2014) were 18.00±0.09, which was 2 days more than the present study.

The egg colour and shape in this study were white and oval. The egg colour and shape of Jalali pigeon were white and oval which are similar with the findings of Bhowmik *et al* (2014) , Saxena *et al.* (2008), Khargharia *et al.* (2003) and Johnston (1992). Pravez *et al* (2016) studied fifteen breeds of pigeons and discovered egg colour and shape to be white and oval which is in agreement with present study. The shape of eggs has an impact on the hatchability indices, since it determines the proper position of the embryo (Narushin and Romanov 2002). Studies on poultry have demonstrated that hatchability may become heavily deteriorated if the shape index deviated from the species-characteristic average (Zgłobica *et al.*, 1995; Harun *et al.* 2001). Darwati *et al.* (2010) found that egg shape index in pigeons ranged from 70.1 - 81.3% and our results remained within this range too. The range of egg shape index in this present study was 74.4% - 96.6% with a mean of 78.090%. This compared favourably with results obtained by research done by Olawumi and Ogunlade (2008) who reported an egg shape index of 76.18% in **e**xotic ISA brown chicken eggs in Nigeria**.** Sezer (2007) reported a shape index of 79.12% for Japanese quails in Turke**y.** In research of pigeon breeds, egg shape index in Polish Owl pigeons was 73.04%, whereas in Warsaw, Butterfly Tumblers was 3% greater compared with the current study.

5.7. Egg Fertility and hatchability

Hatching period in this study were 16-17days. The hatching period of this study closely compares with that of Saxena *et al.* (2008) who stated that, it takes 17–18 days for a pigeon egg to incubate. Egg brooding is to ensure the proper development of the embryo, leading to a successful hatching and birth of the chick. Incubation is influenced by a number of factors, such as its duration, type of nursing of the brood, frequency of egg turning, fresh air supply, weather conditions, nest type, parent health status (Kwieci´nski *et al*. 2009).

Egg fertility in this study was seventy percent (70.4%) with a hatchability percentage of 35.2. Darwati et al. (2010) declared that hatchability of pigeon was 77%. However, Ashraful (2013) said that hatching capacity was 98.92±1.04% for crossed indigenous pigeon in semi intensive rearing. It was reported by Khargharia *et al*. (2003) that the hatchability percentage in Assam breed was higher (84.98%) in monsoon season than (80.01%) in pre monsoon season with average hatchability of 82.86% which is much higher than present study. They further asserted that animal performance varies with years due to differences in climatic variables in different years. For two pigeon breeds, egg fertilization rate in Polish Owl pigeons was, 64.86%, where as in Warsaw Butterfly Tumbler it was 25% higher (Danuta *et al.*, 2016). Fertility rate of present findings is higher than the polish owl and lower than the tumbler. Hatchability was 97.2% in Polish Owl pigeons and 69.57% in Warsaw Butterfly Tumblers which are all higher than present study. Zielezinski and Pawlina (2007) found that the hatchability of homing pigeons was 90.74%, while in King and Wrocław meat pigeons it averaged 75.76–76.00. According to Amal *et al* (2014), the mean hatchability rate in the mud dovecotes system was 80.76% whereas

90.67% was under the wooden lofts system. El- Hanoun *et al*. (2008) declared that percent hatchability in the mud dovecotes for the Nile Delta region ranged from78 to 85.29%.

The low hatchability percentage recorded in this study might be due to genetic factors, environmental factors such as seasonal effect as the study was done in heat season and there is no selection for good hatching characteristics from the maternal ability. Hatchability indices depend on many factors, including nutrition, age of birds, conditions under which eggs are incubated, year season; hence, the literature data on average of this parameter for pigeons (in relation to fertilized eggs) vary substantially (Meleg *et al*., 1999).

5.8. Correlation among egg parameters

The highest correlation for egg characteristics was between egg weight and egg length (0.847). There was also a strong positive correlation between egg width and egg length (0.702). Egg weight was significantly correlated with egg length and egg width. Egg length was significantly correlated with egg width Bhowmik *et al.* (2014) which strongly agrees with the results obtained in this study. This means that egg length and width are important indicators of egg weight. The lowest correlation was between egg shape index and egg width (0.080). This pattern of correlations was similar to that reported by Mogre (2009) for indigenous guinea fowls in northern Ghana. His study found the positive correlations between egg length and egg width, egg weight and egg length, with negative correlations between shape index and egg weight, shape index and egg length.

5.9. Mortality

Adult mortality was 8% while squab mortality was 21.1%. High mortality rate for squab in this study was due to casualty of young birds falling from lofts. From the interaction with farmers in this study, 94.5% of them stated that pigeon mortality was low (0-5%) and 28.9% of the cause of mortality was disease, 57.8% was predators and 8.9% was caused by pest. According to Amal *et al.*, (2014), high percentage of mortality was observed under the commercial mud dovecotes system (12.66%) followed by that of the family system (10.7%). They further stated that, the high mortality in the dovecotes systems was due to predator attacks. Ghosh (2013) reported 14.58% mortality rate while Asaduzzaman *et al.* (2009) recorded 5-15%. They also, stated that most of the mortality occurs from the attack of predators and disease. The low mortality rate in present study might be due to the hardy nature of the local Ghanaian pigeon and their ability to resist diseases.

5.10. Squab body weight and weekly gains

The growth performance and development of pigeon squabs are of crucial importance for meat production as well as racing pigeons. The mean body weight of in this study for day1, week1, week2, week3 and week4 were 22.655g, 157.321g, 224.107g, 267.381g and 271.667g respectively which were lower than averages of body weight at 1, 2, 3, 4 weeks of age of racing pigeons recorded as 79.10, 173.90, 233.55 and 283.85, respectively in Egypt by Mohammed, (2014) but Gao *et al.* (2016) in their findings reported 18.7 ± 0.9g, 115.8± 6.7g, 280.7 ±7.8g, 393.3±11.4g and 487.5± 5.5g for day1, week1, week2, week3 and week4 respectively which is higher than the present findings except that they recorded lower figure for day1. Momoh *et al.*, (2013) recorded 13.17±1.226g, 108.62±7.00g, 221.61±9.20g and 275.52±6.50g for day1, week1, week2, week3 and week4 respectively. This difference is because weight depends upon breed, nutrition, and several other factors.

In this study, growth rate was fast for both male and female but the rate slows down with age from week3 to week4. Weekly gains from day1, week 1, week 2, week 3 and week 4 were 134.666g, 66.786g, 43.274g and 4.286g respectively which is similar to the mean body weight of Jalali pigeon in India at 3-day, 15- day and 1-month of age were 31.68±1.08g, 225.53±3.89g and 275.59±1.48g respectively (Ashraful, 2013). Squabs have an extraordinarily high rate of maturing (0.1466 to 0.1945 g/d) in comparison to other domesticated avian species such as chicken (0.0450 g/d) and quail (0.077 to 0.097 g/d). This growth rate is achieved by regurgitation of a holocrine substance (crop milk) by both parents, formed in response to prolactin secretion and triggered by brooding (Sales et al., 2003[b]). The phenomenal growth rate of young squab has been attributed to crop milk regurgitated by both parents (NRC, 1991).

Sales *et al.*, (2003[a]) indicated that pigeons reach mature body weight at 28 days of age and the increase in weight after that is very low. Pawlina *et al*, (2011) found a similar pattern, they studied a meat pigeon breed and noticed a drop in daily gains at the end of 4 weeks of age. Also, According to Danuta and Tmasz (2016), the body weight daily gains were 8.83g to 12.61 g between day 7 and day 14 of rearing, and next decreased to reach 0.47 to 1.77 g between days 21 and 28 which corroborate with present study. Heritability estimates for body weight at various ages were high and increased with the age of squab, being 0.47±0.04 at hatch and 0.66±0.03 at 4 week of age. It dropped to 0.43±0.04 at maturity. The increase in heritability estimates of body weight from birth to weaning, which decreased at maturity might be due to declining maternal effect Momoh. *et al* (2013) .

Ashraful (2014[a]) in his study stated that, Squabs grow quickly during the third week and slow in fourth week. The age 4 weeks is therefore the optimum when meat pigeons should be slaughtered, as keeping them further would be economically inefficient.

5.11. Carcass Characteristics of Pigeon

The overall least squares means combined over the sexes, preslaughter body weight, defeathered weight, dressing weight and dressing percentage in this study were 280.300±6.007g, 247.667±5.495g, 196.333±4.218g and 69.690±0.849% respectively. A study by Khargharia *et al*. (2002) recorded lower values 215.88±3.83g, 194.63±3.85g, 166.03±3.54g and 71.48±0.59% for the same parameters respectively, all their values were lower than those recorded in this present study except for dressing percentage which was higher. Hena *et al*. (2012) in his comparative study of pigeon and quill reported higher figures 270.88±4.08g and 160.57±7.79g respectively for preslaughter weight which is higher than figures reported for this study.

Also, means for the whole sale cut i.e. breast, back, thighs, wings and drumstick for this study were 66.000±2.309g, 34.700±0.752g, 7.833±0.208g, 28.300±0.946g, 5.467±0.163g which are lower than figures (48.25±1.30g, 39.03±1.01g, 10.30±0.37g, 32.90±0.64g and 10.45±0.20g) reported by Khargharia *et al*. (2002) except for breast which was higher. From the results of present findings for sale (cut carcass parts), the biggest carcass parts were their breast followed by back, wing and thigh. Omojola (2012) and Khargharia *et al*., (2002) reported similar results that the pigeon breast has the biggest percentage compared to other carcass parts.

The heart is similar in shape and construction to the mammalian heart (Sakas, 2002) and the liver of Pigeons was found to be smooth, chocolate in colour and glossy in appearance (Hena *et al*., 2012) . The weights of the heart, liver and gizzard in this study were 3.433±0.129g, 6.267±0.163g and 6.467±0.189g respectively. Comparatively, heart and liver weights in this finding were higher than 2.95±0.22g and 5.96±0.44g reported in similar study of pigeons and 2.38 ±0.25g and 4.53±0.29g for quill (Hena *et al*., 2012). The weight of the liver of pigeon in this study did not rhyme with the findings of Pauline *et al*., (1997) where they found the weight of an adult pigeon liver to be 5.59g, the liver can normally be quite large. In the work of El-Shafey *et al*., (2008) they reported the weight of the liver in pigeon to represent 3.2% of the total body weight. This had been found contrary to the findings in this present research in which the liver weight represented 2.5% of the total body weight. The size of the heart in relation to body mass of pigeons in this study was found to be larger i.e 1.2%, this agreed with the finding as reported by an Anonymous (2012). This may relate to the high demand to meet the physiological activities of the birds. Birds have a much higher metabolic rate than mammals. The average body temperature of an avian is 41-45 degrees Celsius, compared to mammals which have relatively lower body temperature. The pulse rate of birds can reach as high as 400 beats/min (Anonymous, 2012). All of these factors place a great demand on the bird's heart which has to work much harder than a mammalian heart. The bird's heart is adapted to handle the increased stress placed on it by its high metabolic rate (Hena *et al*., 2012).

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Based on results of this study:

- Family pigeon production system is the prevalent system and the most predominant pigeon breed was local. Pigeon farming is not well organized however, it plays an important role in the livelihoods of rural poor people, (economically, nutritionally and socio- culturally). Poor farmers involved in pigeon farming sees it as a good opportunity for generating income. Therefore, pigeon farming may be considered as a profitable business if it is run in a proper way.
- The production system was characterized by minimal inputs, in terms of labour, feeding, housing and health care.
- The birds depended mainly on scavenging feed resources available in their immediate environment. The average flock size and productivity was generally low.
- Diseases, predators, and inadequate nutrition particularly during the dry season were found to be the major causes of high mortality and low productivity in pigeons in the survey.
- The local pigeons are not seasonal breeders, they produce all year round.
- Generally pigeon are small in body conformation with East Mamprusi district having the heaviest pigeons.

- Pigeon have wide range of colours mixture of different colours. The pied, black, blue bar, blue check and white variety had the largest representation in the nine districts of northern regions.
- There were no visible differences between the sexes.
- There is a high demand for white pigeons and red pigeons are the uncommon and most expensive.
- Body length (BL) was the best predictor of body weight. It can therefore be used by farmers to predict body weight of pigeons. High degree of reliability of regression estimates of body weight in the pigeons could aid in the selection of both breeder and meat type pigeons for improved reproductive and production performance, particularly in rural areas or where weighing scale is not readily available.
- The local Pigeons face problem of low hatchability especially in heat seasons.
- The local Pigeons are highly prolific, short hatching period (16-17days) and medium two eggs to a clucth. The egg colour and shape of pigeons were white and oval.
- The highest correlation for egg characteristics was between egg weight and egg length (0.847).
- The pigeons lost 11.6% of their live weight after bleeding and defeathering and lost 30% of it body live weight after dressing.
- The edible internal organs (heart, liver and gizzard) constituted 6% of pigeon body live weight.
- The highest correlation was between body weight and body length (0.467), body weight and wing length had the second highest correlation value of (0.299)

6. Recommendation

- Pigeon owners should be encouraged to enroll in training programs that will educate and inform them better on the proper feeding, husbandry, biosecurity measures and how to utilize the available resources effectively.
- There is little to be gained from measuring several body components in predicting body weight. Body length alone appeared to provide the best single measurement predicting body weight. It is recommended that where labour is expensive body length be used alone to predict body weight using the equation : BWT = BWT = -117.481 + 13.512BL
- More research works should be conducted on characterization of the local Ghanaian pigeon including phenotypic, genetic, molecular, and immunological characterization and genetic parameter estimation. This will aid breeding and conservation decisions.
- Selection and breeding programs should be carried out to improve the production performance of the pigeons. The specific areas that require immediate improvement are body weight, egg fertility and hatchability.
- Also, local pigeon should selectively be bred for a range of pure red and white morphology .This is because the demand for those colours is not fulfilled creating an unreasonably high price, especially for the red pigeons.

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APPENDICES

Appendix 1. Questionnaire for primary data collection

Table.34. Questionnaire for Data Collection on Characterization of Domestic pigeon (*Colomba livia domestica*) in Northern Ghana

A	**IDENTIFICATION**	Sections A1 to A5			
A1	**The Farm**	Address : Town			
A2	**Farmer or Proxy**	Name : Sex : Education : Profession :			
A3	**Type of operation**				
	Species kept alongside pigeons	Ruminants	☐	Pigs	☐
		Other species of poultry	☐	Chicken, Ducks, Geese, turkeys, guinea fowl, Others specify………………………	
	Other production activities	Crops	☐	Livestock	☐
		Milk	☐	Meat	☐
		eggs	☐	Fibre	☐
		other (specify)			☐
A4	**Purpose of keeping pigeons**	○ For fun/hobby ○ Own consumption ○ Sale ○ Religiouspurposes			
A5	**Member of a developmental project?**	If yes, which one :		If no, why :	

Table.34. Questionnaire for Data Collection on Characterization of Domestic pigeon (*Colomba livia domestica*) in Northern Ghana Cont'd

B	**POPULATION HISTORY**	Sections B1 to B3			
B1	**Period of creation**	Approximate year/months (specify)........................			
B2	**Description and origin of the foundation stock**				
	Number of birds	Small (<10)	☐	Average (10 to 50)	☐
		Sizeable (>100)			☐
	Appearance of birds	Homogenous	☐	(see description in section D)	
		Heterogeneous	☐		
	Source	One stockbreeder	☐	Many stockbreeders	☐
		Where? (name, locality).....................			
		Bought from market (specify)..............			
B3	**Subsequent introduction of new stock since creation**				
	Of the same type?	yes	☐	no	☐
		If yes, when? :			
		How many? :			
	Of a different type?	yes	☐	no	☐
		If yes, which type? :			
		When? :			
		How many? :			

Table.34. Questionnaire for Data Collection on Characterization of Domestic pigeon (*Colomba livia domestica*) in Northern Ghana Cont'd

C	**FLOCK MANAGEMENT**	Sections C1 to C14			
C1	**Are the birds Identified**	Males stock		females Adult stock	
	By what means?	Individual tag Visible characteristics: Plumage, Toes, Wings. Others (specify)…………………..			
C2	**Population size**	**Total** (young + adult) =			
	Size calculation	Estimation		Counting	
	Trend of the population size	○ Stable ○ Increasing ○ Decreasing			
C5	**Mode of reproduction**	Two parents known No parent known		Others(specify)...............	
C6	**Type of Reproduction**	Natural incubation			
		Artificial incubation			
		Reproduction season		When?(specify)...............	
C7	**Total number of Breeding pairs**	0-10 10-30 30-50 50- 100		>100	

Table.34. Questionnaire for Data Collection on Characterization of Domestic pigeon (*Colomba livia domestica*) in Northern Ghana Cont'd

C10	**System of rearing**	Intensive Semi-intensive	☐ ☐	Extensive	☐
C11	**Feeding**	No feed provided Balanced ration bought Cereals only	☐ ☐ ☐	Cereals + Concentrates Other feed (Specify)	☐ ☐
C12	**Health**	Vaccines	☐	Specify	
		Deworming	☐	Specify	
		Diseases affecting flock (specify)			
		Medication/Remedy provided (specify).......................			
		Mortality rate ○ Low (0-5%) ○ Medium (6-10%) ○ High (> 10%)			
		Causes of mortality ○ Disease ○ Predators ○ Lack of feed ○ Pest ○ Others(specify)			
C13	**« Destination » of the Animals**	Home consumption Sold for consumption (price ? =)	☐ ☐	Replacement stock Sold as breeding stock (price ?=)	☐ ☐
		What prompt you to sell your pigeons?................			

		At what age do you sell them?
C14	**Describe any specific ability of the variety:**	
		Behavior (aggression, nervousness) ○ Very aggressive ○ Aggressive ○ Nervous ○ Very Nervous Reproduction (brooding, laying season) ○ Breed in rainy season ○ Breed in the dry season ○ Breed in the heat season ○ Breed in all season Adaptation to the climate ○ Very Adapted to the northern climate ○ Moderately adapted to the northern climate ○ Not Adapted to the northern climate Resistance to diseases ○ Highly resistant to diseases ○ Moderately resistant to diseases ○ Not resistant to diseases Others (specify)……….

Appendix 2.Pigeon Body measurements

Plate 23. Picture illustrating how pigeon body weight was taken

Plate 24. Picture illustrating how body length was taken

Plate 25. Picture illustrating wing span was taken

Plate 26. Picture illustrating how wing length was taken

Plate 27. Picture illustrating how shank length was taken

Plate 28. Picture illustrating how bill length was taken.

Appendix 3. Pictures of litter production system with nest provided

Plate 29. Showing pigeons feeding in a litter system

Plate 30. Wall mounted woven baskets for nesting

Appendix 4: Egg measurements

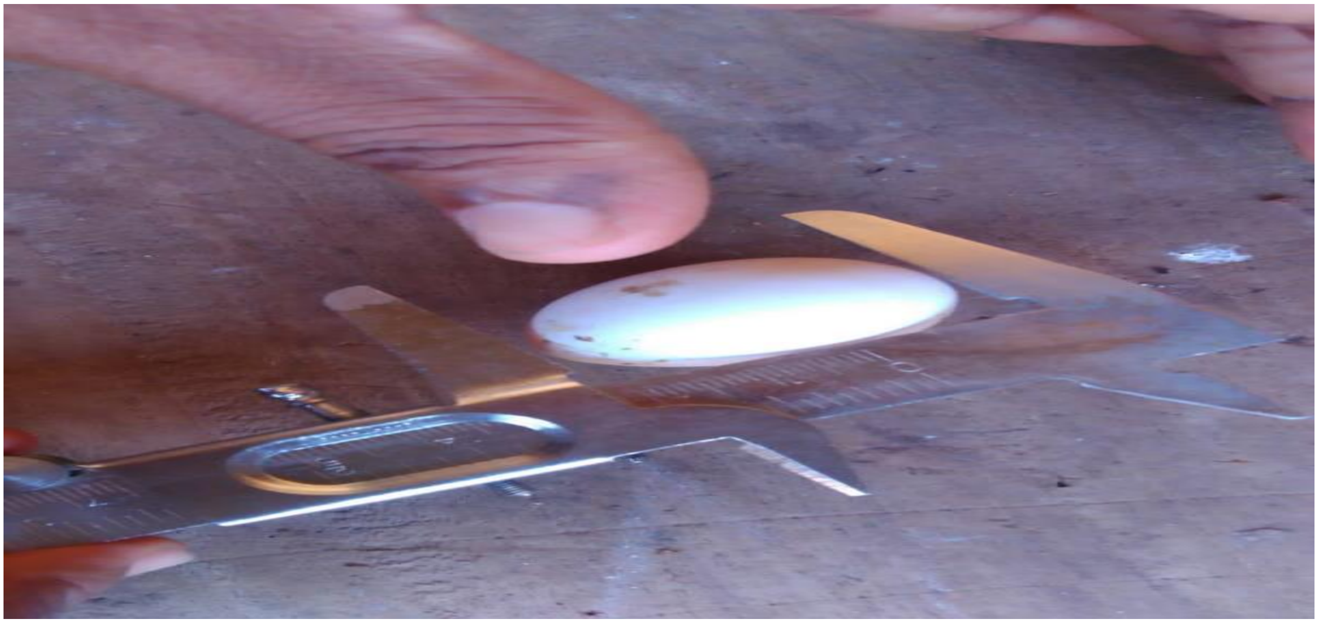

Plate 31: Picture illustrating how egg length was measured

Appendix 5. Pictures Showing Squab growth rate from Day One to week Four

Plate 32. Squab at day1

Plate 33. Squab at week1

Plate 34.Squab at week2

Plate 35. Squab at week 3

Plate 36. Squab at week

Appendix 6. Carcass measurements

Plate 37.Defearthered whole pigeon carcass

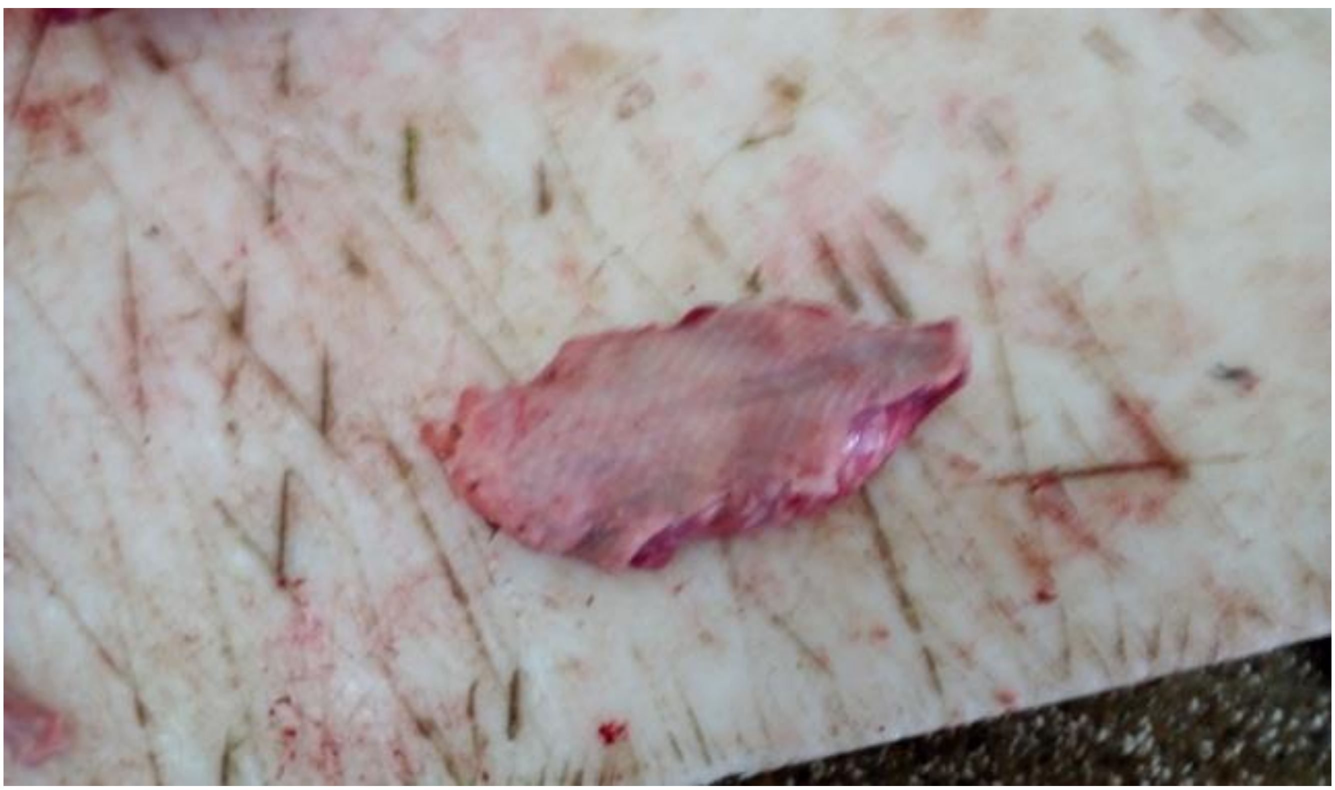

Plate 38. Pigeon back

Plate 39. Pigeon wing

Plate 40. Breast and shank of pigeon carcass

Plate 41. Showing pigeon internal organs

Appendix 7. Pictures of the various pigeon colour varieties.

Plate 42. Blue Bar pigeon

Plate 43. Brown Bar pigeon

Plate 44. Black Spread pigeon

Plate 45. White Spread pigeon

Plate 46. Brown Paid pigeon

Plate 47. Black Paid pigeon

Plate 48. Blue Checkered pigeon

Plate 49. Brown Checkered pigeon

Appendix 8: Picture showing the genetic linkage to colour

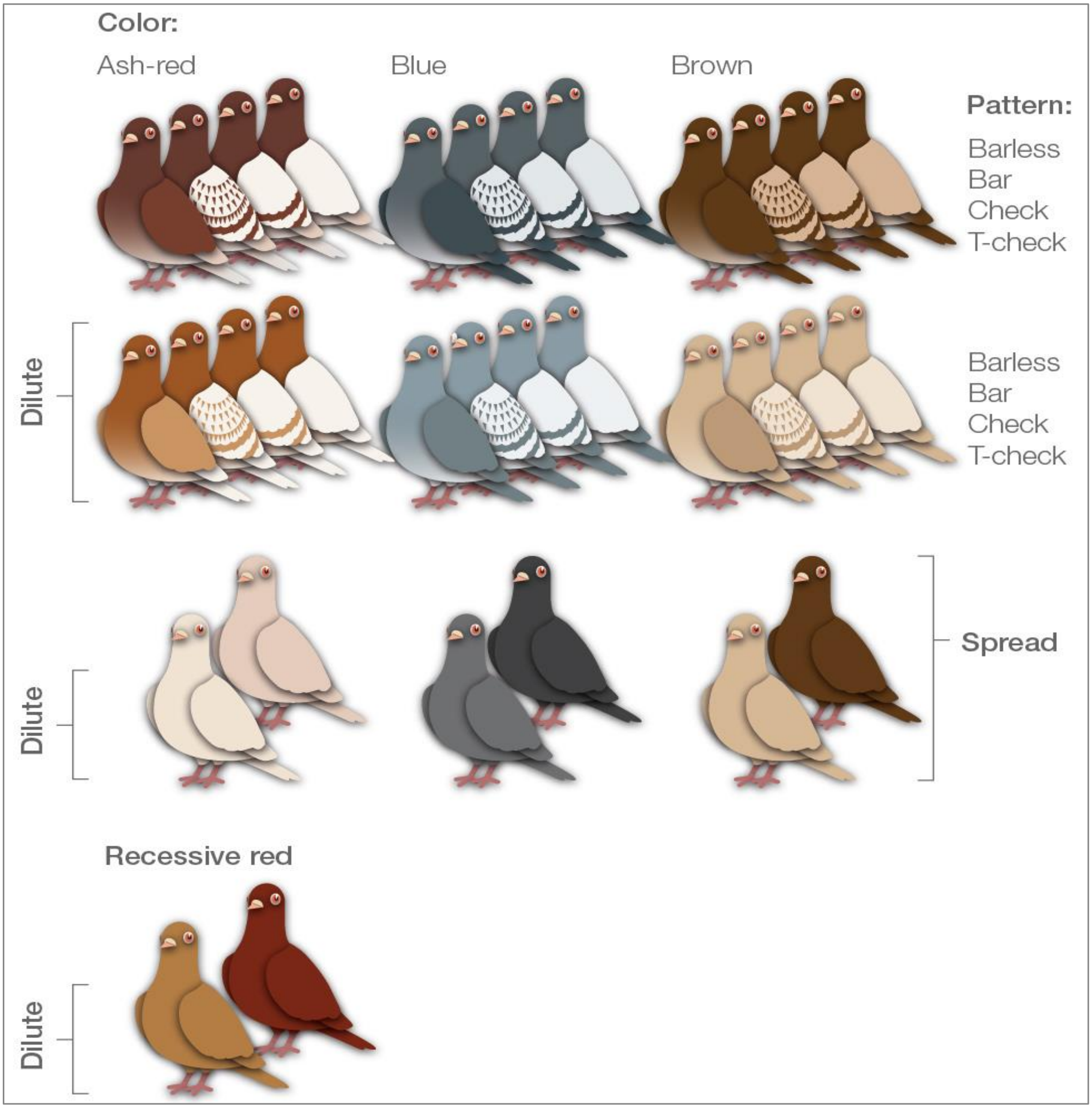

Plate 50 : A colour chat which was used to define the plumage colour type in this study.

Source : Genetic Science Learning Center (2014)