KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

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DEPARTMENT OF ANIMAL SCIENCE

PROTEIN REQUIREMENTS FOR GROWING AND LAYING INDIGENOUS GUINEA FOWLS (*NUMIDA MELEAGRIS*) IN THE HUMID TROPICAL ZONE OF GHANA

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A DISSERTATION PRESENTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF M.SC. (ANIMAL NUTRITION AND MANAGEMENT) DEGREE

CERTIFICATION

This thesis entitled "Protein Requirements for Growing and Laying Indigenous Guinea Fowls (*Numida meleagris*) in the Humid Tropical Zone of Ghana" by Adjetey, Angela Naa Atswei, meets the regulations governing the award of Masters' Degree of the Kwame Nkrumah University of Science and Technology, Kumasi and is approved for its contribution to scientific knowledge and literacy presentation.

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ABSTRACT

This study was undertaken to assess the dietary crude protein (CP) concentrations required by growing and laying indigenous guinea fowls (*Numida meleagris*) for optimum growth performance. A 28- week experiment was divided into two phases namely, growing phase and laying phase. One hundred and eighty (180) nine- week old pearl guinea fowl growers were randomly assigned to experimental diets with 16, 18, 20 and 22% CP, from 9 to 27 weeks of age for the growing phase. During the laying phase, 28 to 36 weeks, 120 pearl guinea fowl pullets were randomly assigned to diets containing 15, 16, 17 and 18% CP. All the eight rations in both experiments one and two were isocaloric, having ME of 12.30 MJ/ kg. Each dietary treatment was replicated 3 times, a pre-weighed amount of feed was given and water was provided *ad libitum*. Feed consumption was measured daily and body weight measured weekly. Mortality was recorded as and when it occurred. Other parameters measured included haematology and biochemical analysis, carcass parameters, age and weight at first lay, weight of first egg and other egg parameters. Results show that diets containing 16% crude protein for growing guinea fowls and 18% crude protein for laying guinea fowls are ideal for optimum growth performance and production.

DEDICATION

To the ever loving memory of my dear sister Zenobia Oko- Odoi. To my parents, Rev. and Mrs. Ala-Adjetey and my siblings Andrew, Clifford, Evelyn and Cindy with much love for their constant support, prayers and unconditional love. Thank you for always being there.

I dedicate this dissertation to Mr. Emmanuel Mannoh for his financial support towards the success of this work. God bless you abundantly.

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If the LORD delights in a man's way, He makes his steps firm; though he stumble, he will not fall, for the LORD upholds him with His hand. Psalm 37:23-24.

I am so grateful to God for His extravagant grace.

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CHAPTER ONE

1.0 INTRODUCTION

The guinea fowl is a bird native to the African continent (Payne, 1990; Smith, 1990). It derives its name from the Coast of Guinea where it is believed to have originated (Teye and Gyawu, 2002). The indigenous guinea fowl (*Numida meleagris*) is widely distributed in Africa where it has distinct popularity among smallholder farmers. It is believed that guinea fowls were taken to Europe and America by the Portuguese. In these regions the guinea fowls have been scientifically improved resulting in faster growth rate, bigger body size and enhanced egg laying capacity (Teye and Gyawu, 2002). Guinea fowl production is beginning to increase all over the world (NRC, 1991).

In Ghana, it is one of the most common poultry species found in the Upper East, Upper West and Northern Regions (Dei and Karbo, 2004). There were no large scale production units in Ghana as occurs for chicken (Awotwi, 1987) until quite recently. In Ghana, indigenous guinea fowls are mostly reared in small backyard units in small scale numbers.

Guinea fowl (*Numida meleagris*) can be kept both for meat and egg production (Smith 1990). The flesh of young guinea fowls is tender and has a fine flavour resembling that of wild game (Awotwi, 1987). The meat of guinea fowl is served extensively in hotels and restaurants because of its wild game flavour (Feltwell, 1992). According to Koney (1993), the guinea fowl yields higher, firmer and tastier meat than chicken. Households usually keep the birds in small numbers as a source of protein for the family (Adjetey, 2006). Guinea fowl eggs are very popular in

Ghana and are sold on the market during the months of May to July (Awotwi, 1987). The eggs keep longer than domestic fowl eggs because of their unusually thick shell (Ayorinde, 2004).

There are hardly any cultural barriers against consumption of guinea fowl products (Saina *et al.*, 2005). It thrives well under semi- intensive conditions, but can be reared intensively on a commercial scale for egg or meat production (Naazie *et al*., 2007, Teye and Gyawu, 2002). The guinea fowl is a promising genetic resource for evolving a low-input poultry enterprise mostly in developing countries, and has a potential for reducing poverty (Teye and Gyawu, 2002).

Despite the renaissance in guinea fowl production, it is important to take cognizance that there is a dearth of information on guinea fowl production, in contrast to indigenous chickens where extensive research is available (Kusina and Kusina, 1990; Maphosa *et al.,* 2002; Muchadeyi *et al.,* 2004). The nutritional requirements of commercial chickens, turkeys, pheasants and related poultry stock have been documented by researchers such as Blum *et al*., (1975), Woodard *et al*., (1977), Potter and Shelton, (1979), Yamane *et al*., (1980) and NRC, (1984). On the other hand, Nsoso *et al.,* (2006) and Awotwi (1987) agreed that information on guinea fowl production despite the tremendous advantages is rather lacking, which hampers rapid development of this industry.

In the 1970s guinea fowl research in Ghana received some attention owing to the studies by Awotwi (1972), Awotwi (1975) and Anamoh (1975) who studied aspects of their reproductive physiology. Prior to this period, research in Ghana on the guinea fowl was virtually nonexistent. After a lull of about twenty years, interest in the Ghanaian guinea fowl was revived (Teye *et al*., 2001, Teye and Gyawu, 2002, Apiiga, 2004, Adjetey, 2006, Avornyo *et al*., 2007).

The Animal Science Department of the University of Ghana has done some studies on sexing of guinea fowls (Alawiye, 1973; Awotwi,1975), reproductive performance (Gordon, 1971; Awotwi, 1972; Alawiye 1973; Laate, 1974; Awotwi, 1975; Anamoh, 1975), incubation of eggs and brooding of keets (Gordon,1970) and management and feeding as well as some aspects of diseases affecting guinea fowls (Gordon, 1970; 1971). The success report by the Animal Science Department of the University for Development Studies which initiated a study in 1998 under the sponsorship of the Smallholder Agricultural Development Project (SADEP) of International Fund for Agricultural Development (IFAD) Ghana showed that significant strides were made in terms of both local and exotic breeds under intensive management conditions. Under Smallholder Agricultural Development Project, exotic guinea fowls were imported and distributed to farmers for crossbreeding with the local ones.

In 2004, the Animal Science Department of the University for Development Studies carried out work on the brooding management of local guinea fowls on-farm in some selected farmers' farms around Nyankpala.

Under the sponsorship of the Ghana Education Trust Fund (GETFUND) in June 2006, the department conducted a study on the comparative growth performance of growing indigenous guinea fowl (*Numida meleagris*) from Upper East, Upper West and Northern Regions of Ghana (Adjetey, 2006). This study concluded that intensive selection based on outstanding performance coupled with well- planned crossbreeding programme is necessary to improve the production potential of the indigenous guinea fowl.

Considering all the above researches, studies on nutritional requirement in particular has not been developed in Ghana and even so, most of the studies are not on Ghanaian indigenous guinea fowls. There is limited information on the feeding or diet of guinea fowls in Ghana (Awotwi, 1987). Some work by Rheam (1950) and U.S.D.A. (1963) recommended that, though the guinea fowl may be fed on the same diet as the chicken, a starting diet containing 25% CP is more suitable and should be fed for the first six weeks. Gordon (1970, 1971) recommends a protein level of 24% in the starter diet for local guinea fowl keets up to the end of the sixth week. Gordon (1971) further recommended a combination of 1.0% calcium and 0.5% phosphorus for guinea keets. Teye and Gyawu (2002) recommended a diet of CP level of 23-24% and energy value of 2,900- 3,000 Kcal for the first four weeks.

Follow- ups on these recommendations must be made to authenticate and attain a more specified nutrient requirement for indigenous guinea fowls in our tropical zone in general, and in Ghana in particular at specific stages of life. Also, due to the fact that these studies were on guinea fowl keets between 1- 6 weeks, work on the other stages of life of the guinea fowl will be expedient. Knowledge of the protein requirements of indigenous guinea fowls will allow producers to strategically offer supplementary sources to meet protein deficits.

Therefore, this study seeks to obtain the protein requirement for

1. growing guinea fowls from 9- 27 weeks old.
2. laying guinea fowls from 28- 36 weeks old.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Poultry Domestication

Poultry is generally a term for describing birds that have been domesticated and raised for their primary (meat and eggs) and secondary (feathers, droppings, etc) products. Poultry is also described as those species of birds that render economic service to man and reproduce freely under his care (Smith, 1990). Kwarteng and Towler (1994), describe poultry as domestic fowl in general, e.g. chicken, turkeys, ducks, or geese, raised for meat or eggs. According to Parkhurst and Mountney (1988), the term poultry is used collectively to designate those species of birds that have been domesticated to reproduce and grow in captivity and render products of economic value. Birds kept only for companionship or beauty are not considered poultry.

Domestication is an ambiguous word and its definition largely depends upon the discipline of the person using it. Reed (1974) states that domestic animals are animals under the control of man throughout their lives, whose breeding is or can be controlled by man and may be dependent on man for protection and food. This excludes most animals in zoos and experimental research centers. Though controlled by man, these zoo and experimental animals are still considered wild. Furthermore, Ledger (1983), defines domestication as the keeping of animals which can be handled with ease, readily be trained and become amenable to the management for the purpose which they are kept. Microsoft Encarta Dictionary (2008) also describes domestication as accustoming an animal to living with or near people, usually as a farm animal or pet.

Birds have been of ecological and economic importance to humans for thousands of years. Archaeological sites reveal that prehistoric people used many kinds of birds for food, feathers for ornamentation, and other cultural purposes. The earliest domesticated bird was probably the domestic fowl or chicken, derived from jungle fowls of Southeast Asia. Domesticated chickens existed even before 3000 BC. Other long-domesticated birds are ducks, geese, turkeys, guinea-fowl, and pigeons (Microsoft Encarta Premium Science and Nature, 2008).

Domestication of poultry dates back as far as 5000 years ago, when man decided to manipulate and modify the habitat of jungle fowls in advancing his own comfortable existence. It is now realized that no species other than poultry was so much modified and manipulated in the history of man for the sake of accomplishing his own desire. The world now knows many varieties of poultry breeds and strains, incredibly highly productive and efficient ones with no comparison at all with their ancestors- the jungle fowl (Hasnath, 2002).

From the utilitarian point of view, wild animals may be considered for domestication in terms of their ability to convert organic products, mainly vegetation, into animal products for human use. These products are meat, milk, eggs, feathers, skins, wool and hair (Ledger, 1983 in Maganga and Haule, 1994). The major advantage of domestication of wild animals is that the animal products and services are obtained with relative ease when required (Maganga and Haule, 1994).

Microsoft Encarta Premium Science and Nature (2008) revealed that Charles Darwin considered the domestic fowls as descendants of a single wild species, the red jungle fowl, which is found in the wild state from India through Southeast Asia to the Philippines. Genetic analyses have shown that every breed of domestic chicken can be traced to the red jungle fowl. Scientists estimate that they were domesticated roughly 8000 years ago in what is now Thailand and Vietnam.

It appears that people probably domesticated chickens over 4000 years ago, after centuries of hunting the wild jungle fowl for food. Chicken then probably spread through eastern Asia. They reached Persia about 1000 B.C. and played a role in their ancient religion. By 500 B.C. chickens were being raised by the Greeks for the "sport" of cockfighting; however, the Romans were probably the first poultry men (Parkhurst and Mountney, 1988).

The chicken was one of the first domestic animals to be mentioned in recorded history. It is referred to in ancient Chinese documents that indicate that this "creature of the west" was introduced into China about 1400 BC. Fowl are depicted in Babylonian carvings of about 600 BC and are mentioned by early Greek writers, notably by the playwright Aristophanes about 400 BC. The Romans considered chickens sacred to Mars, their god of war. Since ancient times the rooster has been a symbol of courage -it was so regarded by the Gauls, for example. In Christian religious art the crowing cock has symbolized the resurrection of Christ. The cock was the emblem of the first French Republic (Microsoft Encarta Premium Science and Nature, 2008).

From all indications, from the information provided by the above literature, one thing is clear and cannot be disputed that domestication has been in existence and dates back as far as between 8000 and 1000 B.C.

Today domestic fowl, which form by far the most important class of poultry, are distributed virtually all over the world. In the United States the current trend is toward specialization, some poultry raisers producing hatching eggs, others eggs for table use, and others raising chickens to market as broilers (Microsoft Encarta Premium Science and Nature, 2008).

Birds are good indicators of the quality of our environment. In the 19th century, coal miners took caged canaries with them into the mines, knowing that if the birds stopped singing, dangerous mine gases had escaped into the air and poisoned them (Microsoft Encarta Premium Science and Nature, 2008).

Birds provided a comparable warning to humans in the early 1960s, when the numbers of peregrine falcons in the United Kingdom and raptors in the United States suddenly declined. This decline proved to be caused by organochlorine pesticides, such as DDT, which were accumulating in the birds and causing them to produce eggs with overly fragile shells. This decline in the bird populations alerted humans to the possibility that pesticides can harm people as well (Microsoft Encarta Premium Science and Nature, 2008).

Today certain species of birds are considered to be indicators of the environmental health of their habitats. An example of an indicator bird is the northern spotted owl, which can only reproduce within old growth forests in the Pacific Northwest (Microsoft Encarta Premium Science and Nature, 2008).

2.2 Poultry Classification

According to Parkhurst and Mountney (1988) presently the American Poultry Association lists and classifies 300 different recognized breeds and varieties of chickens in its book entitled, “The American Standard of Perfection.” Most of these birds are kept for competition in poultry shows as pets. They are classified into classes, breeds, and varieties. Birds classified in the same class have a common origin .Those in the same class with the same general physical features such as body shape or type, skin colour, number of toes, and feathered or unfeathered shanks are classified as breeds. Breeds are subdivided further into varieties, which are based on plumage colour, comb type, and the presence or absence of a beard or muffs.

Some examples of poultry birds are the duck (*Anas platyrhynchos*), the domestic chicken (*Gallus domesticus*), the pheasant (*Phasianus colchicus*), the guinea fowl (*Numida meleagris*), the turkey (*Meleagris gallopavo*), the pigeon (*Columba livea*), the turtle dove (*Streptopelia turtus*) and the ostrich (*Struthio spp*.) (Smith, 1990).

Table 1: Groups/ Orders into which different types of avian belong

ORDER	EXAMPLES
Anseriformes	Waterfowl (ducks, geese, swans)
Apodiformes	Swifts, hummingbirds
Caprimulgiformes	Goatsuckers, nightjars
Charadriiformes	Shorebirds, gulls, alcids, jacanas, skuas, terns, skimmers, oystercatchers, avocets
Ciconiiformes	Herons, storks, ibis, spoonbills, bitterns
Coliiformes	Colies
Columbiformes	Pigeons, doves, sandgrouse
Coraciiformes	Kingfishers, bee-eaters, rollers, hoopoes, hornbills, motmots, todies
Cuculiformes	Cuckoos, anis, roadrunners, hoatzins
Falconiformes	Vultures, hawks, eagles, falcons, osprey, secretary birds
Galliformes	Grouse, pheasants, turkeys, quails, ptarmigans, megapods, guinea fowl, guans, chickens
Gaviiformes	Loons
Gruiformes	Cranes, rails, bustards, limpkins, coots, gallinules, buttonquails, sunbitterns, kagus, trumpeters
Passeriformes	Perching birds (over 70 families), including crows, thrushes, sparrows, swallows, wrens, warblers, flycatchers, larks, nuthatches, vireos, shrikes, blackbirds
Pelecaniformes	Pelicans, boobies, cormorants, gannets, darters, frigatebirds
Phoenicopteriformes	Flamingos
Piciformes	Woodpeckers, honey guides, toucans, jacamars, puffbirds, barbets
Podicipediformes	Grebes
Procellariiformes	Albatrosses, shearwaters, petrels
Psittaciformes	Parrots
Sphenisciformes	Penguins
Strigiformes	Owls
Struthioniformes	Ostriches, rheas, kiwis, cassowaries, emus

Tinamiformes	Tinamous
Trogoniformes	Trogons

SOURCE: Microsoft Encarta Premium Science and Nature, 2006

All birds belong to the class Aves, which is subdivided into 27 orders (Microsoft Encarta Premium Science and Nature, 2008). Table 1 depicts one of the many avian classification systems, which identifies 27 orders of birds, divided largely on the basis of their external features. The debate over bird classification continues with the introduction of new data and information. New fossil evidence appears regularly, while ornithologists continually re-evaluate older evidence and study living organisms. (Microsoft Encarta Premium Science and Nature, 2006)

2.3 Poultry Utilization

Poultry and especially chickens are now found in almost all parts of the world, regardless of climate. As nearly as can be estimated, there is now about one domestic chicken for every human being in the world and the chicken population increase continues to match up human population increase (Parkhurst and Mountney, 1988).

For a long time, birds have been utilized as a food source. Poultry in one form or another are kept in most parts of the world and provide a preferred form of animal protein for many people because they taste well and have fewer religious and social taboos associated with their consumption. In contrast, other forms of animal protein such as that derived from pigs and cattle are not universally accepted because of taboos (Koney, 1993). Smith (1990) agrees by adding that, there are fewer religious or social taboos associated with poultry than there are with pigs and cattle, thus products produced by or from poultry provide an acceptable form of animal protein to most people throughout the world, with the exception of strict vegetarians and vegans.

Many species, breeds and strains of poultry are used in the services of man. Poultry has a short generation period and a potentially high rate of productivity (Koney, 1993). Poultry also constitutes a source of protein of high biological value contributing to improve the nutritional status of rural populations (Idi *et al.*, 2001). They are important and popular for providing meat and eggs to feed millions of people, provide job opportunities and income for several people, certain industries (example, the baking and fast food industries) use eggs as raw material in many preparations and poultry droppings are used as fertilizer in vegetable production and fish farming (Kwarteng and Towler, 1994).

Although the importance of poultry contribution in terms of income and protein supply varies widely from the developed to the developing economies (Smith, 1991), it is enormous in the developing countries where a larger percentage of the human population are basically rural and agrarian (Fasina *et al.*, 2007). Other advantages of poultry, especially for developing countries, include the fact that they can be "stored" on the farm as live birds and slaughtered a few at a time as needed. With larger animals, the slaughter of a hog or steer may require the immediate use of several hundred pounds of meat. Also, the low initial cost of eggs, production equipment, and housing enables low- income farmers with a low fixed investment (Parkhurst and Mountney, 1988) with non- salaried labour for the purpose of income generation, food security and gainful employment especially for women and children (Fasina *et al*, 2007) venture into the production to provide for their family needs.

Poultry have some ability to scavenge and use native feeds. They are also efficient converters of feed. Under ideal conditions with broilers, it requires slightly below 0.907 g of feed for each 0.454 kg of chicken that is produced. However, to attain this efficiency, broilers require a high protein ration and utilize some of the same food which could be used to feed humans (Parkhurst and Mountney, 1988).

The United States is a leader of the worldwide poultry industry. In 2002, for example, it produced nearly 68 billion eggs. Over 400 billion eggs were produced in China, and over 90 billion eggs by the 15 members of the European Union. Within the United States, Iowa produces about 11 percent of the nation's eggs, followed by Ohio, Pennsylvania, California, and Indiana; the leading broiler-producing states are Georgia, Arkansas, and Alabama (Microsoft Encarta Premium Science and Nature, 2008).

2.4 Poultry production in Ghana

Poultry meat and eggs have been a conventional protein source in Ghana for many years (Teye and Gyawu, 2002), but the local domestic poultry in Ghana has been neglected as far as planned management practices are concerned, yet the indigenous fowl is reared all over the country in small backyard units (Williams, 1990) and is well adapted to its environment. It is estimated that Ghana has about 10 million poultry (Teye and Gyawu, 2002). The birds are extensively kept with little financial input into production. Birds scavenge around compounds or farms with occasional feeding of grains or household wastes. Housing (wooden coops or mud pens), if any, are provided only at night (Dankwa *et al*., 2000). However, Idi *et al*., (1995) have indicated that on farms, poultry and small ruminants serve as savings readily available to buy foodstuffs for humans, seeds and even to pay taxes.

2.5 The Guinea Fowl

These birds are terrestrial and prone to run rather than fly when alarmed (Ayorinde, 2004, Wikipedia, 2008). They are, however, like most short- and broad-winged birds, very agile and powerful flyers, capable of hovering and even flying backwards when necessary (Wikipedia, 2008).

Guinea fowls are great runners, and can readily cover 10 km and more in a day. They make loud harsh calls when disturbed. Guinea fowls are equipped with strong claws and scratch the soil for food much like domestic chickens. They have well-developed spurs and use these to great effect when fighting (Wikipedia, 2008).

Guinea fowls belong to family of insect and seed-eating, ground-nesting birds resembling partridges, but with featherless heads and spangled grey plumage (Martinez, 1994). The guinea fowls are one of the lesser known poultry species (Parkhurst and Mountney, 1988) and is a common name for six species of birds native to Africa; one species also occurs on Madagascar and other Indian Ocean islands. The sexes are alike in colour: mostly black, dotted in all except of two species of one genus with small, light-coloured spots. The head and upper neck are bare, but two species of a second genus have a bushy tuft of feathers on the crown (Microsoft Encarta Premium Science and Nature, 2008).

Historical records indicate that the guinea fowl derives its name from the Guinea Coast of West Africa (Roy and Wimberley, 1979; Awotwi, 1987; Smith, 1990; Teye and Gyawu, 2002; Dei and Karbo, 2004) where today some still remain in the wild (Dei and Karbo, 2004). Guinea fowl has ubiquitous distribution in Africa where it has distinct popularity among smallholder farmers (Microlivestock, 1991; Nwagu and Alawa, 1995).

The guinea fowl is a bird that belongs to a group *Carinatae* (flying birds), order *Galliformes* (includes turkeys, chickens and pheasants), and the family *Numididae* (that is the guinea fowl of African origin). It belongs to the genus *Numida*. The genus has two types, *Numida ptilorhycha*, that is the blue- wattled guinea fowl and *Numida meleagris* that is red- wattle guinea fowl of West Africa. The wild guinea fowl is native to West Africa but are now kept in many parts of the world (Smith, 1990; Bell and Smith, 2003; Dei and Karbo, 2004).

2.5.1 Guinea Fowl Types/ Varieties

Guinea fowl has been classified into four genera (*Agelastes- Phasiadus*, *Guttera*, *Acryllium* and *Numida*), six species and sixteen subspecies (Ayorinde, 2004). This is a list of guinea fowl genera, species and subspecies, presented in taxonomic order.

- Genus *Agelastes- Phasiadus*
    - White-breasted Guinea fowl, *Agelastes meleagrides*
    - Black Guinea fowl, *Agelastes niger*
- Genus *Numida*
    - Helmeted Guinea fowl, *Numida meleagris*
- Genus *Guttera*
    - Plumed Guinea fowl, *Guttera plumifera*
    - Crested Guinea fowl, *Guttera pucherani*
- Genus *Acryillium*

    Vulturine Guinea fowl, *Acryllium vulturinum*

SOURCE: Wikipedia, 2008

Many varieties of guinea fowls are found in West, South and Central Africa (Awotwi, 1987; U.S.D.A, 1976). Some are plain headed, plumed, crested, grey-breasted, helmeted and white-breasted. The grey-breasted and helmeted guinea fowls (*Numida meleagris galeata pallas*) are the commonest types found in West Africa (Awotwi,1987; Microsoft Encarta Premium Science and Nature, 2008; Jacob and Pescatore, 2011) and has several subspecies distinguished by the size, shape, and colour of the wattles at the corner of the beak, and by the size and shape of the bony "helmet" on the crown (Microsoft Encarta Premium Science and Nature, 2008, Jacob and Pescatore, 2011).

According to the U.S.D.A. (1976) and Darre (2007), there are three principal varieties of domesticated guinea fowls in the United States- Pearl, White and Lavender. FeatherSite.com

(2007) states that domestic guinea fowl are found in many varieties, including Pearl (the wild type), White, Buff Dundotte, Royal Purple, Porcelain, Slate, Chocolate, Violet or Mulberry, Lavender, and Coral Blue. There are several other species of guinea fowl in the family *Numididae,* including the Vulturine Guinea *(Acryllium vulturinum)* and the Crested Guineas *(Guttera* spp.).

2.5.1.1 The Pearl Guinea Fowl

Picture 1: Pearl guinea fowls in a deep litter house

Source: Adjetey, 2009

Picture 2: The head of a pearl guinea fowl devoid of feathers

Source: Microsoft Encarta Premium Science and Nature

The pearl guinea fowl, one variety or subspecies of the helmeted guinea fowl, is the best known of the guinea fowl bird family, *Numididae*, and the only member of the genus *Numida*. It is found in Africa, mainly south of the Sahara, and has been widely introduced into the West Indies and Southern France (Martinez, 1994). The helmeted guinea fowl is classified as *Numida meleagris*, its western African subspecies as *Numida meleagris galeata* (Microsoft Encarta Premium Science and Nature, 2008).

The pearl guinea fowl (*Numida meleagris*) has a bony casque or helmet on top of its head covered with horny cartilage. Each of the nine subspecies of helmeted guinea fowl has a characteristic helmet shape (Martinez, 1994). In contrast to this finding, Ayorinde (2004) argues that there are actually only four distinct subspecies of the helmeted guinea fowl. Each is also characterized by different colouring of the bare parts of the head, wattle and neck feathers, as well as by the absence or presence of conspicuous bristles near the nostrils (Martinez, 1994). The pearl guinea fowl is a large bird with a round body and small head (Wikipedia, 2008). They are large birds which measure from 40-71 cm in length, and weigh 700-1600 g (Martinez, 1994).

Headley (2003) describes the pearl guinea fowl as round-shouldered, clad in sheer dark feathers with delicate white polka-dots. They weigh about 1.3 kg. The body plumage is gray-black spangled with white (Wikipedia, 2008) or has purplish-gray plumage regularly dotted or "pearled" with white spots (Darre, 2007). They are characterized by the presence of a helmet and lateral wattles, and the bare skin of the neck, chin and throat (Awotwi, 1987). Like other guinea fowls, this species has an unfeathered head, in this case decorated with a dull yellow or reddish bony knob, and red and blue patches of skin. The wings are short and rounded, and the tail is also short (Wikipedia, 2008).

Male pearl guinea fowl celebrate the beginning of breeding season with a parade, a single file of birds chasing each other with their heads lowered and their wings raised over humped backs. This ritual is a display of both aggression and courtship. The male capable of keeping up the chase for the longest distance emerges dominant. Its strength becomes evident to female observers evaluating their potential mates. Pearl guinea fowl (*Numida meleagris),* form stable pair bonds following a two to three-week “dating” period of temporary pairings (Leach, 2009).

2.5.1.2 The White Guinea Fowl

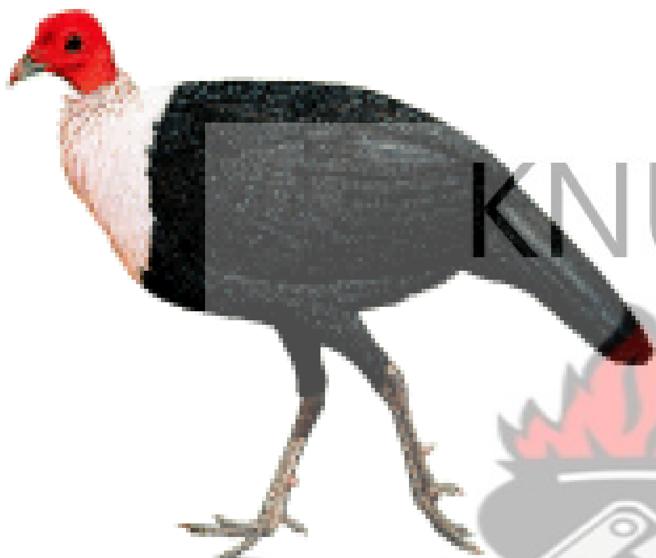
Picture 3: White guinea fowls in a deep litter house

Source: Ayorinde, 2004

The white guinea fowl has pure-white feathers and its skin is lighter than the other two varieties. These birds are not albino and are the only solid white bird that hatches solid white and not yellow offspring or keets (Darre, 2007). The white variety has pure white plumage. Its skin is lighter in color than that of the pearl variety (U.S.D.A., 1976). The white guinea fowl is one example of the two sub-species of the helmeted guinea fowl.

2.5.1.3 The White-breasted Guinea Fowl

Picture 4: The white-breasted guinea fowl



Source: Microsoft Encarta Premium Science and Nature

The white-breasted guinea fowl (*Agelastes meleagrides*), black with a broad white collar, is considered one of the most endangered species of Africa because of habitat destruction and hunting pressure (Microsoft Encarta Premium Science and Nature, 2008). The white-breasted guinea fowl is one of the members of the two species of the genus *Agelastes*. In contrast to what other researchers think, Ayorinde (2004) believes that the white-breasted guinea fowl is actually not a variety *per se* since it does not breed true and segregates to other colours when mated *inter se*.

The white-breasted guinea fowl is a medium-sized, terrestrial bird with a small head. It has a bare red head and upper neck, with a pure white lower neck, breast and upper back. The rest of its plumage is black, finely vermiculated with white. The female is similar to the male but slightly smaller. They have a low deep *kok-kok*, loud, ringing, melodious call, rather vocal, uttering dry ticking calls. They occur singly, in pairs or in small groups, but more commonly in groups of 15-24 birds, constantly moving in search of food and occupying large territories (BirdLife Int., 2009).

2.5.1.4 The Black Guinea Fowl

Picture 5: A black guinea fowl hen

Source: Ayorinde, 2004

The black guinea fowl (*Agelastes niger*) sometimes (*Phasidus niger*) is rare (Microsoft Encarta Premium Science and Nature, 2008), and is one of the two members of the genus *Agelastes*. The black guinea fowl inhabit primarily, unspoiled, rainforests. They live in groups of 15- 20 and roost in trees at night. Their advertising calls are very different from other species of guinea fowls. The calls consist of short, soft, low- pitched whistling sounds reminiscent of the cooing of doves (Martinez, 1994).

2.5.1.5 The Vulturine Guinea Fowl

Picture 6: A vulturine guinea fowl

Source: Microsoft Encarta Premium Science and Nature

The Vulturine guinea fowl (*Acryllium vulturinum*) is from the semi-arid regions of east Africa. The vulturine is not commonly raised in the United States as it is more sensitive to cold and lacks the hardiness of the common guinea fowl. It has a helmetless head and resembles the look of a vulture (Jacob and Pescatore, 2011). It is the largest and most ornate species. It has a cape of long hackle feathers extending from the lower neck to the breast. These feathers are white, edged with black and bright cobalt blue. This species may be readily seen in the nonbreeding season in flocks of up to 30 individuals (Microsoft Encarta Premium Science and Nature, 2008). The head of the vulturine guinea fowl is mostly featherless except for a chestnut- brown patch of short feathers on the sides and back of the head. This species has a hackle of spear- shaped feathers which have lengthwise stripes of black, white and blue. The breast is blue, the edges of the wings are violet, and the rest of the plumage, except for the black ventral feathers, shows the usual spotted design. The central tail feathers are elongated and pointed. This guinea fowl is slender and has longer legs than the helmeted guinea fowl. Their advertising call is similar to that of the crested and the plumed guinea fowl, but is a much higher- pitched “keek-keek-keek,” also given in series. Vulturine guinea fowls also feed on a range of plant and animal items and will sometimes perch in bushes to feed on fruits. Unlike all other guinea fowls, this species appears to survive without readily- available drinking water (Martinez, 1994).

2.5.1.6. The Lavender Guinea Fowl

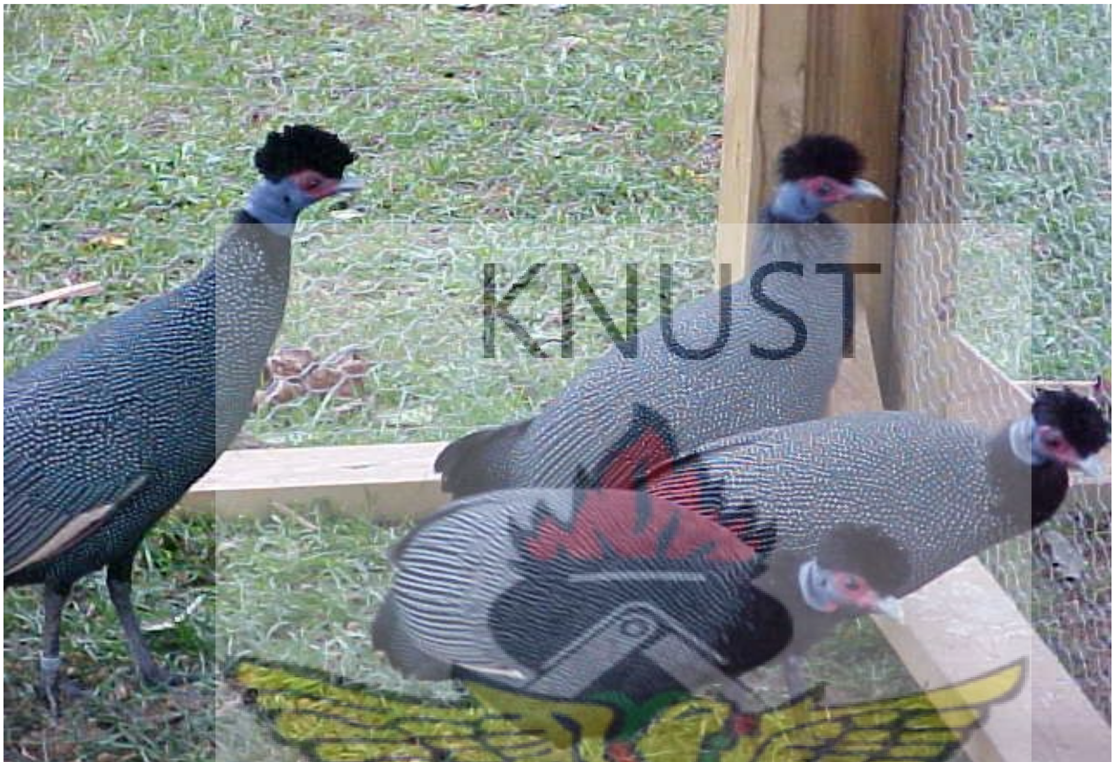
Picture 7: Lavender or ash guinea fowls in a deep litter house

Source: Ayorinde, 2004

The lavender guinea fowls are one of the three variety or subspecies of the helmeted guinea fowl (Ayorinde, 2004, Jacob and Pescatore, 2011). The lavender guinea fowls are similar to the Pearl, but with plumage that is light gray or lavender dotted with white (Darre, 2007).

2.5.1.7. The Crested and Plumed Guinea Fowl

Picture 8: The crested guinea fowl



Source: Microsoft Encarta Premium Science and Nature

The Crested guinea fowl (*Guttera pucherani*) is a member of the *Numididae*, the guinea fowl bird family. It is found in open forest, woodland and forest-savanna mosaics in sub-Saharan Africa (Wikipedia, 2010). They have slightly curled feathers (FeatherSite.com, 2007) and the plumage is overall blackish with dense white spots. It has a distinctive black crest on the top of its head, the form of which varies depending upon subspecies (Wikipedia, 2010). They occur in flocks averaging fewer than 20 birds. During early mornings after descending from their nightly roosts, crested guinea fowl flocks move into forest glades to preen and socialize in the warmth of the morning sun. Crested guinea fowl fly up into trees to feed on fruit rather than eat maize scattered on the ground (FeatherSite.com, 2007).

Although deeper than the call of the helmeted guinea fowl, the crested guinea fowl alarm call is also a staccato "chuk- chuk- chukchukerr." The lower pitch may be due, in part, to its windpipe being housed in the hollowed- out blade of its wishbone. Crested guinea fowl are noisy, sometimes calling well into the night and during the quiet pre- dawn hours. Flock members keep in contact by emitting a low- pitched "chuk" call. Male crested guinea fowl apparently do not have a hump- backed display as in the male helmeted guinea fowl, but rather cock their tails like bantams when alarmed (Martinez, 1994).

Picture 9: The plumed guinea fowl

Source: Microsoft Encarta Premium Science and Nature

The Plumed guinea fowl (*Guttera plumifera*) is a member of the guinea fowl bird family. It is found in humid primary forest in Central Africa. It resembles some subspecies of the Crested guinea fowl, but has a straighter (not curled) and higher crest, and a relatively long wattle on either side of the bill. The bare skin on the face and neck is entirely dull grey-blue (Wikipedia, 2010).

There are five subspecies of crested guinea fowl, but only two subspecies of plumed guinea fowl (*Guttera plumifera*), that vary mainly in the colour of the facial skin on the head and the form of the feathered crest (FeatherSite.com, 2007).

2.6. Guinea Fowls Production in Ghana

The guinea fowl is a promising genetic resource for evolving a low-input poultry enterprise mostly in developing countries, and has the potential for reducing poverty (Teye and Gyawu, 2002). It is an integral part of the rural family system providing a sustainable family income for small, marginal and landless farmers. According to Argüelles *et al*., (2002), guinea fowl is a poultry species suitable for use in meat production to expand and diversify the local poultry industry due to its consumer acceptance, resistance to common poultry disease and tolerance to poor management conditions.

In Ghana, guinea fowls are found mainly in the Northern sector (Naazie *et al*., 2007), particularly in the Northern, Upper East and Upper West regions, where their production over the years has assumed socio-cultural, economic and nutritional significance (Dei and Karbo, 2004). The guinea fowl is prevalent in almost every household in the rural areas in the three Northern region of Ghana. Apiiga (2004) states that the guinea fowl is an important bird in the Upper East region and two out of five households own the bird. He adds that the number in each household ranges from 5 to 200 birds with an average of about 20. The three regions together form about 40% of the total landmass of Ghana (Teye and Gyawu, 2002). In almost all households, males and females as well as children rear these birds (Naazie *et al*., 2007). The birds are an integral part of the lives of the people of Northern Ghana and serve varied functions, including use for ceremonies, courtship and dowry, gifts as well as sacrifice (NRC, 1991).

The birds lay between 90- 120 eggs per annum and since it is not a good brooder (when in confinement) (Apiiga, 2007, Farrell, 2010), the eggs are normally hatched by chicken, ducks and turkeys (Apiiga, 2007). Fertile guinea fowl eggs are normally given to the domestic chicken hen to incubate with or without a mixture of chicken eggs, where the domestic village chicken are reared alongside the guinea fowl (Adjetey, 2006). Guinea fowl eggs hatch out in 26 to 28 days and keets weigh 24 to 25 g (Farrell, 2010). It is therefore a usual scene to see a domestic chicken hen with a mixture of chicks and keets in these households. These young ones are raised till the domestic chicken hen is ready to lay and brood over new eggs (Adjetey, 2006).

The sub-humid tropical pearl guinea fowls are monogamous and seasonal breeders (Awotwi, 1987; Nwagu and Alawa, 1995; Naazie, *et al*., 2007; Wikipedia, 2010) and so there are periods within the year when their eggs are abundant and other periods when they are scarce. The seasonality in reproduction has been recognized as one of the major problems that may hinder large-scale commercial guinea fowl production. The periods of scarcity represent a severe limitation and militate against growth of the industry in the country as a whole and Northern Ghana in particular (Naazie, *et al*., 2007). Factors responsible for this seasonality are however not yet clearly known (Oke *et al*., 2003). Free range domesticated guinea fowls can lay up to 50-

60 eggs per season, each weighing averagely between 37 to 40 g. Guinea fowl eggs are slightly smaller than chicken eggs but with thicker eggshells than that of the chicken (Farrell, 2010).

Guinea fowls are reared traditionally under the extensive system just like the local chicken. They are left to scavenge around farmsteads, open fields and compounds for food scraps, worms, insects, seeds, leaves, fruits etc. As a result of this system of management, their productivity is low as compared to other systems (that is the intensive and semi-intensive systems). Under confinement, good feeding and watering, improved housing/ sanitation, and good medical care, the bird can lay between 150- 220 eggs per year (Apiiga, 2004) and weigh about 1.1125 kg at 18 weeks (Teye *et al*, 2001).

2.6.1. Marketing of guinea fowls

Guinea fowls are marketed in different forms; live bird, frozen carcass, smoked carcass, grilled meat, boiled meat and fried meat. Smith (2001) added that guinea fowl can be kept both for meat and egg production. There are hardly any cultural barriers against consumption of guinea fowl products (Saina *et al*., 2005).

The meat is dark and the birds are often served as game. The prices are therefore normally high (Apiiga, 2004). The bones are quite small, and the carcass produces a relatively large amount of meat. There is good demand for Guinea fowls meat because of their wild game flavor and so the birds are served extensively in large hotels and higher priced restaurants (Feltwell, 1992; Platt, 1997). Stewart and Amerine (1982) stated that, the guinea fowl's attractive plumage and value as a table bird with game type flavour and high meat-to-bone ratio has ensured its wide acceptance in all societies and the meat is highly priced in Africa. The guinea fowl meat also contains less cholesterol and fat but high in protein as compared to other poultry species (Apiiga, 2004).

Guinea fowl production is an integral part of the livestock industry in Northern Ghana (Apiiga, 2004, Teye and Abubakari, 2007). There has been increasing demand for guinea fowl recently (Darre, 2007). The meat is well patronized in southern Ghana (especially Kumasi and Accra) and fetches a lot of money for those who trade in this bird (Apiiga, 2004, Naazie *et al*., 2007). In general, farmers believe they have no problem with marketing and accept seasonal variation in prices as they do not believe they can do anything about it. It appears that bulk purchasers come from cities such as Accra and Kumasi on market days to patronize the birds of these retailers. This can be supported by the fact that most of these retailers sell from 91 to 350 birds per week (Naazie *et al*., 2007).

Table 2: Aspects of Guinea Fowl Marketing by Retailers

District	Bawku East	Bolgatanga	Bongo	Builsa	Kassena-Nankana
No. of Respondents	15	3	8	2	47
Period of abundances	Sept-Dec	Oct-Nov	Oct-Nov	Oct-Jan	Oct-Jan
Mean number sold/week	350	140	140	91	175

Naazie *et al*., 2007

Guinea fowls normally cost more than chicken and are therefore a very good source of income for farmers. The income from the sales of the birds is used by the farmers for paying school fees of their wards, medical bills, buying clothes for wives and children, paying water and energy bills and for buying food in periods of food shortage (Apiiga, 2004). Keeping guinea fowls provide not only more protein but substantial income to peasants, when compared with chicken farming (Idi *et al*., 2001).

Highest prices for guinea fowl are obtained in large cities. Guinea fowl raisers who are near good city markets or who have developed a retail trade usually receive excellent prices for dressed young guinea fowls (USDA, 1976).

Guinea fowls are almost always at least 15 weeks and usually 16 to 18 weeks of age when they are sold (USDA, 1976). At 16 weeks, guinea fowls live weight is 1.48 kg (Saina *et al*., 2005) or 1.4 to 2 kg at 6 months (Onyeyili *et al*., 1992). Guinea fowls rarely attain more than 1.6 kg live weight at maturity, though they appear larger than this when they are alive (Platt, 1997). A matured bird weighs between 800 g and 1.5 kg depending on geographical location (Apiiga, 2007). Bell and Smith (2003) stated that guinea fowls are usually marketed at 14 weeks of age when the male weigh about 1.25 kg and females about 1.2 kg. In contrast to the above findings, Teye *et al*., (2001) stated that it is not possible to predict the market age for the local table guinea fowl (guinea fowl broiler). However, it may be by the end of the 13th week of age when the body weight may be about 700g.

2.7 Management of Guinea Fowls

Guinea fowls are medium sized gallinaceous birds from any of the genera *Agelasters*, *Numida*, *Guttera* and *Acryllium* (Butswat, 2001). Domestic guinea fowl are nervous and noisy birds, and are therefore not widely raised commercially (Microsoft Encarta Premium Science and Nature, 2008). Some guinea fowls are raised in flocks of 100 or more, but most are raised in smaller flocks (USDA, 1976). On small farms and in some large chicken farms they act as alarms, raising a clamor in the presence of predators (Microsoft Encarta Premium Science and Nature, 2008). Little information is available on how management practices impact the performance of caged guinea fowl (Adefope *et al*., 2001). Through lack of good management, many farmers who keep small flocks of guinea fowls obtain only a few young birds from each hen (USDA, 1976).

Guinea fowls are much more active than chickens and not as easily tamed (Darre, 2007). In most parts of sub- Saharan Africa, they are basically semi- domesticated birds which are timid and roost in trees at night. They are great rangers and foragers, adept at scratching with their feet and beaks and picking up insects, their larvae, seeds, berries as well as digging up bulbs and tubers (Naazie *et al*., 2007).

2.7.1 Guinea Fowl Rearing Systems

According to Maganga and Haule (1994), there are three systems of rearing guinea fowls namely, free- range system, semi- intensive system and intensive system. The free- range system is whereby guinea fowls are left free to search for food on their own in a boundless area and return in the evening to sleep in a stall or roost in trees or on roofs. They added that, in the semi-intensive system there is minimum or a reasonable control of the birds. Guinea fowls are confined but allowed to roam in a fenced area. Feed and water may be provided within the area. Fairly spaced shrubs are incorporated in the area to provide hiding places for mating and laying.

Maganga and Haule (1994) concluded that, the intensive system involves retaining guinea fowls within a confinement and providing them with food and water. Mating and laying takes place in confinement. The major drawbacks of this system are that birds do not get enough exercise and there is the risk of diseases or pest outbreaks. Moreover, reproduction is generally poor because guinea fowls are shy breeders.

2.7.2 Guinea Fowl Nutrition

Though feeding problems are gradually being solved in most livestock animals including chicken, guinea fowls have not had their fair share of this development. Not only have non-conventional feed substitutes been understudied when it comes to guinea fowl nutrition, but also feed nutrient requirement, which is first and foremost important has been compromised. Moreover, Adeyemo and Oyejola (2004), Nsoso *et al*. (2006) and Farrell (2010) are in agreement that little studies have been carried out on guinea fowl nutrient requirement in captivity and its production in general. Nwagu and Alawa (1995) supported by adding that there are no standardized nutrient requirements for guinea fowls.

Instead, guinea fowls scavenge around the farmsteads and villages for food scraps, worms and insects. Moreover in the wild, guinea fowl feeds on seeds, grasses and insects. In South Africa, guinea fowl were found to feed on various kinds of leaves, fruits, seeds and insects, in the open field (Adeyemo and Oyejola, 2004). Similarly, in Ghana, local guinea fowls scavenge on grasslands and fields and pick up seeds, insects, leaves and other feed particles from households (Adjetey, 2006, Naazie *et al*., 2007, Teye and Gyawu, 2002).

The nutrient requirements of the guinea fowl have been assumed to be the same as that of the chicken as regards the major nutrients (Koney, 1993, Oluyemi, 1982) and therefore in most cases, feed requirements for chicken are also recommended for guinea fowls. Considerations on feed for guinea fowls are rather basically based on cost and availability rather than on suitability in terms of their nutrient requirement (Naazie *et al*., 2007).

However, earlier studies show some differences in the utilization of some nutrients (Vogt and Stute, 1974). Guinea fowls need a higher protein feed than chickens, but do quite well on regular poultry mash or crumbles (Darre, 2007, Jacob and Pescatore, 2011). It is recommended that they should be given only mash or crumbles instead of pelleted feed (Darre, 2007).

2.7.3 Keet Nutrition

According to USDA (1976), guinea fowl keets are fed much the same as turkey poults. Their first feed may be turkey or pheasant starting mash or crushed pellets (28% to 30% protein) or at least about 25% protein. Smith (1990) suggests that keets can be raised on a broiler starter diet and at the same stocking density as broilers and Nsoso *et al.*, (2006b) fed keets with commercial chick starter mash. The high protein makes them grow fast (USDA, 1976). Dei and Karbo (2004) add that young birds double their weight several times during the early weeks of their lives if their nutritional and other needs are met.

Keets require high protein diets for the first four weeks (Teye and Gyawu, 2002). Keets need a 24% - 26% protein ration similar to turkey starter or gamebird feed. Darre (2007) and Jacob and Pescatore (2011) recommended that unmedicated feed be used to feed guinea keets to avoid potential problems with keets getting over-medicated. Reduce the protein to about 18% - 20% for the fifth through eighth weeks. After that they will do well on regular laying mash that is usually 16% protein (Darre, 2007). Dei and Karbo (2004) suggests an energy level of between 2900- 3000 kcal/kg, crude protein between 23- 24%, 1.1% calcium, 0.6% phosphorus and 0.5% vitamin/ trace minerals premix for keets between 0- 3 weeks of age. For keets of ages between 4-8 weeks, they proposed an energy level of 2700- 2800 kcal/kg, crude protein between 20- 22%, 1.1% calcium, 0.5% phosphorus and 0.5% vitamin/ trace mineral premix. They further added that, when feeding local guinea keets, a formulated diet (24% CP) from 0- 10 weeks in confinement can reduce keet mortality by about 10- 15% and improve weight gain.

Blum *et al.* (2008) reported that mean differences in FCR of birds on 17% CP diets were not different from those of birds on 19% CP diets, except at 9, 13, and 16 weeks of age. At these age groups, birds on 19% CP diets exhibited FCR that were lower than those of birds on 17% CP diets by as little as 7% at 9 weeks of age to 21% at 13 weeks of age. Increasing dietary CP levels from 19 to 21% significantly increased FCR of the Pearl Gray guinea fowl pullets at 9 to 16 weeks of age, except at 13 weeks of age. The average increase in FCR was as low as 6% at 10 weeks of age and as high as 19% at 14 weeks of age. In evaluating the CP and ME requirements of the French variety of guinea fowl, Nahashon *et al*. (2005) observed that increasing the dietary CP levels from 23 to 25% resulted in a 5 to 8% increase in FCR. The increase in FCR that is associated with increase in dietary CP levels may have been attributed to increased feed consumption of birds on higher CP diets, which also tend to have lower energy-to-protein ratios.

A diet of crude protein level of 23 to 24% and energy value of 2900 to 3000 kcal is recommended (Teye and Gyawu, 2002). Oke *et al*., (2003) fed keets on starter ration containing 20.01% crude protein and 2994.74 kcal/kg ME during the first 8 weeks. Oke *et al*., (2004) fed starter ration containing 23.9% crude protein and 2994 kcal/kg ME during the first 8 weeks in another experiment and Gordon (1971) suggests keets will perform well on a diet of 24% crude protein.

The feed can be formulated with commercial starter concentrate, maize and wheat bran or with straight ingredients such as fishmeal, soya cake, wheat bran, maize, oystershell, dicalciumphosphate, salt, vitamins and mineral premixes (Teye and Gyawu, 2002).

2.7.4 Grower Guinea Fowl Nutrition

The management of guinea fowls after brooding to slaughter or laying is less demanding. Grower guinea fowls can scavenge for their survival under the free range rearing. The birds are omnivorous eating vegetation, seeds, insects, ticks, termites, etc. (Teye and Gyawu, 2002). Guinea fowl have their highest protein requirements between 5 and 10 weeks of age (Sales and Du Preez, 1997). But data on the protein and energy requirement of guinea fowl pullets intended for use as layers are limiting (Oke *et al*., 2003).

Oke *et al*., (2003) fed a grower diet containing 20.01 crude protein and 2750 kcal/kg ME to growers between 8 to 20 weeks of age. The birds were further divided into three groups and fed 16%, 18% and 20% CP and 2650, 2750 and 2850 kcal/kg ME respectively between 20 to 28 weeks of age. From the study, it was suggested that diet containing 16% CP and 2750 kcal/kg ME is ideal for optimum body weight gain for growing guinea fowls because it contains a good balance between energy and protein.

Dei and Karbo (2004) proposed crude protein levels of 18- 20%, ME levels of 2900- 3200 kcal/kg, 0.9% calcium, 0.4% phosphorus and 0.5% vitamin- trace mineral premix for growers between 9- 14 weeks. For growers between 9- 25 weeks, they proposed a 16% crude protein, 2700 kcal/kg ME, 1.1% calcium, 0.5% phosphorus and 0.5% vitamin- trace mineral premix.

Adjetey (2006) fed between 18- 20% crude protein and 2700 kcal/kg ME in an experiment to compare the growth performance of growing indigenous guinea fowls and obtained average body weights of 1248.0 g, 1054.0 g and 1148.0 g for birds from Upper East, Upper West and Northern Regions respectively.

For guinea fowl broiler finishers (12- 14 weeks), 18- 20% crude protein and energy level of 2900- 3200 kcal/kg is recommended while guinea fowl breeder- growers require crude protein of 16% and energy value of 2700 kcal/kg up to the 25th week (Teye and Gyawu, 2002).

2.7.5 Laying Guinea Fowl Nutrition

The laying performance of a bird may not only depend on the nature of its management at layer phase but also on the carry over effects of its level of nutrient intake at the starter and grower phases (Adeyemo *et al*., 2006).

It is recommended that a diet containing 18 percent crude protein and 2750 kcal/kg ME would be ideal for the achievement of optimum egg production and revenue- cost ratio for the sub- humid tropical pearl guinea fowl layers (Oke *et al*., 2003).

Breeders/ layers require 16.5- 17% crude protein and energy levels of 2750 kcal/kg (Teye and Gyawu, 2002). Oke *et al*., (2004) in an experiment to determine the phenotypic correlations among body weight, egg weight, egg index and egg quality factors as well as regression equations that can be used to establish models for predicting body weight, fed guinea fowl layers (26- 52 weeks of age) on a diet containing 17.5% crude protein and 2650 kcal/kg ME. The mature body weight when the highest egg production was obtained was 1274 g to 2883 g and their average mature body weight was 1266 g. They concluded that phenotypic improvement efforts in the pearl guinea fowl should be concentrated on establishing a uniform flock body weight of at least 1250 g at sexual maturity. Adefope *et al*., (2001) fed layers a 16.5% crude protein laying ration when he researched on the effect of cage density on the performance of laying guinea fowl hens. Feed to body weight gain averaged 942, 600 and 735 g of feed consumed/g of weight gain for D1, D2 and D3 respectively, on per cage basis. Orji *et al*., (1987a) and Orji *et al*., (1987b) fed guinea fowls layers mash containing 17.8% crude protein and 9.2% crude fibre to check on effect of age, sex and time of bleeding of the haematological values and the effect of age, sex and time of bleeding on protein and electrolyte levels in blood serum respectively. Adeyemo *et al*., (2006) experimented on birds fed with 18%, 16%, 14% and 12% CP and ME of 2600 kcal/kg to test for the best performance of layers. Birds raised on 18% CP and 16% CP dropped their eggs at 162 days old while those 14% CP and 12% CP dropped theirs at 166 and 175 days respectively. Considering other parameters they concluded that, it is most economical to produce a dozen eggs on the 16% crude protein diet.

2.7.6 Abnormal Feeding- Related Behaviour

The main welfare problems of poultry are related to abnormal behaviour, such as feather pecking and cannibalism (Swarbrick, 1985). Feather- pecking can occur in all types of poultry, especially if insufficient trough space is provided (Fraser and Broom, 1990, In Forbes, 1995). This can be alleviated by giving birds something to search for, example, by giving some whole grains in the food or on the floor. Feather- pecking sometimes leads to body- pecking and wounding (Forbes, 1995), that is cannibalism, and in extreme cases results in death.

(Forbes) 1995 observed that egg- eating by hens may be an indication of mineral deficiency in their diet. He suggested that it is reduced by providing grit, although this may still be a question of lack of variety of activities rather than a nutrient deficiency. Birds eat wood shavings on which they are bedded if they have not enough trough space; this can result in gizzard compaction and eventual death if not forestalled by increasing the availability of food and feeding trough space (Forbes, 1995).

Pecking at metal or wood in a stereotypic manner is sometimes observed in birds, when the environment is monotonous. Kostal *et al*. (1992) in Forbes (1995), found that the amount of time spent stereotypically pecking was negatively related to plasma corticosterone levels and they suggested that such activity relieves stress (Forbes, 1995).

2.7.7 Watering Guinea Fowls

Guinea fowls do not relatively drink as much water as domestic chickens. Watering must be adequate though (Avornyo *et al*., 2007) and it should be ensured that guinea fowls have access to clean water (Avornyo *et al*., 2007 and Darre, 2007). Water should be provided in troughs that will prevent spillage, drowning and contamination. Drinkers should be cleaned once a day (Avornyo *et al*., 2007).

2.7.8 Stress affecting guinea fowls

Stress in guinea fowls are mostly caused by factors including environmental or weather conditions (heat stress), inadequate space, strange noises, diseases, internal and external parasites (Microsoft Encarta Premium Science and Nature, 2008).

According Dei and Karbo (2004), the comfort zone for guinea fowls is between 20-30 °C. However, birds usually are more tolerant of low than of high temperatures. The required optimal climatic conditions are as follows: temperature (13-20 °C), wind velocity (5-18 km/hr), relative humidity (55- 65%) and a moderate level of sunshine (Dei and Karbo, 2004). They added that to overcome heat stress, guinea fowls need shade, adequate water, adequate space and feed with high or concentrated energy.

The guinea fowl is fragile, nervous and easily panics (Teye and Gyawu, 2002) and therefore are very easily affected by stress. According to Microsoft Encarta Premium Science and Nature (2006) domestic guinea fowls are very nervous birds. Due to this nervousness, guinea fowls get agitated by the least disturbance. When there is inadequate space, nervous guinea fowls crowd together and suffocation may occur.

2.7.9 Health of Guinea fowls

The period or times guinea fowls experience the highest mortality throughout their lives is during the keet stage (0 to 8 weeks old). During the keet stage, guinea fowls are very fragile, and lose their lives at the least mistakes. Maganga and Haule (1994) reported that a fairly high mortality can be expected with the keets up to the age of six weeks.

According to Avornyo *et al*. (2007), the causes of mortality include ill health, cold, rain beating keets, accidents and predation. The losses can be prevented by farmers improving upon their management practices. Young keets should be housed for a minimum of four to eight weeks. While in confinement, the keets need to be provided with the required space, warmth, lighting, feed, medication and water (Avornyo *et al*., 2007).

2.7.9.1 Stocking density for guinea fowls

Dei and Karbo (2004) recommends that 20 to 30 keets be kept in a 1m x 1m cage space for first 8 weeks. Each bird requires 40- 65 square cm of space.

The caging density required for optimal egg production by various avian species and varieties is highly variable. Even so, little is known of the required cage density for optimum performance of the laying guinea fowl (Nahashon *et al*., 2006). In an experiment to define the caging density of laying guinea fowl hens, Nahashon *et al*., (2006) concluded that laying guinea fowl hens exhibited superior performance when raised at a density of 1 bird/cage (1,394 cm^2/bird) than those reared at densities of 2 and 3 birds/cage (697 and 465 cm^2/bird, respectively). Department of Environmental, Food and Rural Affairs (2010) recommends 2.5 kg live weight per m^2; for guinea fowls.

Table 3: Maximum stocking densities

Growing stock:	0- 4 weeks	20 birds/m^2
	0- 5 weeks	14 birds /m^2
	11- 14 weeks	10 birds /m^2
Adult birds		4 birds /m^2
Adult birds- cages		10 birds /m^2
Range area		1000 birds /ha

SOURCE: Caretaker Conventions (2003)

2.7.9.2 Keet Medication

- Give glucose and vitamin C to day old keets
- Administer antibiotics, minerals and vitamins for the next five days
- Deworm keets with a broad spectrum dewormer at 8 to 10 weeks
- Give antibiotics again as and when keets show signs of illness

(Avornyo *et al*., 2007).

Mortalities in keets according to Teye and Gyawu (2002) are due to inadequate equipment (feeders or drinkers) spaces, environmental conditions (temperature), inadequate space, accidents and worm infection. Guinea keets will peck and ingest litter when space is inadequate. Other causes of death in keets are yolk sac infection and leg paralysis. Mortalities during the growing period are often due to parasitic infections (worms, bacteria, coccidiosis and staphylococcus). The most prevalent and serious diseases are salmonellosis, colibacillosis colisepticaemia) and pullorum (white diarrhoea). A good control of general hygiene is required throughout the growing period especially during brooding (Teye and Gyawu, 2002).

According to Apiiga, (2007), some signs and symptoms of ill- health in guinea fowls include

i. Reduced or no appetite
ii. Dull plumage/ ruffled plumage
iii. Pale and flat wattles/ comb
iv. Dull face pigmentation
v. Dry vent (small and round)
vi. Diarrhoea
vii. Bad gait
viii. Difficulty in breathing
ix. Loss of weight
x. Lagging behind contemporaries

Table 4: Health management Guide (Vaccination and Deworming Schedule)

AGE (DAYS)	MEDICATION
1-2	Glucose in water
6	Antibiotic plus vitamin premix
10	Coccidiostat
16	Newcastle (HB1)
23	Gumboro
25	Antibiotic plus vitamin premix
30	Coccidiostat
35	Dewormer
38	Fowl pox
44	Coccidiostat
49	Newcastle (Lasota)
52	Antibiotic plus vitamin premix
56	Dewormer
60	Coccidiostat
84	Fowl Pox
98	Dewormer
112	Newcastle (Lasota)

SOURCE: Teye and Gyawu, 2002

According to Apiiga (2007), survival of keets can be improved by providing a dry, clean and warm environment (improved brooding) at the early stages of life. For prevention of diseases, the following should be carried out.

i. Vaccinate against New Castle Disease (NCD) two weeks after the keets have been hatched
ii. Use Coccidiostat (Powder type)
iii. Use antibiotics to prevent diarrhoea, salmonellosis etc.
iv. Prevent fowl pox and Gumboro disease by vaccination
v. For ectoparasites, use acaricides to prevent lice, mites and fleas.

2.8 Breeding Season

Most wild guinea fowl birds breed during a restricted period of the year irrespective of the latitude at which they are found (Sharp, 1988). The restriction is usually imposed by the seasonal availability of the appropriate food resources required for feeding and fledging the young (Murton and Westwood, 1977). The sub-humid tropical pearl female guinea fowls are monogamous (Oke *et al.*, 2003) and seasonal breeders (Maganga and Haule, 1994, Nwagu and Alawa, 1995). The seasonality in reproduction has been recognized as one of the major problems that may hinder large-scale commercial guinea fowl production. Factors responsible for this seasonality are not yet clearly known (Oke *et al.*, 2003).

Most guinea fowls start laying from March at the onset of the rainy season and September when the rain stops. Nevertheless, old guinea hens begin laying earlier in January or February (Dahouda *et al.*, 2007). According to Mongin and Plouzeau (1984) in Maganga and Haule (1994), the laying season for guinea fowls in the northern hemisphere extends from April to September. It appears that weather is the major controlling factor when it comes to guinea fowl laying period (Maganga and Haule, 1994). In addition, in captivity, the laying period according to Apiiga (2007) can be increased by increasing day length to between two to five hours in the dry season and providing plenty of water, if possible spraying water on them.

2.9 Reproductive Weight and Age

Body weight is regarded as a function of framework or size of the animal and its condition (Philip, 1970). Though various factors are known to affect egg production, there is conflicting reports on the effect of body weight on egg production. For the development of egg production strains, it is necessary to establish the nature of the relationship existing between body weight of the guinea fowl and egg production parameters (NRC, 1991). Variation in body weight within a flock can be attributed to genetic variation and environmental factors that impinge on individuals (Ayorinde and Oke, 1995). Body weight in poultry is known to be moderately to lightly heritable and hence the selection of heavier individuals in a population of guinea fowl, for example should result in genetic improvement of the trait (Oke *et al.*, 2004). Larger hens within a bloodline lay larger eggs than those with smaller body weights. This means that the larger the hen, the bigger the egg that will be laid thereof.

Most guinea fowl keepers do not know the age at which guinea fowls lay for the first time. This is mainly because of lack of records or interest to take note of such events. However, it is reported that guinea fowls are able to lay their first eggs at the age of 18 weeks (NRC, 1991). Dahouda (2003) found that under improved conditions, point of lay began at 36 weeks.

Many local guinea fowls begin to lay from 6 months onwards depending on the feeding and other management practices provided (Avornyo *et al*, 2007, Apiiga, 2007) and a matured bird weighs between 800 g and 1.5 kg depending on geographical location (Apiiga, 2007).
The weight and the age of the guinea fowls are directly related. Depending on the nutritional provisions and other factors such as health, genetics etc. provided during life, the weight and the age of the bird will correlate.

2.9.1 Weight and age at First Lay

A desirable trait in poultry is early attainment of puberty and consequently greater egg production. It is generalized that if a pullet matures too early in life, eggs will be smaller, and a long time will be required to attain maximum egg size; maximum egg size will also be smaller than that of late maturing pullet (Oke *et al*., 2003). However, it is reported that guinea fowls are able to lay their first eggs at the age of 18 weeks (NRC, 1991). The point of lay of guinea fowls under the free range (extensive) system is about 30- 32 weeks of age. Under the intensive system, laying starts at 22 weeks of age. Some of the birds may drop their first egg by the 17th week of age under continuous lighting. However, for good health and high productivity, the birds should come into full laying at 25 weeks of age (Teye and Gyawu, 2002).

Three groups of guinea fowl pullets in a study by Oke *et al*. (2003) laid their first egg at the ages of between 231, 219 and 220 days at mean liveweights of 1126.40 g, 1137.45 g and 1128.61 g respectively. Adeyemo and Oyejola (2004) recorded the age at first lay as 164, 167 and 171 days in guinea fowl pullets. According to Oke *et al*. (2004), average body weight at first egg is 1163±85.02 g. Adeyemo *et al*. (2006) obtained their age at first lay of 152, 156 and 165 days. The above records may imply that a mature body weight or point-of-lay body composition must be attained by guinea fowl pullets before the onset of egg production.

2.10 Laying ability and clutch size

The guinea fowl hen begins to lay in April or May, but do not become broody early in the season (Platt, 1997). According to USDA, (1963), Guinea hens usually start laying in March or April, and may continue to lay until October. Bell and Smith, (2003) added that, Guinea hens start laying in the spring (with increased daylight) and continue laying for about nine (9) months.

The number of eggs a guinea hen will lay depends on her breed and management. A hen that is of good stock and is carefully managed may lay 100 or more eggs a year (USDA, 1976), 36 to 60 eggs (Platt, 1997) or 90- 120 eggs per annum (Apiiga, 2007). Breeder guinea hens generally will be in production for about 2 to 3 years; sometimes they are kept as long as 4 to 5 years in small farm flocks. In such flocks, hens usually will lay about 30 eggs and then go broody. If broken of broodiness, they may continue laying into the fall, and may produce from 50 to 100 eggs a year (USDA, 1976). The local guinea fowls can lay between 70- 100 eggs per year while the improved exotic birds lay on the average 200 eggs per year (Teye and Gyawu, 2002). Exotic guinea fowls lay about 100 eggs in 4 to 5 months (Bonkoungou, 2005).

Wild guinea fowls commence egg laying at the age of 9 to 12 months (Ayorinde and Okaeme, 1984) with each hen laying 12 to 20 eggs per breeding season. On the range, guinea fowls come into lay at about 10 months of age (Ayorinde, 1990a). Eggs are laid in well-concealed nests and more than one hen normally use a single nest. Broodiness is delayed by removing eggs from nests leaving only one or two. By this method, egg production can be increased to between 60 and 80 instead of 15. Under improved intensive management that involves feeding of balanced diets, local guinea fowls come into lay between the ages of 25 and 36 weeks (Ayorinde and Okaeme, 1984, Ayorinde, 1987a, Ayorinde and Ayeni, 1987b, Ayorinde, 1995b).

The egg laying period can be extended and egg fertility improved by using artificial lighting (Bell and Smith, 2003) which is by increasing day length to between two to five hours in the dry season and provide plenty water, if possible spray water on them (Apiiga, 2007).

A clutch of eggs refers to all the eggs produced by birds or reptiles often at a single time, particularly those laid in a nest (Wikipedia, 2010). The clutch size of a guinea fowl hen is 15 to 20 eggs (NRC, 1991). It lays its large clutch of 20-30 eggs in a well-hidden lined scrape (Wikipedia, 2008) however, under proper management of systematic removal of eggs from the nest leaving not less than two eggs, they will keep on laying up to about 200 per laying season. Complete removal of eggs or leaving one egg in the nest may discourage the guinea fowl and it may abandon the nest (Maganga and Haule, 1994). Although nests are provided for caged guinea fowls almost all of the eggs are laid on the floor (Nwagu *et al*., 1997).

Guinea fowls which are about to lay make a peculiar monosyllabic sound like "kien kien kien" which is similar to the sound produced after dropping an egg. Most guinea fowls lay between 9:00 a.m. and 2:00 p.m. Eggs should be collected once in a day preferably after 2:00 p.m. (Avornyo *et al*., 2007).

2.10.1 Egg Weight

The guinea fowl egg has a distinctive pyriform shape but it is pointed at one end and rounded at the other. The average length of the egg is 4.78 cm and the diameter is 3.80 cm (Ayorinde, 1987c). The average surface area of the guinea fowl egg is 52 cm^2 with an area: weight ratio of 1.37. The shell is usually of varying shades of brown, and white shelled eggs are not common. Guinea fowl eggs are smaller than chicken eggs (Ikani and Dafwang, 2004). Local guinea fowl egg weighs between 34 g and 45 g according to Ayorinde (1987c) and 35 g to 40 g according to Ikani and Dafwang (2004) and is only about 60 to 70 percent of the weight of the chicken egg. Egg weight in the first year usually starts at about 28 g, increases to an average of 39 g by the end of the first breeding season and improves slightly further in the second and third breeding seasons (Ayorinde *et al*, 1989).

The ovary of the guinea fowl is much smaller than that of the domestic fowl and ranges in size from 18 to 35 g compared with 40 to 60 g in the chicken. The uterus and magnum are also quite small. Since the size of the magnum is positively related to egg size and egg laying capacity this might be responsible for the lower efficiency of egg production in the guinea fowl as compared to chicken. However the guinea fowl has proportionately larger uterine size that is probably responsible for the thick, hard and well-formed calcareous shell of the guinea fowl egg (Ayorinde, 2004).

Oke *et al*. (2003) obtained a 34.3 g average weight of first egg in their experiment. Egg weights range from 24.7 g - 41.3 g (Saina *et al*., 2005), 40g (Bell and Smith, 2003; Apiiga, 2004), 40- 58 g (Teye and Gyawu, 2002) and 55.4- 64.24 g (Adeyemo *et al*., 2006).

2.11 Incubation and Hatching

There is little information on the hatching characteristics of guinea fowl eggs (Nwagu *et al*., 1997). Eggs can be hatched either naturally or artificially (Bell and Smith, 2003; Avornyo *et al*., 2007). Embryos are very susceptible to damage from fumigation between 12 hours and 4 days after setting and after pipping has commenced. The incubation period for guinea fowl eggs is 26 to 28 days (Bell and Smith, 2003; Apiiga, 2004). However, according to Avornyo *et al*., (2007), guinea fowl eggs take 24- 28 days to hatch. The normal incubation period for guinea fowl eggs is 26 to 28 days and 24 to 25 days for crossbreds (Bell and Smith, 2003).

Only clean eggs must be set (Avornyo *et al*., 2007). The soiled eggs are washed in water containing potassium permanganate solution and cleaned with cotton wool (Nwagu *et al*., 1997). (Bell and Smith) 2003, stated that dry cleaning with fine steel wool is the best method of cleaning eggs for hatching. They also advised that eggs should be fumigated with formaldehyde gas shortly after being collected and cleaned. All eggs are stored in an air conditioned room (10°C) for a period not exceeding 5 to 10 days after being laid and then incubated in an incubator (Nwagu *et al*., 1997). At temperatures above 18^{o}C the embryos can start developing, causing uneven hatching or many early embryonic mortalities (Bell and Smith, 2003). Good or fertilised eggs can be selected by the methods of candling and immersion in water (good eggs sink: bad eggs will float) (Avornyo *et al*., 2007). Eggs are candled on the tenth day of incubation to detect infertile eggs and dead germs, and on the twenty-fourth day to identify dead embryos (Nwagu *et al*., 1997; Avornyo *et al*., 2007). Nwagu *et al*. (1997) recommended that eggs with rough shells and deformities should not be used for incubation. Eggs may be positioned flat on their side but never with the narrow end up. Eggs should not be turned on the first day and the last two days of incubation. The number of eggs hatching normally are counted plus those from which keets are helped to hatch (late hatches). (Nwagu *et al*., 1997). Hatched keets are allowed 6 to 12 hours to dry (Avornyo *et al*., 2007).

During candling, the following features may be detected. These features show which egg is viable and those ones that not good enough for incubation. These include:

Infertile eggs: These are easy to detect, as the egg is clear.

Early deaths: The embryo has developed for several days and then died. Candling will reveal a small dark area and disrupted blood vessels. Often deteriorating blood vessels will appear as a dark ring around the egg. Discard.

Late Deaths: These are often difficult to tell apart from a viable embryo at the same stage of development. Look for the absence of movement and the breakdown of the blood vessels.

Viable Embryos: These move in response to the light and have well defined blood vessels. Mark the air sac and the inoculation site and then return the eggs to the incubator ready for inoculation.

SOURCE: Grimes, 2002

Egg handling prior to incubation is very important (Bell and Smith, 2003). Apiiga (2007) recommends that good hatchability could be achieved if the following instructions are followed carefully.

i. Do not keep eggs more than five days after laying (hatchability decreases after five days)

ii. Use the correct breeding ratio (male: female) 1:5.

iii. Do not shake eggs meant for hatching

iv. Do not use eggs from nests exposed to too much rain and sunshine

2.12 Mating Ratio of Guinea Fowls

In their wild state, guinea fowl mate in pairs. This tendency prevails also among domesticated guinea fowls if males and females in the flock are equal in number. As the breeding season approaches, mated pairs range off in the fields in search of hidden nesting places in which it is difficult to find the eggs (USDA, 1976). They seldom lay in the chickens nests in the hen house (Nwagu *et al*., 1997; Platt, 1997). USDA (1976) suggests that under domestic conditions, it is not necessary to mate the birds in pairs to obtain fertile eggs. On most general farms, one male is usually kept for every four or five females. When guinea fowls are kept closely confined, one male may be mated with six to eight females, and several hens will use the same nest (USDA, 1976). Ikani and Dafwang (2004) explained that it is because the cock often prepares the nests for a group of guinea hens that flock with him. This is why it is common to find 20 to 30 eggs in a single nest during the eggs producing season in the wild. They further explained that because the nests are usually located in well hidden places, it makes it difficult for the farmer to locate the nests when many males are kept. Such eggs may also be of poor fertility due to the monogamous tendency of the males.

The recommended sex ratio for guinea fowls during the rainy season is one male to five females (Nwagu *et al*., 1997; Apiiga, 2007; Avornyo *et al*., 2007). In the dry season, the sex ratio should be changed to one male to three females (Avornyo *et al*., 2007). Breeders are usually housed on the ground and the mating ratio is 1 male with 4 to 8 females (5 appears to give optimal fertility) (Bell and Smith, 2003).

2.13 Sexing Guinea Fowls

A male guinea fowl is termed a cock, while a female is called a hen. Like any species, there are some signs to look for when determining gender. The ability to determine sex aids the local breeder, farmer and fancy bird show-person to appropriately house and feed both genders (eHow, 2008). There are no outstanding external features that can be easily used in the first two months of age to identify the sex of the bird (Awotwi, 1987; Bell and Smith, 2003; Guinea fowl UK, 2009; Teye and Gyawu, 2002; Platt, 1997). However, when keets are gently handled from about the forth week of age, it is possible to identify a rudimentary phallus in the males, which distinguishes them from the females. The phallus becomes fully developed and protrudes when a slight pressure is applied on the cloaca when the bird is about three months of age. At this age, the female exhibits a labia-like structure in the cloaca or there may be no structure at all (Teye and Gyawu, 2002).

Although guinea keets are naturally loud from hatch, the distinctive call that most easily determines the gender is not fully developed until two months. At two months of age and older, a guinea fowl will emit either a one or two syllable call. The female emits a two syllable call, which, according to folklore sounds like "buck-wheat, buck-wheat". A male emits a one syllable call that sounds like "chit chit chit chit." (eHow, 2008; Bell and Smith, 2003).

Differences in the size and shape of the head can also be observed. Males exhibit a more elongated and larger head, especially in the rear section of their heads. Females' skulls appear much more rounded. The bird's wattles (the ornamentation on the sides of their heads) vary in size and males exhibit much larger and more erect wattles (eHow, 2008).

Studies at the Animal Science Department (University of Ghana) have shown that the length and width of head, width of abdomen, length of ceres (the leathery patch of skin just above the beak where their nostrils are located (Microsoft Encarta Premium Science and Nature, 2010) and length of tail feathers of young guinea fowls are related to body weight rather than to the sex of the bird and cannot therefore be used as sexing indicators. Preliminary studies however, showed that young female guinea fowls tend to have a wider pelvic inlet than the males and this difference in pelvic inlet width is evident as early as 2 weeks of age. At this age the pelvic inlet width of the male averaged 4.6 mm (Range: 3.6- 6.1 mm) while the average for the females was 5.8 mm (Range: 4.4- 7.5 mm) (Awotwi, 1987). The male has slightly larger head appendages (Platt, 1997).

Regardless of the above mentioned ways, according Guinea fowl UK (2009) and Teye and Gyawu (2002) the surest way to determine sex differences in guinea fowls is to wait until they start calling at about 9 weeks as only the females have a two note sound. The male birds produce a single note. Nevertheless, females can also produce a single call. (Guinea fowl UK, 2009; Teye and Gyawu, 2002).

The male is generally slightly larger, has larger wattles, its voice is a more shrill shriek and it has a peculiar habit of strutting on tiptoe and arching his back. Perhaps the female is easier to recognize, since, the hen alone uses the call note 'come back, come back,' accenting the second syllable strongly, from which they are often called 'come backs' (Headley, 2003).

Some indicators that may be used to tell the sex of a guinea fowl from the egg stage through the various stages of development are:

Table 5: Sex indicators at different stages of life

Stage of Development	Indicator	Sex
Egg	Eggs with the narrow end more pointed	**Male**
	Eggs with narrow end slightly rounded	**Female**
4 weeks keets	Longer necks Bigger keets in the clutch	**Male**
	Shorter necks Smaller Keets in the clutch	**Female**
10 weeks and above	Higher body frame Pronounced and more concave wattles More protruding helmet Monosyllabic sound like "kir ke ke ke ke"	**Male**
	Lower body frame Less pronounced and flatter wattles Less protruding helmet Disyllabic sound like "chekwen chekwen"	**Female**

SOURCE: Avornyo *et al*., 2007

2.14 Importance of Guinea fowl

Guinea fowl (*Numida meleagris*) is a poultry species suitable for use in meat production to expand and diversify the local poultry industry due to its consumer acceptance, resistance to common poultry diseases, and tolerance to poor management conditions (Argüelles *et al*., 2004). The guinea fowl in many ways have varied advantages no matter what way it is observed.

It is useful, ornamental and interesting during life and a desirable addition to the table, if properly prepared, when dead (Headley, 2003). The shell of guinea fowl egg is thick and less porous with better keeping quality than chicken's egg (Teye and Gyawu, 2002; Koney, 1993; Karbo *et al*., 2001; Apiiga, 2004; Maganga and Haule, 1994; Dei and Karbo, 2004).

2.14.1 Nutritional Value

The yield of edible meat in guinea fowl is higher than that in chicken due to the slenderness of its skeleton thus, after dressing it yields 80% edible meat as compared with 65% for chicken (Koney, 1993). The meat of a young guinea fowl is tender and of especially fine flavour, resembling that of wild game, and therefore has been substituted for game birds such as partridge, quail and pheasant. Guinea fowl meat has a taste similar to other game birds and has many nutritional qualities that make it a worthwhile addition to the diet. It is second only to turkey in calories, having 134 Kcal (Calories) per 100 grams (turkey has 109 Kcal). The meat is lean and is rich in essential fatty acids (Ayeni and Ayanda, 1982; Okaeme, 1982; Biswas, 1999; Darre, 2007). According to Koney (1993), the meat of guinea fowl is lean containing 4% fat as against 7% for chickens and its flesh is tastier and firmer than that of chicken. Ayeni (1980) added that guinea fowl meat has higher protein content (about 28%) than that of chicken (about 20%).

Table 6: Composition of fresh guinea fowl meat.

Component	Content (%)
Water	65.9-71.8
Crude protein	32.2-35.8
Fat	3.7-5.4
Ash	4.9-6.5
Calcium	0.51-0.94
Magnesium	0.54-0.68
Sodium	0.26-0.40
Phosphorous	0.05-0.07
Iron	10.5-116 (mg kg-1)

(Ayorinde, 1989, 1991a)

The chemical composition of the carcass of the intensively raised guinea fowl (Table 6) shows that guinea fowl meat is quite nutritive. The carcass fat and cholesterol levels are lower than in chickens but other nutrients especially protein, minerals and some vitamins are higher (Ayorinde, 1989, 1991a).

2.14.2 Pest Control

Guinea fowls eat some seeds and grains but are mostly bug eaters and are widely valued as such (Headley, 2003; Amberg, 2009). Since one of the main sources of food for wild guinea fowls is insects, they have gained popularity for use in reducing insect populations in gardens and around the home, especially because, unlike chickens, they do not scratch the dirt much and do very little damage to the garden (Darre, 2007). They are reputed to be good tick eaters and have been used in parks and public areas for this reason (Amberg, 2009). Recently, guinea fowls have been used to reduce the deer tick population, associated with Lyme disease (Darre, 2007, Duffy *et al*., 1992, FeaterSite.com, 2007).

2.14.3 Aesthetic Value

Other people raise guinea fowls for their unique ornamental value (Darre, 2007). Guinea fowls are of great aesthetic value to man not only because of their bright colours and interesting ways, but because of the beautiful sounds they make (Prasad and Kashyap, 1995).

2.14.4 Security

On small farms and in some large chicken farms guinea fowls act as alarms, raising a clamor in the presence of predators (Microsoft Encarta Premium Science and Nature, 2006, Darre, 2007), no strange person or noise escapes them, and then their screaming is not only effectual, but calculated of itself to frighten off any evilly disposed marauder (Headley, 2003).

Both male and female have a very distinctive alarm cry which they sound at the slightest disturbance. This could be someone walking, a dog, a hawk, a car or truck, or any thing that is different to them at that moment in time. This alarm probably evolved in the wild when there was a great benefit in the flock being warned of danger as early as possible. They are great watch birds (Amberg, 2009).

2.15 Social Behaviour of Guinea Fowls

Guinea fowls begin to fly at a very early age and can be confined only in covered pens. It is not unusual to find adults roosting 20-30 feet above the ground. They are very strong fliers and the birds may often fly 400-500 feet high at a time when moving around the farm, especially if startled. Guinea fowls are extremely good runners and use this method, rather than flying, to escape predators. They are much more active than chickens and not as easily tamed. They seem to retain some of their wild behaviour and will remind you of this whenever they get spooked (Darre, 2007).

2.16 Guinea Fowl Haematology

Reports in the literature on the haematological values of indigenous guinea fowls are limited. Yet, such reports are very important in current attempts at increasing the contribution of the guinea fowl in the production of meat and eggs. Haematological values of domestic chickens have always provided veterinary clinicians the diagnostic baseline for routine management of guinea fowls. This however, could be misleading because of species differences (Orji *et al*., 1987a). Sex and sometimes age, time of bleeding and their interactions have significant effect on haematological values (Orji *et al*., 1987b). Diet, in so many ways, also affect haematological values of guinea fowls.

Of the five blood components evaluated by Oke *et al*. (2003), total protein, vitellogenin and serum calcium were optimized by the 2750 kcal/kg ME and 18% crude protein up to 36 weeks of age. However, two other parameters evaluated, packed cell volume and cholesterol levels were maximized at 2650 kcal/kg ME and 18% crude protein diet. In laying domestic fowl hens, blood vitellogenin concentration ranges from 10- 25 mg/ml while the ranges for guinea fowl ranges from 13- 17 mg/ml which shows that the basal level is higher in the guinea fowl than in the chicken indicating that the calcium demand for guinea fowls may be slightly higher than for the chicken.

The results obtained by Orji *et al*., (1987a), showed that erythrocytes values were $2.43\pm0.04\times10^6$/ mm^3; packed cell volume, 37.44%; haemoglobin concentration (gm%), 13.17; erythrocyte sedimentation rate (mm/hr) 1.69; length of red blood cell, 12.89 microns; width of RBC, 6.63 microns, leucocyte count, $22.18\pm0.64\times10^3$/ mm^3 and clotting time, 7.30 min.

The study by Onyeyili *et al*. (1992) concluded that, the haematological values of the grey breasted guinea fowl may be affected by temperature changes due to seasonal variations.

Table 7: Haematological values of guinea fowls in hot and cold seasons

Parameters	Hot Season (n= 12)	Cold Season (n= 12)	P
Hb Conc (g/dl)	**11.70±0.73**	**10.71±0.57**	**>0.05***
RBC (×10^6/ul)	**3.78±0.42**	**2.67±0.40**	**<0.05**
PVC (%)	**38.2±3.68**	**28.5±5.05**	**<0.05**
MCV (fl)	**101.44±5.83**	**105.98±4.11**	**>0.05***
MCNC (g/dl)	**30.82±1.29**	**38.62±4.66**	**<0.05**
MCH (Pg)	**30.61±1.50**	**41.22±3.43**	**<0.05**

SOURCE: Onyeyili *et al*., 1992

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1 Study Location

This experiment was carried out at the Poultry Section of the Department of Animal Science, Kwame Nkrumah University of Science and Technology, Kumasi. The experiment was conducted from October 2008 to May 2009. The area is located within the semi-deciduous humid forest zone of Ghana. Altitude is 261.4 m above sea level. The zone is characterized by a bimodal rainfall pattern with an annual rainfall averaging around 1400 mm. The major rainy season (62% of total precipitation) occurs from March to July and the minor season (38% of total precipitation) from September to November. Daily temperatures range from 20 ^{0}C to 35 ^{0}C with a mean of 26 ^{0}C. The relative humidity varies from 97% during the early morning in the wet season to as low as 20% during the late afternoon in the dry season. The average photoperiod is 12h (Osafo, 1976).

3.2 Climate and Relative Humidity

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

3.3 Duration of Experiment

The experiment was carried out over a period of 28 weeks, between October, 2008 to May, 2009. An adjustment period of two weeks was allowed. Phase One (Growing Stage) of the experiment lasted for nineteen (19) weeks, whiles Phase Two (Laying Stage) lasted for nine (9) weeks.

3.4 Procurement of Experimental Birds

Two Hundred (200) unsexed six -week old local pearl guinea fowl keets were obtained from the Animal Research Institute (ARI), Nyankpala, Northern Region. The Keets were hatched at the Station with manual electric incubators and brooded in a deep litter structure for the first six (6) weeks of their lives. The Institute, under its project to reduce keet mortality, brooded the keets for six weeks post -hatching. They were transported in large locally manufactured cages to the experimental station.

Twenty (20) out of the two hundred (200) keets were lost in transit due to heavy rains during transportation from the place of procurement to the destination of the experiment. The one hundred and eighty (180) indigenous pearl guinea fowl growers that survived were randomly assigned to the experimental diets containing 16, 18, 20 and 22% CP, respectively, from 9 to 27 weeks of age for experiment one, which is the growing phase.

An additional fifty (50) sixteen -week old growing pearl guinea fowl pullets were bought to supplement pullets from Phase One for the Phase Two Experiment. They were procured from the Animal Science Department of the University for Development Studies (UDS), Nyankpala

Campus, Northern Region. One hundred and twenty (120) indigenous pearl guinea fowls were randomly assigned (though in the ratio of eight females to every two males) to the experimental diets containing 15, 16, 17 and 18% CP, respectively, from 28 to 36 weeks of age for experiment two, which is the laying phase.

3.5 Source of Experimental Feed Ingredients and Drugs

The raw ingredients used for the formulation of the experimental diets were yellow maize, fishmeal, wheat bran, soyabean meal, dicalcium phosphate, oyster shells, vitamin- mineral premix and sodium chloride (common salt). The ingredients were purchased mainly from Rakeb Farms and Company Limited and ingredients that were unavailable at the time were bought from Emmapab Enterprise, all in Kumasi, Ashanti Region.

Drugs and medications used during the experimental period include Glucose, Multi-Vitamins, Antibiotics, Coccidiostat and Dewormers. They were obtained from the Animal Health and Production Department Veterinary Laboratory, Osiebros Company Limited, Naak-Vet Enterprise and Multivet all in Kumasi, Ashanti Region.

3.6 Building for Guinea Fowls

The guinea fowls were kept in a partitioned open-sided deep-litter structure. Twelve (12) cages measuring about 7 × 8 feet per cage were constructed to separate the treatments. Each cage was covered from top to down with wire mesh leaving an entrance into the cage. The cages were built as deep litter cages. Six cages were on each side of the main building, allowing for enough light and ventilation. The aisles were left for easy movement, cleaning and storage space for feed. Energy efficient light bulbs were fixed at vantage points at the ceiling of the main building to illuminate the building. The floors of the deep litter cages were covered with wood shavings to serve as floor litter for the birds.

Materials used for building of the cages include 2”×3” wood, 1”×3” wood, wire mesh, 3” nails, concrete nails and door hinges. Materials for the lighting include flexible wire, lamp holders, insulation tape and light bulbs. The building and lighting materials were obtained from Oluman Business Enterprise and Always Give Thanks Enterprise respectively, Kumasi, Ashanti Region.

3.7 Management of Experimental Birds

3.7.1 Health, Medication, Mortality and Culling

The guinea fowl keets were given glucose as an anti-stress on arrival, dewormed later and appropriate medication given thereafter throughout the experimental period.

Birds were observed for signs of ill-health and the right steps taken to restore health. Dead birds were examined by both the veterinarian of the Department of Animal Science and the Animal Health and Production Department Veterinary Laboratory for post mortem. Reports from the post mortem examinations determine the appropriate management practice to check and the medication to use to curtail the problem. Death was recorded as and when they occurred.

3.7.2 Feeding

The project was divided into two parts comprising the growing phase (experiment one) and the laying phase (experiment two). Each experiment comprised of four (4) treatments, each replicated three (3) times. Therefore, there were twelve (12) groups in all. Fifteen (15) unsexed guinea fowl keets were allocated to each cage in experiment one and ten (10) (eight females and two males) were allocated to each cage in experiment two.

The birds were fed early in the morning daily. Feed to be given was weighed on a top loading scale to obtain the required quantity of feed per treatment per replicate. Each treatment had a different composition of feed as required by the protein content of that feed. The birds were fed per treatment at a time. The orts (leftover) was collected, weighed and recorded daily to know the amount of feed consumed by the birds per day.

3.7.3 Formulation of Experimental Diet

Table 8: Composition of experimental diets fed to guinea fowls at ages 9- 27 weeks.

DIETARY TREATMENTS (EXPERIMENT 1)

	T0	T1	T2	T3
Ingredients, air dry basis, %				
Maize	65	63	59	**57**
Wheat Bran	25	22.5	23	**22**
Soy Bean Meal	4	5.5	4	**5**
Fish Meal	4	7	12	**15**
Oyster Shell Meal	0.2	0.2	0.2	**0.2**
Dicalcium Phosphate	0.6	0.6	0.6	**0.6**
Vitamin- Mineral Premix	0.6	0.6	0.6	**0.6**
Sodium Chloride	0.6	0.6	0.6	**0.6**
Chemical Composition (g/kg)				
CRUDE PROTEIN	16.05	18.00	20.10	**22.14**
CRUDE FIBRE	4.5	4.3	4.2	**4.2**
ETHER EXTRACT	3.45	3.46	3.56	**3.62**
CALCIUM	0.4	0.5	0.7	**0.8**
PHOSPHORUS	0.6	0.6	0.7	**0.8**
LYSINE	0.6	0.8	1.0	**1.2**
METHIONINE	0.3	0.3	0.4	**0.5**
METABOLIZABLE ENERGY (Kcal/kg)	**1230**	**1230**	**1230**	**1230**

Table 9: Composition of experimental diets fed to guinea fowls at ages 28- 36 weeks.

DIETARY TREATMENTS (EXPERIMENT 2)

	T0	T1	T2	T3
Ingredients, air dry basis, %				
Maize	66	65	64	**63**
Wheat Bran	26	25	24	**22.5**
Soy Bean Meal	3	4	4.2	**5.5**
Fish Meal	3	4	5.8	**7**
Oyster Shell Meal	0.6	0.6	0.6	**0.6**
Dicalcium Phosphate	0.6	0.6	0.6	**0.6**
Vitamin- Mineral Premix	0.6	0.6	0.6	**0.6**
Sodium Chloride	0.2	0.2	0.2	**0.2**
Chemical Composition (g/kg)				
CRUDE PROTEIN	15.20	16.10	17.00	**18.00**
CRUDE FIBRE	4.70	4.60	4.50	**4.40**
ETHER EXTRACT	3.50	3.60	3.50	**3.50**
CALCIUM	0.70	0.70	0.80	**0.90**
PHOSPHORUS	0.80	0.80	0.80	**0.80**
LYSINE	0.60	0.60	0.70	**0.80**
METHIONINE	0.30	0.30	0.30	**0.30**
METABOLIZABLE ENERGY (Kcal/kg)	**12.30**	**12.30**	**12.30**	**12.30**

3.7.4 Watering

The water troughs were washed thoroughly with soap and water every morning and fresh, clean water provided *ad libitum* daily. Troughs were disinfected fortnightly.

3.7.5 Housing

The deep litter cages were cleaned, disinfected and fresh wood shavings (litter) spread on the floor before the arrival of the guinea fowl keets in experiment one and before the commencement of experiment two. The aisles were cleaned daily to rid them of litter spillage from the cages. The floors of the cages were scraped and the litter collected and changed fortnightly.

3.8 Chemical Analysis of feed samples

Feed samples were analysed for crude protein (N x 6.25), crude fibre (CF), ether extract (EE), calcium, lysine, methionine and phosphorus by standard AOAC methods (AOAC, 1990). Metabolisable energy contents of the diets were calculated from the chemical analysis data using the equation:

$$ME\ (kcal/kg) = 4.26X_1 + 9.5X_2 + 4.23X_3 + 4.23X_4$$

The calculated digestible crude protein, crude fat, fibre and nitrogen free extractives (g/kg feed) are represented by X_1, X_2, X_3 and X_4 respectively.

3.9 Statistical Analysis

Data on various parameters were subjected to statistical analysis using analysis of variance (ANOVA) for a completely randomized design using General Linear Model procedure of GENSTAT Release 7.22 DE statistical software for windows. Where there was a significant F-test (P< 0.05) difference between means, the Least Significance Difference (LSD) method was used to separate the means (Steel and Torrie, 1980).

3.10 Data Collection

The parameters measured for the growing phase include feed intake, body weight, feed conversion ratio, mortality, haematology, age at first lay, weight at first lay, and weight of first egg. Parameters measured for the laying phase were feed intake, body weight, feed conversion ratio, mortality, haematology, egg weights, egg numbers, hatching parameters and carcass parameters.

3.10.1 Feed Intake

A known quantity of feed was given per cage in the mornings. The feed trough was emptied the next day and the orts taken out before fresh feed was given. The orts were weighed and recorded per day per cage (that is per replicate). Daily feed intake was obtained by subtracting the weight of the orts from the total amount of feed given. Daily feed intake per bird was measured by dividing the result of the daily feed intake per replicate by the number of birds in the replicate.

3.10.2 Body Weight

The experimental birds were wing tagged for ease of identification and their individual body weights taken fortnightly by catching them into an empty box. The box was placed on a measuring scale. The weight of the box was nullified by calibrating the scale to zero with the empty box still on it. The birds were put into the box and the weight recorded. The mean weight per bird per replicate were measured by dividing the weights obtained by the total number of birds in the cage.

3.10.3 Feed Conversion Ratio

Feed conversion ratio (FCR) was calculated by dividing weekly feed consumption by weekly body weight (BW) gain for each replicate (g/g).

3.10.4 Mortality

Mortality was recorded as and when it occurred. Percentage mortality figures per replicate were obtained by dividing the number of mortalities by the total number of birds per replicate, all multiplied by hundred.

% mortality is calculated as $\frac{\text{Number of mortality}}{\text{Number of birds}} \times 100$

3.10.5 Haematology and Biochemical Analysis

At 22 weeks of age, some blood parameters were determined on a total of 24 guinea fowls (2 per replicate, and therefore 6 per treatment). After removal of feathers around the wing vein, a sterile cotton swab soaked in 70% ethanol was used to slightly dilate the vein prior to bleeding. Blood samples were obtained by puncturing the brachial vein of the underside of the web of the wing and 1.0 ml blood was drawn from each hens using needles and syringes and rapidly transferred into appropriate blood tubes pretreated with EDTA (Ethylene-diamine-tetra acetic acid) an anticoagulant. All haematological parameters were determined within an hour of sample collection. Red Blood Cell (RBC), White Blood Cell (WBC), Haemoglobin (Hb) and Packed Cell Volume (PCV) values were determined using a haemoanalyzer.

A portion of each blood sample was drawn onto a glass slide to make thick and thin films for the examination of blood parasites. The blood films were fixed with methylated spirit to preserve the structures in the blood film. The films were then stained with Geimsa stain for 10 minutes, washed under slow running tap water and dried. The blood films were examined under a microscope for blood parasites. The blood samples were centrifuged at 500 rpm (revolution per minute) for 3 minutes in a macro centrifuge to generate serum for biochemical analysis. The serum was kept frozen until further analysis. The frozen plasma was allowed to thaw prior to analysis and the thawed plasma was pipetted into dry clean bottles and stored at -20 ^{0}C by refrigeration. Total protein, albumin, globulins and total cholesterol were analyzed using a spectrophotometer at a wavelength of 500 nm. Globulin level was calculated as the difference between total plasma protein and albumin.

3.10.6 Egg Parameters

The collected eggs to be used in the research were numbered at first. Then they were weighed in order to determine their weights. Later, the width and the shell length of the eggs were measured. After this process, the eggs were broken into a small preweighed glass container in order to weigh the yolk and check the yolk colour. The yolk and albumen were separated by breaking a small part of the egg shell at one end and separating the egg albumen from the yolk. The yolk, separated from the albumen, was weighed together with the membrane and the yolk weight was obtained. The shells were washed under slightly flowing water so that the albumen remains are removed. The washed shells were left to dry in the open air for 24 hours. Then they were weighed together with the shell membrane.

Egg Shape Index was determined according to Reddy *et al*., (1979) as given below;

Egg Shape index (%) = [Wd (cm)/ L (cm)] × 100

Wd = Egg Width (cm)

L = Egg Length (cm)

W = Egg Weight (g)

Shell Thickness (mm) = average of three readings at the broad, narrow and mid sections.

3.10.6.1 Age at First Egg

The age at first egg per replicate was recorded as the ages of the guinea fowls when the first bird per that replicate dropped her first egg.

3.10.6.2 Weight at First Egg

The weight at first lay was recorded as the average weight of the guinea fowls when the first bird per that replicate dropped her first egg.

3.10.6.3 Weight of First egg

The weights of the first eggs were calculated as the average weights of the first eggs per replicate.

3.10.6.4 Hatching

Eggs were collected daily from all the treatments and replicates and stored under a room temperature of 25°C. Eggs collected were identified using a marker so that eggs from each treatment and replicate could be traced and set into their respective trays in the incubator. Eggs collected over a period of seven days were then sent to Fairway Hatchery at Kwapra-Kronum (20 km away from the research station). Proper cleaning, disinfection and fumigation were carried out before setting of eggs. The eggs were turned automatically through 90^0 in the incubator. On the 18th day of incubation the eggs were candled to identify and remove infertile eggs. The remaining fertile eggs were transferred to the hatcher. The records kept were

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

% Fertility is calculated as: $\frac{\text{Total number of fertile eggs}}{\text{Total number of eggs set}} \times 100$

% Hatchability of fertile eggs is calculated as: $\frac{\text{Total chicks hatched}}{\text{Total number of fertile eggs}} \times 100$

% Hatchability of eggs set is calculated as: $\frac{\text{Total chicks hatched}}{\text{Total number of total eggs set}} \times 100$

3.10.7 Carcass Parameters

The carcass composition of the guinea fowls were analysed at the end of the experiment from a sample of representative birds. Two guinea fowls from each of the replicates per treatment were slaughtered at 36 weeks of age to determine the proportions of body components such as bled body weight, dressed body weight, defeathered weight, head, heart, crop, empty gizzard, oviduct, legs, liver and weight of digestive tract.

CHAPTER FOUR

4.0. RESULTS AND DISCUSSION

4.1. Experiment One (Growing Phase)

Table 10: Feed Intake as affected by different dietary protein levels up to 27 weeks of age.

Treatments/ Parameters	T_0	T_1	T_2	T_3	LSD	SEM
Average Daily Feed Intake (g)	805.40	803.30	796.20	766.50	45.62	**13.99**
Average Daily Feed Intake/Bird (g)	53.69	53.55	53.08	51.10	3.04	**0.93**
Average Weekly Feed Intake (g)	5511.00	5496.00	5448.00	5245.00	312.10	**95.70**
Total Feed Intake (average) (kg)	104.70	104.43	103.51	99.65	5.93	**1.82**

*P<0.05

The various dietary protein levels up to 27 weeks of age did not record significant (P>0.05) differences in feed intake levels between treatments. This might be due to variations within the treatments. Variations within treatments could be attributed to the fact that birds have their individual hidden potentials that has not been explored and selected. Despite the absence of statistical differences between the treatments, T_0 recorded a slightly higher (805.40 g) feed intake value as compared to all the other treatments. Feed intake per bird reduced with increasing protein levels. This is might be because birds eat to satisfy their protein requirements (Kamran *et al*., 2004). Hence, birds on lower protein levels had to consume more feed or had to increase their feed intake to meet their physiological demands. Though between treatments no differences existed, the weekly intake figures recorded were close to weekly figures recorded by Adeyemo and Oyejola (2004) which are 5.28, 5.49, 5.68 and 6.04 kg. The relatively lower feed intake for birds on higher CP diets are contradictory to recent reports. Using the French variety of the guinea fowl, Nahashon *et al*. (2005) reported a 3 to 4% increase in feed consumption in birds fed

25% CP diets when compared with those fed 21 and 23% CP diets. There were no known stress related problems influencing their feed intake. Kingori *et al*. (2003) stated that growth in animals is influenced by genotype of the birds and by nutrition, hormones, tissue specific regulatory factors and other aspects of the bird's environment. In a stress-free environment, given adequate intake of essential nutrients, growth will increase until a genetically determined upper limit is reached.

Table 11: Body weight gain (g) of pearl guinea fowls fed diets with varying concentrations of dietary protein up to 27 weeks of age.

Treatment/ Parameters	T_0	T_1	T_2	T_3	LSD	SEM
Average Daily Gain (g)	6.18	6.35	6.55	6.52	1.98	**0.61**
Average Weekly Weight Gain (g)	43.25	44.46	45.83	45.64	3.71	**1.14**
Total Weight Gain (average) (g)	865.00	889.00	917.00	913.00	74.20	**22.80**

*P<0.05

The influence of varying concentrations of dietary crude protein on body weight gain of the pearl guinea fowl at 9 to 27 weeks of age is presented in Table 11. No significant (P>0.05) difference was observed among the treatments. Nahashon *et al*. (2006) reported that the cumulative body weight gain of birds fed diets containing 20% CP was not different (P>0.05) from that of birds fed diets containing 22% CP. The average daily gains of all the treatments were however, higher than what was reported by Ayorinde (2004) a value of 5.58 g under intensive system of management but this finding however, supports the report of Ayorinde (1999) that daily weight gain in guinea fowls range from 6- 8 g under intensive management. Ayorinde and Ayeni

(1987a) added that growth of the local unimproved guinea fowl is generally slow. Therefore, since the birds are unimproved, live weight gain is not as rapid as in improved meat and egg chickens. The body weight was improved when the local unimproved guinea fowl was raised in battery cages. For instance, as stated by Ayorinde (1990b, 1991a), body weight at 20 weeks was 849 g on the deep litter and 1036 g in battery cages while daily weight gains to 20 weeks of age were 7.51 g (cage) and 5.58 g (floor).

In this present trial, it could be deduced that, though body weight gain increased with increasing crude protein inclusion in the diet, except between T_2 and T_3, where birds fed with 20% CP gained slightly more weight than birds fed on 22% CP, it did not result in significant (P>0.05) differences among treatments. The more balanced a protein is, the higher the efficiency with which it is used (Harper, 1958). The good tolerance to the increasing levels of protein among the treatments may well be explained on the basis that there was a good balance of amino acids in the protein and the fact that the amino acid balance remained constant as the protein levels increased.

Table 12: Average weight of first egg, age and weight at first egg

Treatment/ Parameters	T0	T1	T2	T3	LSD	SED
Age at first egg (days)	166	167	177	177	-	-
Weight of first egg (g)	28.33	29.33	27.33	32.00	1.63	**0.50**
Weight at first egg (kg)	**0.98**	**0.98**	**1.01**	**1.02**	-	-

*P<0.05

On the average the guinea fowls on diets with 16%, 18%, 20% and 22% crude protein came into lay at 166, 167, 177 and 177 days of age at mean live weights of 976.60 g, 983.33 g, 1013.33 g, 1018.33 g and weight of first egg as 28 g, 29 g, 27 g and 32 g respectively.

Guinea fowls in a study by Adeyemo and Oyejola (2004) had their first lay at 164, 164, 167 and 171 days at 0%, 20%, 40% and 60% levels inclusion of poultry droppings respectively. These figures are similar to what have been obtained in this study.

In contrast, Oke *et al*. (2003) had their age at first egg at 237, 231, 225, 227, 219, 228, 223, 220, 225 days, their first egg weighed 34.10 g, 34.75 g, 34.42 g, 34.20 g, 33.95 g, 34.80 g, 34.20 g, 33 89 g, 34.55 g and their weight at first egg was 1129.74 g, 1126.40 g, 1128.70 g, 1135.40 g, 1137.45 g, 1134.50 g, 1134.78 g, 1128.61 g and 1139.45 g respectively. These figures are higher in all cases. This means that birds in this study had an earlier age at sexual maturity and therefore came into lay at an earlier age, which resulted in smaller egg weights than did the latter. This can be interpreted as, the later the age at sexual maturity, the older the bird at first lay and therefore the heavier the first egg.

Ayorinde and Ayeni (1983) working with different breeds of guinea fowls observed that the body weight at the beginning of egg production were 1052.25 g for pearl and 1088.50 g for black guinea fowl which were quite close to the values obtained in this study. Oke *et al*. (2003) in another study to compare dietary proteins had live body weights of 1126.40 g, 1137.45 g and 1128.61 g which are higher than the values obtained in this study.

Table 13: Mean blood values and profiles of growing indigenous guinea fowl.

Treatment/ Parameters	T_0	T_1	T_2	T_3	LSD	SEM
Albumin (g/l)	23.60	26.20	25.90	27.20	14.13	4.33
Globulin (g/l)	13.90	11.00	9.60	9.70	7.97	2.44
Total Cholesterol (mmol/l)	2.22	2.52	2.82	2.53	1.37	0.42
Total Protein (g/l)	34.10	37.20	35.40	37.70	9.53	2.92
Hematocrit (HCT) (%)	35.25^{ab}	33.25^{b}	36.97^{a}	34.07^{ab}	3.02	0.93
HGB (g/dl)	17.92^{ab}	17.03^{b}	18.75^{a}	17.82^{ab}	1.22	0.37
Red Blood Cells (RBC)$\times10^{12}$/l	2.31	2.19	2.48	2.24	0.29	0.09
White Blood Cells (WBC)$\times10^{9}$/l	177.30	177.20	184.60	174.90	12.00	3.68

$^{a-b}$ values within the same row followed by different superscripts differ significantly ($P<0.05$).

Albumin levels did not differ from each other between treatments. The serum content of the soluble proteins, those circulating in extracellular and intracellular fluids, have been used as a marker to aid in clinical diagnosis. The main diagnostic tests are those measuring serum albumin and serum total protein. This test is often done to diagnose nutritional problems, kidney disease or liver disease. Collectively, serum albumin and serum total protein are mainly involved in the maintenance of normal water distribution between tissues and the blood responsible for maintaining the osmotic pressure of plasma and is used to transport many substances including macromolecules (Linear Chemicals, 2002). Though there is no standard to compare with, since there were no significant differences between treatments, it could mean that differences in dietary protein levels did not affect their normal osmotic pressure, and there are no nutritional, kidney and liver problems.

Globulin levels did not differ statistically ($P>0.05$) among treatments despite the numerical differences in dietary proteins as shown in Table 13. Globulin is one of the two types of serum proteins, the other being albumin. Serum globulin can be separated into several subgroups by serum protein electrophoresis. Some globulins are made by the liver, while others are made by the immune system. Certain globulins bind with hemoglobin while other globulins transport metals, such as iron, in the blood and help fight infection (Linear Chemicals, 2002). Serum globulin levels of guinea fowls, whether low or high, designate the chances of developing an infection and to see if there is a rare blood disease, such as multiple myeloma or macroglobulinemia.

Total Cholesterol levels though not significantly ($P>0.05$) different, was maximized at 20% protein. Oke *et al*. (2003) noted cholesterol levels of 3.65, 3.70, 3.58, 3.45, 2.98, 3.14, 2.65, 3.40 and 3.25 for guinea fowls which are close to those observed in this study. Cholesterol exists in the blood as a free sterol and in an esterified form. The knowledge of the plasma level of lipids (cholesterol and triglycerides) together with lipoproteins of high and low density aids in the detection of many conditions bound to metabolic disorders of high risk. Low total cholesterol values with normal ester fractions are noted mainly in malnutrition (Linear Chemicals, 2002).

Since no real standard has been set by researchers for guinea fowl total cholesterol, it is not known if these figures are up to, below or above standards, though close to the findings of other researches.

The total protein values in growing guinea fowls are as presented in Table 13. The mean total protein values as produced by different dietary protein levels were not significantly (P>0.05) different from each other. Studies by Orji *et al*. (1987a) produced 25.0 and 24.3 g/l for adult guinea fowl females and males respectively showing that females had significantly higher serum proteins than males. They gave a range of between 16.0 and 35.4 g/l as the requirement. This shows that though no significant (P>0.05) differences existed between the treatments and some of the values of the present study are slightly above what has been given, they are still within range.

Total protein works closely along-side albumin and globulin (Linear Chemicals, 2002). A total serum protein test measures the total amount of protein in the blood. It also measures the amounts of two major groups of proteins in the blood: albumin and globulin. The amounts of albumin and globulin also are compared. Normally, there is a little more albumin than globulin. Though statistically there are no significant differences existing among treatments in each case of albumin and globulin, as stated above, the amounts of albumin are more than those of globulin and this therefore proves a possibility of normalcy in the trend.

Malnutrition, mal-absorption and edema can usually lead to hypoproteinemia. Since albumin is present in such high concentration low levels of this protein alone may also cause hypoproteinemia. The standards given by Orji *et al*. (1987b) (Range- 16.0- 35.4 g/l), shows that birds from this study had a normal serum total protein level though birds from T_3 had the highest value.

From table 13, percentage hematocrit (HCT) levels were significantly ($P<0.05$) different between birds from treatment 1 and 2, but did not produce any significant ($P>0.05$) differences among the rest of the treatments.

There was significant ($P<0.05$) difference in mean haemoglobin concentration between birds from treatment 1 and 2, but not among the rest of the treatments. Though, no specific standard was found for guinea fowl haemoglobin levels, the reason for the significant differences in haemoglobin values of treatment 1 and 2 could be assigned to the fact that since treatment 1 recorded the least value, in contrast to treatment 2 which recorded the highest value, there could have been some nutritional deficiency (iron, vitamin B12 and folate) in the feed for treatment 1. This means that birds from treatment 1 could have been anemic. The significant differences could also mean that since treatment 2 values were the highest recorded, they could have also been abnormally high. Orji *et al*. (1987a) in a study obtained haemoglobin levels of 13.10 and 11.5 for females and males respectively. Since the differences were not too varied, and all except treatment 1 and 2 showed statistically significant differences, haemoglobin levels for birds in this study might be acceptable.

The result of the present study shows that guinea fowls may be susceptible to marked fluctuations of red blood cell counts caused by changes in the environmental temperatures and not necessarily by dietary protein levels. Orji *et al*. (1987a) in their studies obtained mean RBC counts of 2.58 and 2.24 10^{12}/L for males and females respectively. Normal red blood cells in the domestic fowls have been reported to range from 2.6 to 3.3 10^{12}/L (Epelle, 1982). The mean counts of 2.31, 2.19, 2.48 and 2.24 10^{12}/L in the present study on guinea fowls are slightly below the normal range of such parameters in the domestic fowl. This would therefore seem to suggest strong species differences in the various classes of poultry.

Mean white blood cell values were 221.8, 209.2 and 233.7 10^9/L for guinea fowls in a study by Orji *et al*. (1987a). Normal white blood cells in the domestic fowls have been reported to range from 244- 321 10^9/L (Epelle, 1982). The mean counts of 177.30, 177.20, 184.60 and 174.90 ($\times10^9$/l) recorded in this study are below the range given for the domestic fowl. This can also be related to the species differences that exist between these classes of poultry. T_2 recorded the highest values though there were no significant (P>0.05) differences between treatments.

Table 14: Mortality of growing guinea fowls fed varying levels of protein

Treatments/ Parameter	T_0	T_1	T_2	T_3	LSD	SEM
Mortality (%)	0.00	2.23	2.23	0.00	5.15	-

*P<0.05

There were no statistical differences in the mortality rate for the growing guinea fowls during the growing phase of the experiment. The only cause of death at the time was pecking. Guinea fowls peck at each other due to different natural and nutritional reasons. During struggling when startled by strange obstructions, guinea fowls injure themselves. These injuries open up wounds with or without blood, and these openings or wounds attract other fowls to peck at the spot. When bleeding occurs, more guinea fowls are attracted and this pecking may cause death.

Guinea fowls may also peck a weaker member of the group to show dominance. Nutritionally, guinea fowls will peck when there are deficiencies in particular nutrients in their diets.

4.2. Experiment Two (Laying Phase)

Table 15: Effect of different dietary protein levels on feed intake

Treatments/ Parameters	T_0	T_1	T_2	T_3	LSD	SEM
Average Daily Feed Intake/bird (g)	71.00	74.80	76.30	74.10	7.23	**2.22**
Average Weekly Feed Intake (kg)	5.59	5.90	6.01	5.84	0.57	**0.18**
Average Total Feed Intake (kg)	44.71	47.15	48.06	46.71	4.55	**1.40**

*P<0.05

No significant (P>0.05) differences were observed in the feed intake of layers during the experimental period of nine weeks. Feed intake per bird increased with increasing protein levels of 15%, 16% and 17% with 18% being the only exception. This reduction in feed intake in T_3 after the consistent rise in intake could be associated to provision of surplus amino acids. Surplus amino acids in the portal circulation after consumption of an imbalanced diet stimulate synthesis or suppress breakdown of limiting amino acids in the liver leading to their greater retentions. The supply of limiting amino acids for peripheral tissues such as muscle is thereby reduced, although protein synthesis in these tissues continue unimpeded. Eventually, the free amino acid patterns of both muscle and plasma may become so deranged that it will trigger the intervention of the appetite- regulating system to reduce feed intake (Kingori *et al*., 2003).

The total feed intake recorded by birds fed 16% and 18% crude protein by Adeyemo *et al.*, (2006) were 9270 g and 9280 g respectively, contrasting what has been recorded in this study.

The current findings may suggest that the birds were reared under optimum environmental conditions which were favourable. Ambient Temperature can affect bird's performance through its effect on the latter's energy requirement for its maintenance. As energy is mainly derived from food, it is easy to understand why the birds attempt to regulate their feed intake in accordance with the prevailing environmental temperature. At high temperatures the energy intake may be too low, and as heat production goes up, the birds are no longer able to maintain their performance at an acceptable level. Poultry performance under tropical conditions is therefore mainly determined by the actual feed intake (Saxena and Ketelaars, 1993).

Table 16: Mean weight gain values in laying guinea fowls as affected by different dietary protein levels.

Treatments/ Parameters	T_0	T_1	T_2	T_3	LSD	SEM
Average Daily Gain (g)	-1.35	-0.83	-0.68	-0.54	2.94	**0.90**
Average Weekly Weight Gain (g)	-9.5	-5.8	-4.7	-3.8	20.55	**6.30**
Total Weight Gain (average) (g)	-76.00	-46.00	-38.00	-30.00	164.4	**50.40**
Live Body Weight (average) (kg)	1.17	1.23	1.27	1.27	0.14	**0.04**

*P<0.05

Table 16 shows the average daily, weekly, total and live body weights of layers during the experimental period.

Although the birds were fed feed varying in crude protein levels viz, 15%, 16%, 17% and 18% for T_0, T_1, T_2 and T_3 respectively, this did not have any significant (P>0.05) effect on their weight. The trend though, shows that the birds lost weight with reducing protein levels. This might mean that birds need a certain amount of protein to meet their physiological needs, and beyond that requirement, gains are no more attained. Feeding above the protein requirements does not result in an increase in protein deposition, but rather nitrogen excretion through the urine increases rapidly (Kingori *et al*., 2003).

This finding agrees with Oke *et al*. (2003) that various dietary protein and energy levels (16%, 18%, 20% CP against 2650, 2750, 2650 K cal/kg) at laying stage (age at sexual maturity) did not produce consistent or significant changes in body weight gain. The overall average live body weight of all birds is however, higher than that recorded by Oke and Nwachukwu (2004), a value of 992 g, but within the range of what Oke *et al*. (2003) recorded (between 1164.30- 1205.64 g). These fluctuations in body weight losses following the onset of egg production may have perhaps resulted from increased use of physiological reserves to meet the demand for egg production. Ayorinde *et al* (1988) reported consistent reduction in body weight, which they attributed to increased use of physiological reserve to meet the demand for egg production. It could also be argued that the similar weight losses were related to the feed intake of the birds, where birds were fed on different crude protein levels, but consumed similar quantities of feed. The non- existence of significant differences could also be attributed to the similar genetic background of the birds.

Table 17: Effects of different dietary protein levels on some egg parameters

Treatment/ Parameters	T_0	T_1	T_2	T_3	LSD	SEM
Length (cm)	4.618^{a}	4.515^{b}	4.537^{ab}	4.545^{ab}	0.09	**0.03**
Width (cm)	3.403^{a}	3.333^{ab}	3.331^{b}	3.347^{ab}	0.07	**0.02**
Egg Weight (g)	32.50^{a}	33.30^{ab}	32.77^{ab}	34.10^{b}	1.56	**0.48**
Shape Index (%)	73.69	73.82	73.42	73.64	-	**-**
Shell Thickness (mm)	0.42	0.41	0.42	0.40	-	**-**
Yolk Weight (g)	9.08	9.09	9.08	9.10	-	**-**
Albumin Weight (g)	16.41	17.21	16.69	18.00	-	**-**
Shell Weight (g)	7.01	7.00	7.00	7.00	-	**-**

$^{a-b}$ values within the same row followed by different superscripts differ significantly (P<0.05).

Table 17 shows the egg parameters as influenced by different protein levels. Egg length was significantly (P<0.05) different between T_0 and T_1, but not significantly (P>0.05) different between T_2 and T_3 and between the former and latter. Egg width was also significantly (P<0.05) different between T_0 and T_2, but not significantly (P>0.05) different between T_1 and T_3 and between the former and latter. Results from Table 16 shows that the live body weights of the birds from T_0 and T_1 were the highest and lowest recorded respectively. Live body weight of birds may have affected some external egg parameters including the length of egg. In many studies carried out on chickens and Japanese quails researchers reported a negative, although not always significant, correlation between the egg shape index and bird weight (Kul and Seker, 2004) which would mean that heavier eggs are more elongated. Egg length is an important parameter when it comes to the measurement of egg shape index. Shape index and other external qualities of the egg according to Kul and Seker (2004) have significant effect on hatchability of fertile incubated eggs and also on egg shell quality for the table egg market.

Egg weights did not differ (P>0.05) significantly from each other except between T_0 and T_3 in all protein levels offered with T_3 recording the highest weight with T_0 recording the least. Since age and weight at first lay directly affects weight of eggs, the trend can be accepted since T_0 was the first to lay with T_3 being the last.

Egg shell thickness and yolk weight for birds offered diets containing 15%, 16%, 17% and 18% crude protein did not differ (P>0.05) significantly from each other. This suggests that the different protein levels in the different diets did not affect the shell thickness and weight of egg yolk in any way. From other studies including Butswat *et al* (2001) and Adeyemo and Oyejola (2004), it could be suggested that the bigger or larger the guinea fowl egg, the thinner the egg shell, meaning smaller eggs had thicker egg shells as compared to bigger eggs.

The egg weight has an indirect relation with the shell quality of the egg. Thus the shell thickness that has a direct relation with the egg weight has positively significant correlations with the shell weight. Kul and Seker (2004) suggested that a positive correlation value of 0.26 is between the egg weight and the shell thickness. This study indicates that, the egg shell thickness can be seen to have an opposite correlation with the increase of the egg weight. This case probably resulted from the fact that the portion of the total weight of egg that was contributed by the shell weight and shell thickness was less than the increase of the other components that formed the egg.

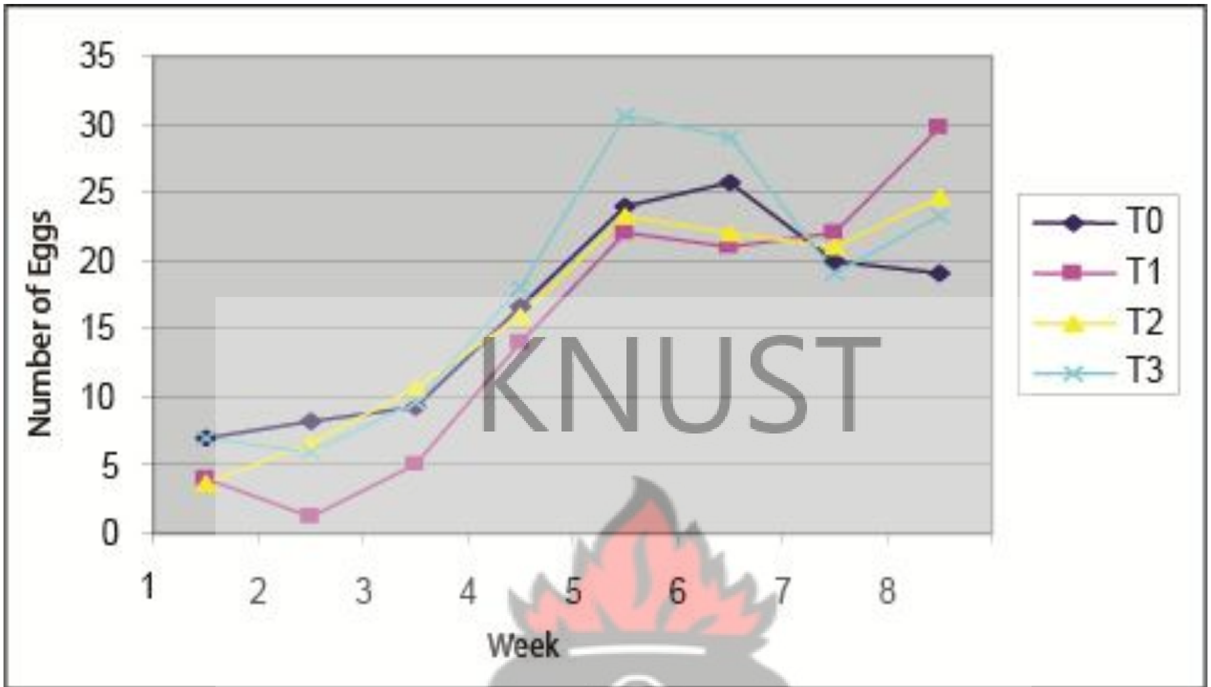
Figures from this study for egg shell thickness were higher than that obtained by Adeyemo and Oyejola (2004), but slightly lower than eggs of similar category in findings of Butswat *et al* (2001).

Table 18: Effects of different dietary protein levels on weekly number of eggs produced.

Treatments/ Parameters	T_0	T_1	T_2	T_3	LSD	SEM
Average Number Eggs Collected	16.20	14.90	16.00	17.80	7.17	**2.20**
WEEKLY						
1	7.00	4.00	3.67	7.00	5.27	**1.62**
2	8.30	1.30	6.70	6.00	7.35	**2.25**
3	9.30	5.00	10.70	9.70	11.83	**3.63**
4	16.70	14.00	16.00	18.00	9.93	**3.05**
5	24.00	22.00	23.3	30.70	13.27	**4.07**
6	25.70	21.00	22.00	29.00	16.50	**5.06**
7	20.00	22.00	21.00	19.00	12.17	**3.73**
8	19.00	29.70	24.70	23.30	11.53	**3.54**
Total Eggs Collected	130.00	119.00	128.00	142.70	57.36	**17.59**
Average Daily Number of Eggs Coll.	2.32	2.12	2.29	2.55	1.02	**0.31**

*P<0.05

Figure 1: Number of eggs collected per week as affected by different protein levels



The influence of the different dietary protein levels on number of eggs collected per week for the egg collection period is as shown in Table 18 and Figure 1. Though there were no significant (P>0.05) differences among the treatments for all the weeks of collection, the trend shows that T_3 performed better than the rest between the fourth and sixth weeks and all treatments dropped drastically on the seventh week. The gradual rise of all treatments with the progression of the weeks could imply that more of the birds were beginning to come into lay. All things being equal, without the interruption of diseases, pests, which could result in reduction in feed intake and other limiting factors, all birds will come into full lay and the eggs laid per week would increase. The general rise in hen day production with age is an indication that efficiency in egg production is directly affected by age of the hen. On the other hand, the fall in number of eggs collected on week seven by all treatments could be an indication of feeding abnormalities, disturbances etc. Average daily number of eggs collected was best in T_3.

Table 19: Mean weights per week of the guinea fowl eggs

Treatments/ Parameters WEEK	T_0	T_1	T_2	T_3	LSD	SEM
1	28.40	31.60	29.30	30.37	1.50	0.46
2	30.07	32.57	29.80	31.87	2.34	0.72
3	30.17	31.77	30.93	32.47	2.05	0.63
4	31.13	33.03	32.03	33.90	1.89	0.58
5	33.30	34.17	33.10	34.30	1.83	0.56
6	33.33	34.13	34.23	35.07	1.33	0.41
7	34.80	34.03	34.33	36.47	2.23	0.68
8	35.90	34.47	35.20	37.07	1.75	0.54
Grand Mean	32.50	33.30	32.77	34.10	1.56	0.48

*P<0.05

Figure 2: Mean egg weight of the guinea fowl as affected by different dietary protein levels

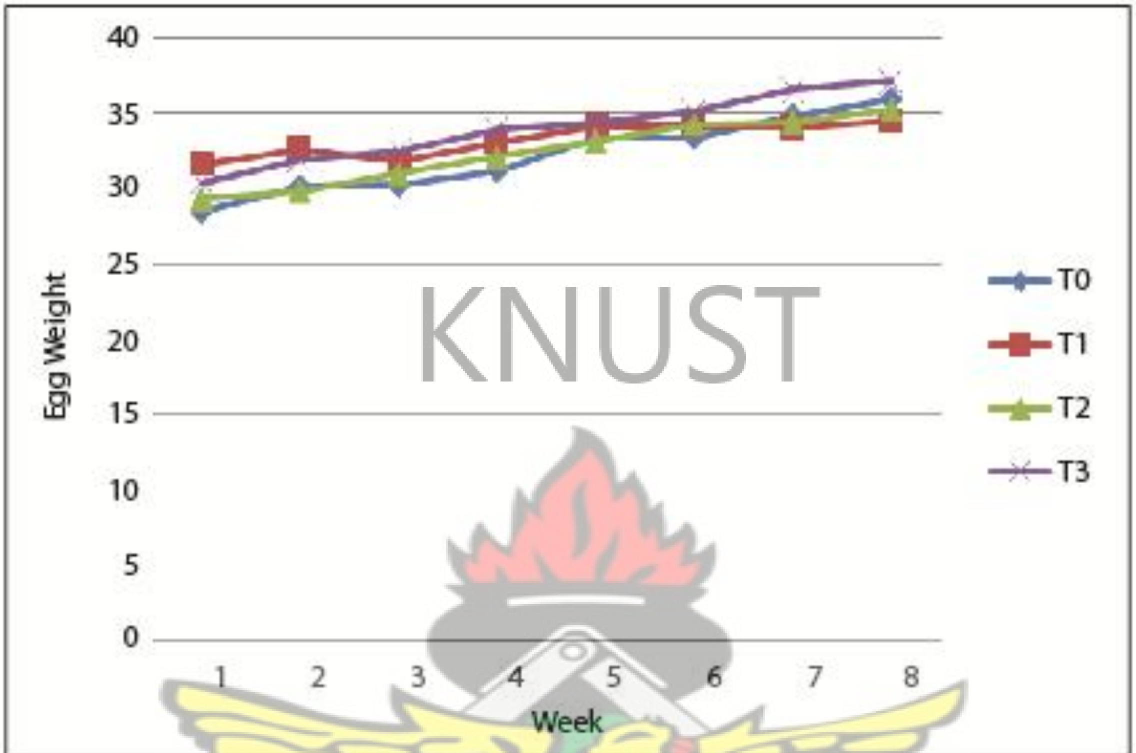
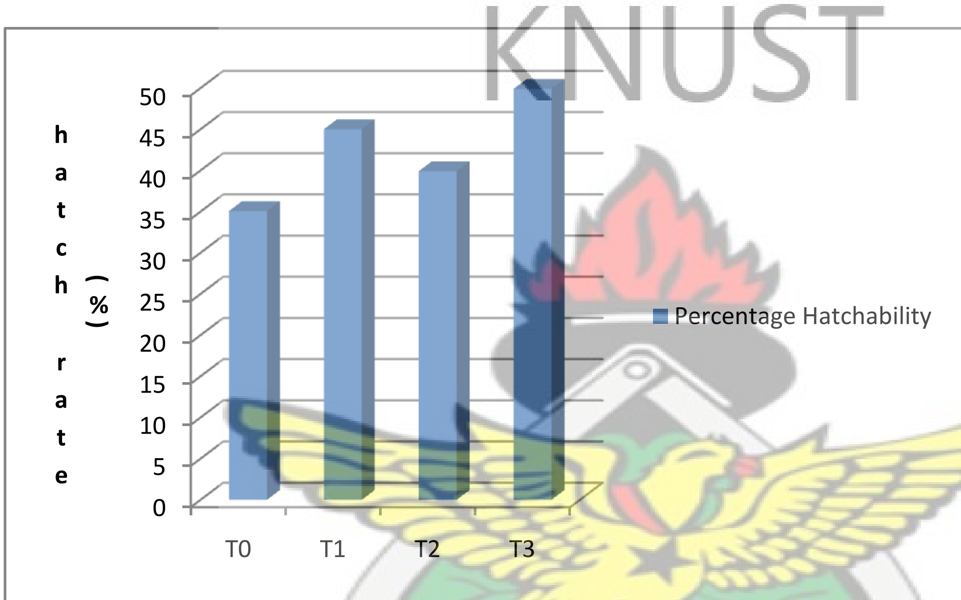


Figure 2 shows the graphical representation of egg weight during the first eight weeks of egg production. It is apparent that egg weight increased with age in all the dietary treatments. This is expected with egg production, that the oviduct becomes bigger and more efficient with age and this result in a corresponding increase in egg production.

Table 20: Hatchability of the guinea fowls eggs.

Treatments/ Parameters	T_0	T_1	T_2	T_3
Percentage Hatchability	35.07	45.00	39. 90	49.90

Figure 3: Hatchability values of the guinea fowl during laying period



Hatchability values recorded in this study are quite poor if compared to what were obtained by other researchers including Ayorinde (2004), Saina (2005), Binali and Kanengoni (1998) and others. The poor hatchability values from this study could be associated with handling of the eggs prior to hatching. Eggs transportation could have exposed the embryo to shocks which in turn destroyed embryonic developments. Though these values were low, Chrysostome (1993) obtained the hatchability values of 48% or higher with eggs from farmers, against 35% when eggs were purchased in the market. Other reasons possibly responsible for this low values were the time of the season the eggs were laid. In village areas, Ayeni and Ayanda (1982) obtained values as low as 16.4% during the wet season. Moreover, egg hatchability was lower at the beginning and at the end of the breeding period. Dahouda *et al*. (2007) stated that peak hatchability was reached in June and July. Higher fertility and hatchability values were also observed in June by Chrysostome (1993). The relative egg sizes also are related to hatchability values. According to Nwagu (1997), the main factors affecting hatchability are egg size, shell quality and variation in the brooding temperature. T_3 birds recorded the best hatchability values.

Table 21: Mean weights of some carcass parameters.

Treatments/ Parameters	T_0	T_1	T_2	T_3	LSD	SEM
Live Body Weight (g)	1174.00	1230.00	1268.00	1266.00	137.80	**42.20**
Bled Weight (g)	1136.00	1187.00	1232.00	1231.00	131.20	**40.20**
Defeathered Weight (g)	1029.00	1092.00	1131.00	1141.00	135.70	**41.60**
Dressed Weight (g)	890.00	913.00	934.00	972.00	82.50	**35.80**
Head (g)	31.50	31.50	31.27	31.83	4.08	**1.21**
Crop (g)	4.83^{c}	13.67^{a}	7.00^{b}	6.50^{bc}	2.09	**0.64**
Empty Gizzard Weight (g)	26.80	31.70	37.20	26.50	13.72	**4.21**
Heart Weight (g)	5.50	5.50	4.83	5.67	1.02	**0.31**
Liver Weight (g)	18.83	19.17	19.17	19.50	0.94	**0.30**
Oviduct Weight (g)	23.67	22.67	25.00	24.83	3.94	**1.21**
Total Intestine Weight (g)	40.33^{a}	40.67^{a}	43.50^{a}	37.17^{b}	5.03	**1.54**
Legs (g)	29.17	28.00	27.67	28.83	2.05	**0.63**

$^{a-c}$ values within the same row followed by different superscripts differ significantly (P<0.05).

Birds fed diet containing 17% crude protein recorded the highest live body weight although this did not differ (P>0.05) statistically from all other treatments. The live and dressed body weights recorded in this study are above what has been reported by Teye *et al*. (2001).

Body weight in poultry is known to be moderately to highly heritable. The high body weights recorded in this study may suggest that the hens could potentially lay larger and heavier eggs if they are given more time. The younger the bird after the attainment of puberty, the smaller the relative size of egg as compared to an older bird. Heavier dressed body weights coupled with the high body weight may demonstrate their potential use as dual purpose birds.

A similar observation was made for bled, defeathered and dressed body weights. The various dietary protein levels did not have much influence on the weights of birds and this agrees with the finding of Oke *et al*. (2003). The non-existence of differences among the treatments with respect to bled weight is supported by a suggestion by Teye *et al*. (2001) who indicated that even breed does not influence the amount of blood that oozes out from birds.

The study also suggests that although the birds were fed on different crude protein levels, feather development and feather masses were not affected by different diets.

The heart weight recorded for birds fed diets of crude protein levels 15%, 16%, 17% and 18% were 5.50 g, 5.50 g, 4.83 g and 5.67 g respectively, where the differences among them were not significant (P>0.05). This however, does not agree with what Adeyemo and Oyejola (2004) reported when they fed poultry droppings containing 0%, 20%, 40% and 60% inclusion levels and obtained 3.87, 3.63, 3.55 and 3.33 respectively for heart weight/ kg live weight.

Head weights recorded by various treatments are shown in Table 21 where no significant difference was observed among them. Teye *et al*. (2001) recorded heavier head (50.0 ±12) weights than what has been recorded in this study. The weights also contradict what Teye *et al*. (2004) reported among female broiler chickens in Ghana when they compared the male and female broiler chickens. They reported that the male broiler chicken had significantly ($P<0.05$) heavier head weight than the latter.

Empty gizzard weighed 26.8 g, 31.7 g, 37.2 g and 26.5 g for T_0, T_1, T_2 and T_3 respectively, where there were no significant ($P>0.05$) differences among the treatments. Teye *et al*. (2001) found significant differences in empty gizzard weights between exotic and indigenous breeds of guinea fowls. They attributed the significant differences to the different genetic backgrounds of the strains. The similar gizzard weights recorded in this study may indicate that there exist no differences between birds of similar strains.

The different levels of crude protein used in the experiment had significant influence on the weight of the crops. T_1 had significantly ($P<0.05$) greater crop weight as compared to the other treatments. T_2 differed significantly ($P<0.05$) from T_0 but the difference between T_2 and T_3 were however, not significantly ($P>0.05$) different. The higher crop weight recorded by T_1 may be due to the proper development of the crop.

With reference to liver weight, there were no recorded significant differences.

T_0, T_1, T_2 and T_3 recorded oviduct weights of 23.67 g, 22.67 g, 25.00 g, 24.83 g respectively, but the differences were not statistically ($P>0.05$) significant. The oviduct of the guinea fowl is smaller than that of the domestic fowl and weighs 18- 35 g compared to 40- 60 g in the chicken (Ayorinde, 2004). The results of this study fall within this range.

Protein forms the structure of organs and tissues. Adequate protein in diet if properly utilized will more likely lead to more deposition of protein in tissues and organs that increase weight (Oduguwa *et al*. 2000).

Table 22: Mean blood values and profiles of the laying guinea fowl.

Treatment/ Parameters	T_0	T_1	T_2	T_3	LSD	SEM
Albumin (g/l)	17.67	17.78	17.10	16.78	2.75	0.84
Globulin (g/l)	20.42	17.82	19.85	18.03	4.90	1.50
TotalCholesterol (mmol/l)	3.27^{a}	2.90^{b}	3.08^{ab}	2.80^{b}	0.32	0.10
Total Protein (g/l)	38.10	35.60	36.90	35.60	7.23	2.22
Hematocrit (HCT) (%)	31.90	29.35	32.20	30.40	4.30	1.30
HGB (g/dL)	15.06	13.58	14.57	14.18	2.16	0.66
RBC ($\times 10^{12}$/l)	2.21	2.02	2.15	2.06	0.24	0.07
WBC ($\times 10^{9}$/l)	154.60	150.20	152.00	155.20	15.46	4.74

$^{a-b}$ values within the same row followed by different superscripts differ significantly ($P<0.05$).

Mean blood profile of indigenous pearl guinea fowl layers fed various levels of protein at ages 28- 36 weeks of age is shown in Table 22.

Albumin, globulin, total protein, hematocrit (HCT), haemoglobin, red blood cell and white blood cell contents showed no significant ($P>0.05$) differences among diets. Of the eight blood components evaluated in this study, globulin, total protein, total cholesterol, haemoglobin and red blood cell levels were optimized by 15% crude protein (T_0). Albumin was maximized at 16% crude protein (T_1), HCT at 17% crude protein (T_2) and white blood cell at 18% crude protein (T_3).

Serum globulin, serum total protein, serum haemoglobin and red blood cell were all recorded as the highest for the least crude protein (15%) level and the second highest egg production.

Total cholesterol levels recorded significant ($P<0.05$) differences between birds fed T_0 and T_1 and also between T_0 and T_3 though T_1 and T_3 were not significantly ($P>0.05$) different from each other. There were no significant ($P>0.05$) differences between T_1 and T_2, T_1 and T_3 and T_2 and

T_3. Apart from T_3 which recorded the least cholesterol level but had the highest egg production, all other treatments followed a consistent trend; T_0 had the highest cholesterol level and the second highest egg production, T_2 recorded the second highest cholesterol level and the third highest egg production, with T_1 the third highest cholesterol with the least egg production. Griffin *et a*l. (1984) observed a cholesterol level of 3.8 for laying birds which is quite close to what was obtained in this study.

This study suggests that moderately high values of cholesterol in diets are associated with higher egg production.

The least cholesterol level recorded in this study was associated with the highest egg production. This agrees with Oke *et al*., (2003), that due to increase in the demand of cholesterol for the egg laying process, high egg laying birds have lower levels of cholesterol. This suggests that a basal level is required for egg formation.

Table 23: Mortality of laying guinea fowls fed varying levels of protein

Treatments/ Parameter	T_0	T_1	T_2	T_3	LSD	SEM
Mortality (%)	10.00	3.30	6.70	0.00	7.69	-

*P<0.05

Different levels of protein did not result in any significant (P>0.05) differences among treatments in terms of mortality. With the nutritional aspect of management taken care of, other factors that may predispose guinea fowls to disease conditions are other management practices. This may mean that, under good management and nutrition, guinea fowls will do well under confinement without any serious incidence of diseases, all things being equal. The low mortality records may also probably be because guinea fowls in confinement may be able to withstand diseases which are important to birds under confined condition.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

Different dietary protein levels for the growing phase (9- 27 weeks old) did not affect (P>0.05) parameters like average feed intake, average daily gain, mortality, weight of first egg, weight at first egg, age at first egg, blood parameters like, albumin, globulin, total cholesterol, total protein, red and white blood cell values.

Though not significantly different, guinea fowl growers raised on 16% CP levels had better feed intake levels and consequently attained sexual maturity faster. It is therefore concluded that 16% CP should be adopted as crude protein requirement for growing indigenous guinea fowls in the tropical climates during 9- 27 weeks of age for optimum growth. This will save cost, since the higher protein levels are associated with higher production costs.

Results from the laying study, show that guinea fowls did not exhibit any significant (P>0.05) differences per the different levels of protein they were fed with. Average feed intake and body weight, mortality, egg weight, live body weight, bled body weight, defeathered weight, dressed weight, head and leg weights, some internal organs like the heart, liver, oviduct and empty gizzard weights, blood parameters like, albumin, globulin, total protein, hematocrit, haemoglobin, red and white blood cell values were all not different.

Though not significantly different, guinea fowl layers on diets containing 18% CP performed better than those on diets containing 15, 16 and 17% CP. It is therefore concluded that 18% CP should be adopted as crude protein requirement for laying indigenous guinea fowls in the tropical climates during 28- 36 weeks of age for achievement of optimum egg production.

From the study of the protein requirements of growing and laying indigenous guinea fowls (*Numida meleagris*) in the humid tropical zone of Ghana, it is recommended that diets containing 16% CP for growing guinea fowls and 18% CP for laying guinea fowls are ideal for optimum growth performance and production.

Some general recommendations to future areas of study on the indigenous guinea fowl are as follows:

a. Nutrition as a single factor may not completely improve the reproductive and general performance of the indigenous guinea fowl. It is recommended that genetic improvements such as selection for and manipulation of particular qualities and traits of preferred birds be done along with the nutritional adjustments to bring possible improvement.

b. Another area of possible improvement is to investigate the kind of influence the presence of males have on the laying performance of the guinea fowl hens.

c. Also, qualitative and quantitative manipulation of light to bring about reproductive responses in the guinea fowl has not been properly investigated. It is therefore recommended that manipulation of light in terms of restriction of light, eight (8) hours light and sixteen (16) hours light comparison on egg production and attainment of sexual maturity be experimented.

d. Another area of interest which could be investigated to help in the indigenous guinea fowl improvement is the behaviour of caged guinea fowls. This would help know and identify particular and specific behaviour patterns of our indigenous guinea fowls and not assume their behaviours according to other birds from other countries.

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