UNIVERSITY FOR DEVELOPMENT STUDIES

GROWTH PERFORMANCE AND SURVIVABILITY OF GUINEA FOWLS (*Numida meleagris*) RAISED THROUGH THE SUPPLY OF YOUNG GUINEA FOWLS AND EGGS TO FARMERS IN NADOWLI DISTRICT OF UPPER WEST REGION

DADA YARO

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BY

DADA YARO (B.Sc. AGRICULTURE TECHNOLOGY)

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MARCH, 2016

DECLARATION

Student

I, Dada Yaro hereby declare that this thesis is the original work of my own research outcome and that no part of it has been submitted for another degree elsewhere. However, all sources of information from other authors and researchers in this work have been duly cited and acknowledged.

Candidate's Signature: .... Date: 22/03/2016

Name: Dada Yaro

Supervisors

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

Principal Supervisor's Signature: .... Date: 22/3/16

Name: Prof. Herbert K. Dei

Co-Supervisor's Signature:............................ Date: 22-03-16

Name: Dr. Richard W. N. Yehoah

ABSTRACT

The traditional method of brooding and rearing of Guinea fowls poses a threat to the sustainability of Guinea fowl production in Ghana. An on-farm experiment was conducted in five communities (Goli, Goriyiri, Papu, Gyilli and Nato-Douri) in the Nadowli District of Upper West Region of Ghana to determine the growth performance and survivability of Guinea fowls through supply of young Guinea fowls and eggs. In all, 50 farmers were selected for the study. A Randomized Complete Block Design with a community as a block was used. Two hundred 9 weeks old (T_9) and Two hundred 12 weeks old (T_{12}) young Guinea fowls were assigned to 10 farmers each in Goli and Goriyiri communities with each receiving 20 Guinea keets. Seven hundred and fifty (750) Guinea fowl eggs were assigned to the selected farmers with each receiving 15 eggs. Out of this, two hundred and thirty-three (233) Guinea keets were hatched representing 31.1% and brooded at the farmer level of which one hundred and twenty-seven (127) keets survived representing 54.5% (T_0). The semi-intensive system of production was used by the farmers. The control birds recorded significantly lower ($P<0.05$) growth performance than their counterparts in T_9 and T_{12}. The control birds recorded significantly higher ($P<0.05$) mortality (32.3%) than their counterparts in T_9 (25.5%) and T_{12} (24.5%). It was more economical to raise Guinea keets intensively up to 9 or 12 weeks of age (67.3 and 53.4%) before rearing under the semi-intensive system of production. Based on the results of this study, it can be concluded that the birds raised under the artificial brooding system performed better than those raised under the natural brooding system.

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DEDICATION

This thesis is dedicated to my lovely wife, Patience Atimbisa Apalibe and Professor Herbert Kwabla Dei.

LIST OF ACRONYMS

ADG	Average daily gain
BDG	Brewer's dried grain
BW	Body weight
C_e	Cost of eggs and keets
C_f	Cost of supplementary feeding
C_k	Cost of transportation of keets
C_l	Cost of labour
C_m	Cost of medication
CP	Cost price
CP	Crude protein
C_{te}	Cost of transportation of eggs
Dical. PO_4	Dicalcium per Phosphate
FAO	Food and Agriculture Organization
FCE	Feed Conversion Efficiency
FCR	Feed Conversion Ratio
FI	Feed Intake
GM	Gross Margin
ME	Metabolizable Energy
MoFA	Ministry of Food and Agriculture
SNC	Shea Nut Cake
TC	Total Cost
TR	Total Revenue
USDA	United States Department of Agriculture

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CHAPTER ONE

1.0 INTRODUCTION

Rural poultry, particularly domestic chicken (*Gallus domesticus*) and Guinea fowl (*Numida meleagris*), play a very important role in the supply of poultry meat and eggs in most parts of Ghana (Teye and Gyawu, 2002). It is an integral part of farming systems in Ghana, especially, in the rural areas of the three northern regions (Karbo and Bruce, 2002; Dei and Karbo, 2004).

They are regular source of income for meeting household needs including food for the farm family, particularly during the dry season (Karbo and Bruce, 2000; Jacob *et al.*, 2011). They are also given as gifts, used for sacrifices, naming and marriage ceremonies (Sonaiya *et al.,* 1999; Dei and Karbo, 2004). They play a role in nutrients recycling through the provision of manure which enhances soil fertility for good yield of crops (Teye and Gyawu, 2002). Guinea fowl production makes a significant contribution to animal protein availability through cheap meat and eggs which serve as buffer to shortages of poultry products (Obike *et al.,* 2011).

The Guinea fowl is one of the main species of poultry found in almost every household in the three northern regions of Ghana (Dei and Karbo, 2004). However, guinea fowl production is faced with many challenges. These include poor fertility and hatchability of eggs, high mortality of keets due to pests and diseases infestation, poor growth rates due to poor nutrition, theft and predation of eggs and birds, and poor management practices under the extensive system which is the main system practiced in the three northern regions in Ghana (Teye and Adam, 2000).

Any attempt to intensify Guinea fowl production in Northern Ghana must address these challenges. So far, some improvements have been made through improved housing (Teye *et al*., 2001a; Dei *et al*., 2009), feeding (Teye *et al*., 2003, Dei *et al*., 2009 and Dei *et al*., 2015) health-care (Teye and Gyawu, 2002) and management (Teye *et al*., 2001a). It is envisaged that further improvements in Guinea fowl production can be obtained if farmers are spared losses associated with hatching of eggs and brooding of keets. These are the two critical stages in the Guinea fowl value chain in Ghana. Therefore, this study sought to determine the effects on growth and mortality of Guinea fowls when keets were hatched by farmers or supplied to farmers at 9 and 12 weeks of age for rearing under semi-intensive system.

The study was undertaken at the Upper West Region particularly in the Nadowli District because farmers in those areas met the criteria for the selection. For example, there were having chickens that were ready to brood.

1.1 RESEARCH OBJECTIVES

1. To determine the growth performance and survivability of Guinea fowl when hatched by farmers or supplied to farmers at 9 and 12 weeks of age.

2. To compare growth performance and survivability of Guinea fowls supplied to farmers at 9 and 12 weeks of age.

3. To determine the economics of production of Guinea fowls under the semi-intensive system of production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin of Guinea fowl

The Guinea fowl is one of the lesser known poultry species (Parkhurst and Mountney, 1998) 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. Historical records indicate that the Guinea fowl derives its name from the Guinea Coast of West Africa (Teye and Gyawu, 2002; Dei and Karbo, 2004; Jacob and Pescatore, 2011) where today some still remain in the wild (Dei and Karbo, 2004). 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 (Bell and Smith, 2003; Dei and Karbo, 2004).

2.2 Guinea fowl types/ varieties

Guinea fowl has been classified into four genera (*Agelastes, Numida, Guttera and Acryllium*), six species and sixteen subspecies (Ayorinde, 2004).

Guinea fowl genera and species are presented in taxonomic order in Table 1.

Table 1: List of guinea fowl species in taxonomic order

Genus	Species	Description
Agelastes	*Agelastes meleagrides*	White breasted Guinea fowl
	Agelastes niger	Black breasted Guinea fowl
Numida	*Numida meleagris*	Helmeted Guinea fowl
Guttera	*Guttera plumefera*	Plumed Guinea fowl
	Guttera pucherani	Crested Guinea fowl
Acryillium	*Acryillium vulturinum*	Vulturine Guinea fowl

Source: Annor *et al.* (2012)

Many varieties of Guinea fowls are found in West, South and Central Africa (Nwagu and Alawa, 1995; Dondofema, 2000; Smith, 2000; Saina, 2001). 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 (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 (Jacob and Pescatore, 2011).

Darre (2007) and Annor *et al.* (2012), also reported that, there are three principal varieties of domesticated Guinea fowls, thus the pearl, white and lavender. There are several other species of Guinea fowl in the family *Numididae*, including the Vulturine Guinea *(Acryllium vulturinum)* and the Crested Guineas *(Guttera* spp.).

The pearl Guinea fowl (Plate 1), one variety or subspecies of the helmeted guinea fowl, is the best known of the Guinea fowl 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 Indians and Southern France (Martinez, 1994). The helmeted Guinea fowl is classified as *Numida meleagris*. 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 which can measure 40-71 cm in length, and weighs 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. The body plumage is grey-black spangled with white or has purplish-grey 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. 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).

Plate 1: Pearl Guinea fowls in a deep litter house (Adjetey, 2006)

The white guinea fowl (Plate 2) has pure-white feathers and its skin is lighter than the other varieties (Ayorinde, 2004). 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 Guinea fowl is one example of the two sub-species of the helmeted Guinea fowl.

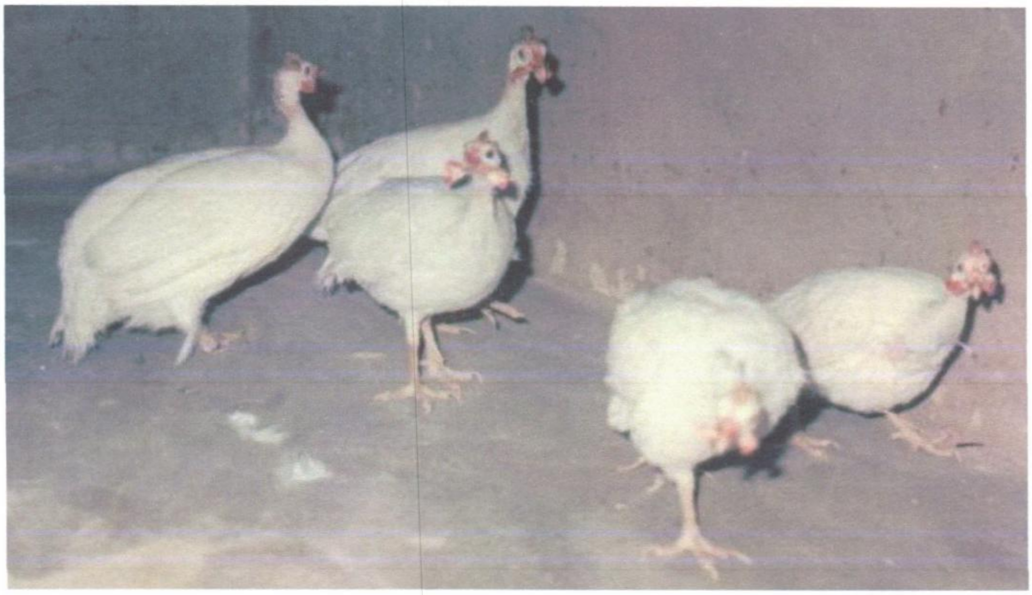

Plate 2: White Guinea fowls in a deep litter house (Ayorinde, 2004)

The black Guinea fowl (Plate 3) inhabits primarily unspoiled rainforests. They live in groups of 15-20 and roost on 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 (Ayorinde, 2004).

Plate 3: A black Guinea hen (Ayorinde, 2004)

The lavender Guinea fowls (Plate 4) 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 grey or lavender dotted with white (Darre, 2007).

Plate 4: Lavender or ash Guinea fowls in a deep litter house (Ayorinde, 2004)

2.3 Importance of Guinea fowl

Guinea fowls (*Numida meleagris*) are 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 over the domestic chicken. It is useful, ornamental and interesting during life and a desirable addition to the table, if properly prepared (Headley, 2003). The shell of Guinea fowl egg is thicker and less porous with better keeping quality than chicken's egg (Karbo *et al*., 2001;

Teye and Gyawu, 2002; Apiiga, 2004; Dei and Karbo, 2004).

2.3.1 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 about 80% edible meat as compared with 65% for chicken (Koney, 1993). The meat of a young Guinea fowl is tender and of special fine flavour, and therefore has been substituted for game birds such as partridge, quail and pheasant (Feltwell, 1992; Platt, 1997). 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. The meat is lean and rich in essential fatty acids (Moynihan, 2005; Darre, 2007 and Moreki *et al.*, 2010). The meat of Guinea fowl is lean containing 4% fat as against 7% for chickens as well as higher protein content of 23% against 21% of the chicken (Moreki *et al.*, 2010) and its flesh is tastier and firmer than that of chicken (Koney, 1993). The chemical composition of the carcass of the intensively raised Guinea fowls (Table 2) 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, 1991).

Table 2: Composition of fresh Guinea fowl meat

Component	Content (%)	mg/kg
		-
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	-	10.5-11.6

Source: Ayorinde (1991)

2.3.2 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 are insects, they have gained popularity for use in reducing insect populations in gardens and around the home (Darre, 2007). They are reported to be a good tick eaters and have been used in parks and public areas for this reason (Amberg, 2009). Guinea fowls have been used to reduce the deer tick population, associated with Lyme disease (Duffy *et al.*, 1992; Darre, 2007).

2.3.3 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).

2.3.4 Security

On small farms and in some large chicken farms, Guinea fowls act as alarms, raising a clamor in the presence of predators (Darre, 2007), no strange person or noise escapes them, and then their loud cracking is not only effectual, but calculated of itself to frighten off any evilly disposed marauder (Headley, 2003). Both males and females Guinea fowls 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 anything 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).

2.3.5 Profitability of poultry production

Poultry production is noted to be a big business throughout the world (Mahama *et al.,* 2003). Unfortunately this industry in Ghana started to decline from 1981 when prices of inputs of production began to shoot up and many farmers could not afford the cost of production. However, by 1987, production of poultry had picked up again as a result of increased demand due to increase in population (Tachie-Menson, 1992).

Reports by Mahama *et al*. (2003) revealed that the poultry industry including the Guinea fowl industry is a highly competitive and lucrative industry in the developed countries and becoming so in the less developed countries. Karbo and Avornyo (2006) reported similar findings for guinea fowl production in Northern region of Ghana.

Berkoh (1998) noted that the prospects of Guinea fowl production in the Northern Ghana are bright because it can be raised more cheaply than chicken. Similarly, Koney (2004) reported that, expenditure on local birds is generally minimal and in most cases no expenditure is made. This could be due to the type of the system of production used (semi-intensive system).

Bonkoungou (2005) also reported that little equipment is used in Guinea fowl farming. In many rural farms, the use of local drinkers made with local materials such as broken clay pots, wood and empty tins, are observed and equipment if existed was used for all poultry species (Bessin *et al.,* 1998; Kondombo *et al.,* 2003).

A report by Yakubu and Baba (1999) indicated that Guinea fowl contributed between 104 and 156 Ghana Cedis as income annually to rural household in northern Ghana. Studies indicate that integrating Guinea fowl business with other enterprises makes it more profitable, viable as well as less risky (Karbo and Avornyo, 2006). It may even be more profitable to the rural farmer who practices mixed farming because manure from the Guinea fowl can be applied on crop farm. Quartey (1992) has indicated that poultry offal can be processed into feed or serve as manure. It is claimed that about 800 cubic feet of poultry manure can be produced in deep litter by 500 layers in a period of one year (Quartey, 1992). There are hardly any cultural barriers against consumption of Guinea fowl products (Saina *et al.,* 2005).

There is good demand for Guinea fowls and are therefore served extensively in large hotels and higher priced restaurants (Feltwell, 1992; Platt, 1997). There has been increasing demand for guinea fowl (Darre, 2007) especially in the dry season and festive periods (Ibrahim, 2008). The meat is well patronized in southern Ghana (especially Kumasi and Accra) and fetches a lot of income for those who trade in it (Apiiga, 2004, Naazie *et al.*, 2007a).

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 are 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).

2.4 Guinea fowl production

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). The Guinea fowl has proven to be adaptable wherever it has been taken to ranging from the tropics to the Siberia although its natural habitat is woodland savannah with ground level cover for its nest and trees for roosting at night (Biswas, 1999). Guinea fowls are reared on commercial basis in India, Belgium, France, Italy and South Africa (Robinson, 2000; Embury, 2001; Champagne, 2003). However, in West Africa where the Guinea fowl originates, it is still raised on small scale basis under the traditional system of management with a local chicken hen or a guinea hen brooding on the eggs to hatch and taking care of the keets (Dondofema, 2000; Smith, 2000; Saina, 2001; Dougnon *et al.,* 2012). Plates 5 and 6 show a typical Guinea fowl nests and Guinea fowl hen and its keets.

Plate 5: Typical Guinea fowl nests

Plate 6: Typical Guinea fowl hen and its keets

It is an integral part of the rural family system providing a sustainable family income for small, marginal and landless farmers (Annor *et al*., 2012). Authors such as Teye *et al*. (2001a), Teye and Gyawu (2002), Apiiga (2004) and Adjetey (2006) reported that, the 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*., 2007b), 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). Apiiga (2004) stated that the guinea fowl is an important bird in the Upper East region. However, the number in each household ranges from 5 to 200 birds with an average of about 20 (Apiiga, 2004). 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*., 2007b). 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 (Teye and Adam, 2000; Dei and Karbo, 2004). 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 the local chicken, ducks and turkeys (Apiiga, 2007; Dahouda *et al.,* 2008). Fertile guinea fowl eggs are normally given to the domestic chicken 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 takes between 26 to 28 days to hatch with the keets weighing about 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 is ready to lay and brood over new eggs (Adjetey, 2006).

The sub-humid tropical pearl guinea fowls are monogamous and seasonal breeders (Nwagu and Alawa, 1995; Naazie *et al*., 2007b) and so there are periods within the year when their eggs are in 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*., 2007a). 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 with each egg weighing averagely between 37 to 40 g. Guinea fowl eggs are slightly smaller than chicken eggs but with thicker egg shells 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 such as scraps, worms, insects, seeds, leaves and fruits. 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 birds can lay between 150-220 eggs per year (Apiiga, 2004) and weigh about 1.1125 kg at 18 weeks (Teye *et al*., 2001a).

Guinea fowl farmers acquire their stock by purchasing the eggs from other farmers or from the market, the eggs are set for the local domestic fowl (hen) to incubate for a brooding period of about 28 – 30 days (Annor *et al*., 2012). The system of production of Guinea fowl in Ghana is mostly extensive (free-range) and in some cases, some farmers provide the birds with poorly ventilated accommodation during the night but in majority of cases, the birds roost on trees around houses (Karbo *et al*., 2002; Naazie *et al*., 2007b; Annor *et al*., 2012). Annor *et al*. (2012) reported that Guinea fowls are fed with a variety of supplementary feed such as grains (maize, millet and sorghum), termites and other agro-industrial by-products such as pito mash, corn chaff, rice bran, and left over feed from around the household in the mornings and evenings as a means of taming the birds so that they always return to the house.

Inbreeding is a major concern of Guinea fowl breeding in rural communities of Ghana as the birds are hatched together from the same parents and live together and interbreed among themselves; the consequence of this in most communities is reduction in growth rate and size of birds, poor reproductive performance, genetic defects and unexpected high mortality (Annor *et al*., 2012).

The productivity of the Ghanaian local Guinea fowl is far below that of the European breeds (Table 3). Annor *et al*. (2012) attributed the lower productivity of the indigenous breed of the Guinea fowl to the extensive production system with its accompanying poor feeding, poor health care and management in addition to the use of unimproved breeds of birds unlike in Europe, where within breed selection has been carried out over a long period of time and genetic improvement achieved in egg size, growth rate and body weight of the birds are reared intensively as shown in Table 3.

Table 3: Productivity of Ghanaian and European guinea fowls

Parameters	Productivity in Ghana	Productivity in Europe
Annual egg production	100	180
Laying period (week)	20	40
Egg size (g)	32	60
Fertility rate (%)	42	88
Hatchability (%)	45	83
Mortality (%)	40-100	3-4
6 weeks weight (g)	245	650
12 weeks weight (g)	500	1600
24 weeks weight (g)	1200	2500

Source: Annor *et al*. (2012)

2.4.1 Guinea fowl rearing systems

Several studies have shown that in most African countries Guinea fowl are reared mainly under extensive (free-range or traditional) and semi-intensive systems (Dahouda *et al*., 2007; Kusina *et al*., 2012). Moreki (2007) stated that the free-range system is the predominant rearing method common in Africa. Konlan and Avornyo (2013) in Ghana showed that 98% of farmers housed their Guinea fowl in the night and offered them few handfuls of grains and allowed them to scavenge the whole day. Free-range Guinea fowl constitutes an important resource for resource-poor farmers in developing countries. In Botswana, Guinea fowl are raised mainly under the intensive system (Moreki and Seabo, 2012) probably due to a requirement by government that domestic Guinea fowl should be confined to avoid mixing with the wild ecotypes. In the extensive system, birds depend mainly on scavenging with no or very little inputs committed resulting in low productivity. Additionally, housing is rudimentary, indicating that losses due to predation are high (Moreki and Radikara, 2013). Also, health management practices are based mainly on ethno veterinary medicine probably due to its availability in the villages (Moreki and Radikara, 2013). The belief that Guinea fowls are resistant to diseases could be a contributing factor to why farmers do not adopt preventative measures against diseases such as NCD, which devastates flocks (Moreki and Radikara, 2013).

Koney (2004) also reported that, there are three systems of rearing Guinea fowls namely, free-range, semi-intensive and intensive systems. Under the free-range system, 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 on trees or roofs. In the semi-intensive system there is minimum or a reasonable control of the birds (Koney, 2004). 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 (Koney, 2004).

2.4.2 Traditional knowledge of farmers in guinea fowl rearing

Guinea fowls are raised in the extensive system in northern Ghana. There exists a wealth of local knowledge on the production of Guinea fowl in northern Ghana. Such local knowledge take recognisance of the agro-ecological systems, climate and cosmovision influence (Karbo and Avornyo, 2006).

In Northern Ghana, after brooding, the birds are allowed to fend for themselves by scavenging. This is probably a norm in Guinea fowl management in West Africa. During the first weeks of brooding, the keets are fed with termites, supplemented with sorghum and millet grains.

In order to trap termites, cow dung is mixed with straw in an earth pot, dig a small hole in the termiterium and cover the hole with the pot and it would attract the termites to feed on the content in the pot, the pot is then opened in the following morning, usually early before the sun rises to prevent the termites from moving back.

Once brooding is completed, the Guinea keets may be fed with a little grain in the evening in order to attract them back home (Williamson and Payne, 1978).

Table 4 below provides some recorded indigenous knowledge practices in Guinea fowl production among farmers in Northern Ghana. Some of these will certainly require scientific validation. The weakness includes preparation of herbal medicines under unhygienic conditions and absence of standardization of concoction preparations.

Table 4: Indigenous knowledge in guinea fowl rearing in northern Ghana

Condition	Practice	Location/Source
Control of fowl lice	Herb "kinkima" (Frafra) or "Dunra" (Dagaari)	Yaroyeri near Langbensi
Worm infestation	Bark of mahogany and Dawadawa in water	Garu
Increase in egg production	Feed sorghum malt (kie-Frafra or kpie-Manpruli)	Yaroyeri near Langbensi
Enhance hatchability	Candling of set of eggs at two weeks using sun rays or flashlight. Testing eggs for rotational movement.	Garu, Savelugu
Sexing before hatch	Egg shape and size; male is "elongated oval" and female is "rounded oval"	Garu, Savelugu, Damango
Sexing at two weeks	The cry produced by keets during feeding	Zoggu, Savelugu-Nanton
Increase keet production	Adopt a foster mother that may be a brooding hen or a young cockerel	Northern Ghana
Loss of hen at advance stage of incubation	Put incubating egg in cotton or dawadawa seeds to hatch	Damango
To induce laying	Spray guinea fowls with water	Upper East Region
Fowl fox	Smear affected birds with palm oil	Northern Region
Egg fertility testing	Sound produced upon scratching the outer surface of the egg with the finger nail; loud sound means egg is infertile	Northern Region
Ill health	Provide honey in water	Garu

Source: Karbo and Avornyo (2006)

2.4.3 Distribution of guinea fowl in Ghana

The Ministry of Food and Agriculture studied the state of Ghana's genetic resources of the local poultry and reported that the local fowls are widely distributed throughout the country (LPIU, 2006).

The total number of Guinea fowl population was 2,093,625 in the three northern regions representing 81.4 percent of the national Guinea fowl population in Ghana (Table 5). It could safely be inferred that, northern Ghana represent a major investment potential for local poultry (chicken and Guinea fowl) in the country. The large number also goes to confirm the reviewed studies carried out in such a critical area of the Agricultural sub-sector that has reportedly been given little attention by policy makers, development agents and the local indigenes themselves (Panda, 1998).

Table 5: Regional distribution of Guinea fowl in Ghana

REGION	NUMBER OF GUINEA FOWL
Northern	1,414,649
Upper East	622,616
Upper West	56,360
Brong Ahafo	354,351
Volta	56,076
Ashanti	36,103
Eastern	11,881
Western	12,045
Greater Accra	5,447
Central	2,468
Total	2,571,996

Source: Veterinary Services Directorates (2010)

2.5 Problems of Guinea fowl production

Rural poultry keeping is well integrated into most rural farming systems with local breeds including the guinea fowl representing 40-70% of the national meat and egg supply in most tropical countries (Sonaiya, 1990). Due to their scavenging adaptability, production ability and low cost, the local breeds especially the Guinea fowl, are kept by rural smallholders, landless farmers and industrial labourers (Muchadeyi *et al.,* 2004). In spite of these inherent positive potentials and numerous benefits derived from the rural poultry industry, there are challenges that militate against the full expression of their potentials (Kıtalyi, 1998).

Some of these problems include feed and feeding (Buamah, 1992), inadequate funds (Alidu, 2003), diseases and health-care (Koney, 2004), predation and theft (Karbo *et al.*, 2002), poor management practices (Koney, 1993), unavailable improved breeding stock (Koney, 1993), heat stress (Smith, 1990) and irregular supply to eggs and day-old-keets.

2.5.1 Feeds and inadequate nutrition

Feed is the most important factor to be considered in poultry production. Feed cost alone accounts for about 70-80% of the total cost of production as reported by Ademola and Farinu (2006). Durunna *et al*. (1999) also reported that feed represents about 65-80% of poultry production. This agrees with the report by Dei and Karbo (2004) that, the major factor affecting poultry production is high cost of conventional feed inputs. High cost of feed is as a result of competition between human and animal for feed ingredients such as maize in Africa (Gopalakrishnan and

Lai, 1985), shortage of conventional feed ingredients (Buamah, 1992), importation of most conventional feeds such as yellow maize, fishmeal (Buamah, 1992) and the diversion of maize to the production of fuel (biogas) has brought about scarcity due to high demand with limited supply and hence high cost of the product (Chauynavong *et al.*, 2009).

Gono *et al.* (2013) reported that an inadequate feed supply is a challenge to Guinea fowl production. Inadequate feed supplies gives rise to poor growth rates, low egg production of Guinea fowl and elevated mortalities. Losses of birds are also attributable to starvation (Saina *et al.*, 2005).

Though feeding problems are gradually being solved in most livestock 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.* (2006a) 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) also added that there are no standardized nutrient requirements for Guinea fowls. Feeds provided to the birds are usually supplementary cereal grains such as millet, sorghum, maize, rice and agro-industrial by-products of these grains (pito-mash, corn chaff, rice bran) (Karbo *et al.*, 2002; Kusina *et al.*, 2012).

The day-old keets are also usually given termites with or without crush cereal grains as supplementary feed. These feed ingredients contains a lot of crude fibre except the termites and does not meet the nutritional requirements of the birds, hence result to poor growth performance as reported by Dei and Karbo (2004). It was confirmed by Dari (2004) that, feed is given in any form regardless of the nutritional composition or level, hence result to poor growth of birds.

The feed resource base for rural poultry (Guinea fowl) production is scavenging and consists of household waste, anything edible found in the immediate environment and small amounts of grain supplements provided by the women and children (Kitalyi, 1998; Boko *et al.*, 2011). A study by Tadelle and Ogle (1996) revealed that protein supply may be critical, particularly during drier months, whereas energy may be critical during the rainy season. This agrees with the findings of Cumming (1992) that the feed resource base of the village is very variable, depending on the season. Tadelle and Ogle (1996) concluded that supplementation of the diet of local birds with food sources containing energy, protein and calcium brought a considerable increase in egg production.

A work done by Sonaiya (1990) revealed the chemical composition of crop contents of local layer chicken. This crop contents consisted of 52.3% dry matter, 9.1% crude protein, 0.9% calcium, 0.7% phosphorus and 11.9 kJ/kg ME. These work confirmed that, farmers do not meet the nutritional requirement of birds which leads to low productivity.

Sonaiya *et al.* (2002) recommended that, to improve production, rural poultry farmers should feed their birds with supplementary ration compounded from locally available agro-industrial by-products twice a day with cool drinking water. They added that feed resource base for scavenging is limited and varies with seasonal circumstances such as rainfall, cultivation, harvest and crop processing.

2.5.2 Disease and Health-care

Diseases affect the poultry industry greatly in Ghana. It causes low productivity and profitability. Lony and Mopaté (1998) reported that, the health problems related to infectious diseases and parasites constitute a major bottleneck in the development of the rural poultry industry in Chad. Aini (1998) also observed that infectious diseases remain the biggest hindrance to the growth of rural poultry production in villages in South-East Asian countries. One of the major constraints of rural poultry production in Africa is undoubtedly the prevalence of various diseases (Guèye, 1998).

The problem of diseases in rural poultry is compounded by the interactions of different entities that are of significant importance to disease epidemiology (Jordan and Pattison, 1996). At the rural level, contacts between flocks of different households, the exchange of birds as gifts, sales and purchases are the main sources of infection transmission (Kitalyi, 1998), while noting that the critical management objective for free-range systems is to reduce the high mortality in both growing and adult age groups. Due to the scavenging nature of the local breeds of poultry, there is the likelihood of infection between other domestic fowls and wild birds.

Chrysostome *et al*. (1995) observed that, the local breeds like the guinea fowl have a reputation for hardiness and resistance to diseases. However, a review by Guèye (1998) and Mourad *et al.* (1997) revealed high mortality in rural flocks, ranging from 46 to 80% and diseases might have contributed highly to these mortality. Control of mortality is therefore important in the development and growth of the rural poultry industry especially the Guinea fowl.

Major diseases of poultry in Africa that have been predominantly identified are Newcastle, Infectious Bursal or Gumboro, Mareks, Mycoplasmosis and Coccidiosis (Adene, 1996; Boko *et al*., 2012). Other diseases that affect the rural poultry industry to a lesser extent (3% to 14%) are fowl pox, pullorum and fowl cholera (Atteh, 1989; Bonfoh, 1997; Mourad *et al*., 1997). In addition to the diseases mentioned, there is a high degree of internal and external parasites such as worms, lice, mites and ticks infestations (Koney, 1993).

Newcastle is a viral disease which occurs worldwide and is enzootic with several outbreaks which is a major problem in many countries (Allan *et al.,* 1978). Newcastle disease is one of the main causes of mortality (Guèye, 1998; Chrysostome *et al.,* 1995; Sonaiya *et al.,* 1999). A work done by Mourad *et al.* (1997) indicates that the Newcastle disease causes mortality in adult birds. The wild birds are a reservoir of NCD-virus (Guèye, 1998). Appiah (1993) reported that, the mortality rate due to Newcastle disease is as high as 100% and can be transmitted through activities such as transporting live birds, poultry products and manure from one farm to the other (Jordan and Pattison, 1996). Losses caused by Newcastle disease are highest in the cold dry season in West Africa (Sonaiya *et al*., 1999).

Guèye (1998) also reported that outbreaks of Newcastle disease occur generally during the dry season (January-June) in Senegal. Mourad *et al*. (1997) reported in a study that Newcastle outbreaks were observed at the beginning of the rainy seasons (May and June) and during the cold dry season (December, January and February). Alders *et al*. (1994) stated that the introduction of an effective vaccination against Newcastle disease should be the first step in assisting in the development of the rural poultry production.

Gumboro (Infectious Bursal Disease) is also a viral disease which usually affects birds of all ages. There is no treatment but birds can be vaccinated against the disease and its mortality can be as high as 25-30% (Koney, 1993).

Coccidiosis is caused by a protozoa and is prevalent under the intensive system because of the chance that birds can pick oocyst in excreta of infected ones (Smith, 1990).

The incidence of worm infestation exists with other conditions in poultry reared under the extensive or semi-intensive systems (Koney, 1993). Worms are everlasting burdens that weaken the birds (Veluw, 1987). A study on the incidence of worms in chicken farms in Nigeria found that the most common species were *Ascaridia galli*, *Prosthogonium spp*, *Strongyliods avium* and *Heterakis gallinarum* (Tona, 1995). A study on ectoparasites of domestic fowls in Nigeria showed that lice (*Menacanthus staminen*) were the major problem in rural poultry (Zaria *et al*., 1993).

Guéye (1998) indicated that, high mortality, especially in growers, constitutes the greatest constraints to the development of the rural poultry industry in Nigeria. Bessin *et al.* (1998) studied the causes of mortality in young guinea fowls in Burkina Faso and showed that mortality rates were as high as 80% in unimproved and traditional farms, with the highest mortality rate observed in August during the rainy season.

Appropriate measures such as vaccination against poultry diseases have been suggested by several authors (Card, 1961; Alders *et al.,* 1994; Nguyen *et al*., 1996). In West Africa, the months of June and December are the most strategic months to vaccinate poultry. These months were chosen to ensure that immunity is established before the outbreaks are most likely to occur (Alders *et al*., 1994).

2.5.3 Adverse environmental conditions

Rural poultry production depends on environmental conditions. A high mortality of birds is observed due to unfavourable environmental conditions in relation to housing, theft and predators. Guèye (1998), Sonaiya *et al*. (1999) and Kitalyi (1998) have reported on housing conditions for rural poultry and indicated that the birds may perch on high places, on verandas or shelter in human houses or kitchens. There are several traditional housing units available for the birds. These traditional poultry housing structures are small and have poor hygienic conditions. Often there is high infestation with external parasites (Kitalyi, 1998). In Mali, fowl houses were mostly small and constructed from sun-dried clay (Kuit *et al*., 1986). Predation and theft accounts for one of the greatest causes of loss of poultry and is a serious problem that is a setback to the rural poultry industry (Mohapatra, 2003). Snakes, hawks, cats and dogs also reduce the number of surviving chicks/keets (Karbo *et al*., 2002). Mohapatra (2003) reported that predation is ranked second highest after Newcastle disease. This mortality is rampant in birds on the free-range system.

Smith (1990) reported that the growth rate of poultry is affected in linear manner by ambient temperature range of 7 °C-21°C. The author further explained that, the growth and feed intake decrease as the environmental temperature rises over this range. When the temperature exceed this range both growth and feed intake are affected in a curvilinear manner resulting in a rapid increase in the time the bird takes to attain maturity. The gain/feed ratio is maximum in a range of 21-26°C (Smith, 1990). Climatic stress depresses appetite which affects production. When birds are exposed to heat most of the times causes their core ambient temperature to rise above their thermo-neutral zone which adversely affects the survival of birds (Bell and Weaver, 2002).

The use of flex-house (Weaver, 1996), wet feeding (Tindan, 2010; Dei and Bumbie, 2011) and provision of cool water or cool water mixed with recommended quantity of alcohol in time of high ambient temperature (Mohammed and Dei, 2010) could help reduce its adverse effect on growth performance of poultry.

2.5.4 Unavailable Improved Breeding Stock

Kitalyi (1998) reported that there is little information on the genetic make-up of the indigenous local breeds of Africa. Any meaningful stride in the rural poultry industry should also include improvement of breeding stock for major production.

Genetic materials or new breeding stock are obtained from the farmers which might not be readily available throughout the year (Koney, 1993). The most common method used in the productive performance of the local breeds is crossing them with exotic ones, and then leaving the hybrid offspring to natural selection (Kitalyi, 1998). Another method adopted is the use of hybrids under free-range rural conditions. This strategy sometimes leads to increased egg and meat production, but only when there is a corresponding improvement in nutrition and health hygiene. One problem encountered with the use of this strategy is that the use of exotic, high egg producing layers results in the elimination of broodiness in hens, due to the negative genetic correlation between high egg production and broodiness (Kitalyi, 1998). Any effort to improve on the gene pool of the local poultry must take into consideration the problem of local poultry breeding which is uncontrolled and indiscriminate. Under this, the male and the female poultry run together resulting in the hen producing chicks all year round. Although many strategies deemed appropriate for rural poultry production systems have been implemented, most have not succeeded due to a lack of management input to support the improved potential (Kitalyi, 1998).

Factors that have contributed to the failure of most rural poultry genetic improvement programmes in a number of African countries are operational and financial problems of state-owned farms or stations maintaining the parent stocks, inability to maintain higher management level of improved stock in the villages, lack of adequate extension support and poor or inadequate institutional and organizational support (Kaiser, 1990). The preference for meat from commercial poultry is low. Many traditional consumers complain of commercial poultry meat having less flavour and the texture being too soft, although higher price were paid for village-produced poultry meat and eggs. Thus, for any meaningful and sustainable breeding strategy, there is the need to maintain and improve local birds to meet this demand (Kitalyi, 1998), and also the strategy should focus on the genetic potentials of the indigenous breeds, especially, the Guinea fowl and the domestic chicken (Yalcin *et al*., 1997).

The poor management systems and environment that the birds are exposed to are also factors that militate against the full expression of the genetic potential of the crossbred birds (Barua and Howlider, 1990). Another constraint to local poultry breeding is the easy flow of genetic material as a result of extension of markets and economic globalization. This has resulted in the loss of local breeds through indiscriminate crossbreeding and dilution of gene pool of local genetic material (Tisdell, 2003).

There is also a problem of adaptability of exotic breeds under harse climatic conditions as reported by Cowan and Michie (1988). The exotic birds are more susceptible to heat and diseases compared to the local ones. When the exotic birds are exposed to high temperature and high humidity, they experience reduced feed intake and retarded growth rate which consequently lead to death (Kitalyi, 1998).

2.5.5 High keet mortality rate and irregular supply of day-old keets

One of the major problems that is of great worry to the Guinea fowl industry in Ghana is identified to be high keet mortality (Teye and Adam, 2000; Opoku, 2006) and absence of a source of quality day-old keets (Teye and Adam, 2000). Similarly, Dahouda *et al.* (2007) in Benin found keet mortality to be a major constraint in Guinea fowl rearing and estimated it to be 74%. Keets mortality is estimated to be 50% (Nwagu and Alawa, 1995; Bessin *et al.*, 1998) in Nigeria and 80-100% in Ghana (Adam, 1997; Teye and Gyawu, 2001; Karbo *et al.*, 2002). The major causes of high keets mortalities are exposure of keets to bad weather, poor feeding and worm infestation, diseases and parasites and poor management (Teye and Gyawu, 2001; Saina *et al.*, 2003a; Saina *et al.,* 2003b).

Mortality in keets is due to inadequate equipment (feeders and drinkers), environmental conditions (temperature), inadequate space and accidents (Idi *et al.*, 2001; Teye and Gyawu, 2002; Bonkoungou, 2005). They added that guinea keets will peck and ingest litter when space is inadequate. Other causes of death in keets are yolk sac infection and leg paralysis (Teye and Gyawu, 2002). Diseases associated with Guinea keets are relatively higher than in adult Guinea fowls (Downes, 1999). High mortality rate of keets is usually recorded in their first eight weeks of age (Karbo *et al.*, 2002; Bonkoungou, 2005; Osman, 2006). The most prevalent and serious disease are samonellosis, colibacillosis and pullorum (Teye and Gyawu, 2002; Moreki *et al.,* 2011). Also, aerial and terrestrial predators contribute to mortality (Chrysostome *et al.,* 1995; Sonaiya *et al.*, 1999).

Some hatcheries also contribute to the high mortalities of day-old keets through poor performance during hatching of the keets as well as low standard of hygiene (Appiah, 1993). Poor management of the hatcheries and feed mills results in the production of poor quality day-old-keets/chicks (Koney, 1993).

Teye and Gyawu (2002) therefore suggested that a good control of general hygiene is required throughout the growing period especially during the brooding phase. Vaccination and deworming schedules should also be strictly followed. Good sanitation, comfortable housing, proper feeding and general good management are the best preventive measures to keep the birds free of diseases (Dei and Karbo, 2004).

The Veterinary Services Department of Ghana should also put some measures in place to monitor activities of these hatcheries to forestall this problem (Koney, 1993). Table 6 below shows the pattern and causes of keet losses in Ghana.

Table 6: The pattern and causes of keet losses

Week	Disease	Predation	Missing	Bad wea	Unknown	Accident	Total
1-4	41	1	13	6	16	11	88
%	36.6	0.9	11.6	5.4	14.3	9.8	78.6
5-8	4	0	3	0	17	0	24
%	3.6	0	2.7	0	15.2	0	21.4
Total	45	1	16	6	33	11	-
%	40.2	0.9	14.3	5.4	29.5	8.9	100

Source: Dei and Karbo (2004)

An experiment conducted in Burkina Faso by Bonkoungou *el al*. (2005), revealed that management of Guinea keets at the rural level had influence on their general performance. It was observed that, the cumulative mortality was lower in the improved system than under the scavenging condition (Table 7). The mortality was about 34% in their first two weeks of age under the scavenging group while the improved system group had 9% mortality. The entire scavenging group died between the fifth and sixth week (100%) while improved system group had about 55% remained (Table 7). Table 7 shows the cumulative mortality (%) of guinea keets in two production systems.

Table 7: Cumulative mortality (%) of Guinea keets of two production systems

	Period (weeks)			
System	1-2	3-4	5-6	7-8
Improved	9	27	55	59
Scavenging	34	77	100	-

Source: Bonkounguo *et al.* (2005)

2.5.6 Poor management practices

Management practices such as feeding, watering, housing, health-care and general sanitation contributes very immensely to the productivity of rural poultry. However, management in the rural areas are very poor and so reduces productivity greatly (Osei and Dei, 1998). Management systems such as suitable housing, adequate quality feeding, provision of clean drinking water, maintaining high level of sanitation are carried out haphazardly in the rural set up, which leads to poor output (Koney, 1993; Dei and Karbo, 2004; Kusina *et al.,* 2012; Naandam and Issah, 2012).

Guinea fowls are medium sized gallinaceous birds from any of the genera *Agelasters, Numida, Guttera* and *Acryllium* (Butswat *et al*., 2001). Domestic Guinea fowl are nervous and noisy birds, and are therefore not widely raised commercially (Saina, 2001). Little information is available on how management practices impact the performance of caged Guinea fowl (Adefope *et al*., 2002). 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 are 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.

Majority of rural Guinea fowl farmers (80.6%) raise their birds on purely extensive system, with few of them (16.7%) practicing the semi-intensive system (Naazie *et al*., 2002) in the northern regions of Ghana. Under the extensive system, the birds are exposed to a lot of dangers that impede on their performance in terms of growth and laying. Housing (wooden coops or mud pens), if any, are provided only at night (Dankwa *et al*., 2000). Boko *et al*. (2011), also attested that, the scavenging farming system is the basis of Guinea fowl breeding with overnight housing in overcrowded coops and "natural" feeding/watering conditions. Boko *et al*. (2011) observed that the scavenging system is predisposed to the onset and spread of microbial and parasitic diseases. With the free-range system, houses for birds are improperly constructed. Houses are small in sizes, roofed with thatch, poorly ventilated, inadequate space with narrow entrance (Plate 7) causing overcrowding which leads to easily spread out of diseases in the houses (Boko *et al*., 2011; Kebede *et al*., 2012). In the view of Surges (1981), in building a house, its form, or beauty, or size will depend very much on the taste or wealth of the owner; but it should provide a healthful habitation for the birds. Farmers do not pay attention to sanitation measures such as cleaning of the coops, provision of clean water and clearing around the coops.

Plate 7: Traditional poultry mud house (Dei *et al.*, 2014)

Water is provided in locally made clay pot with small holes around which makes it difficult for young birds to reach and drink water (Plate 8). These pots are rarely washed due to the design. Therefore, a lot of dirt accumulates at the base of the pots. This could cause the spreading of disease very fast among the birds (Singer, 1976).

Plate 8: The locally made clay pot (Dei *et al.*, 2014)

Feeding of the birds are on supplementary basis. A handful of feed is usually thrown on the ground for the birds (Konlan and Avornyo, 2013). Feeding is done without taking into consideration of the age differences of the birds. The keets, young and the mature birds are fed together which leads to bullying of the young birds by the mature ones. The young birds do not get enough feed due this bullying attitude of the mature birds. The nutritional requirement of birds are not met by the farmers because, the kind of feed (cereal grains) given has high content of crude fibre (Dei and Karbo, 2004).

Health-care practices are poor at the rural level. Birds perceived to be sick are treated with either traditional herbs or orthodox drugs. The ethno-veterinary medicines used include leaves or barks of plants such as 'dawadawa', mango, mahogany, moringa and tobacco (Dei *et al.*, 2014). The orthodox medicines used by farmers include Amoxycillin, Ampicillin, Teramycin, Chlorophynide capsules and flagyl which used for treatment by majority of farmers. More so, these drugs are usually administered wrongly to the birds which turn to pose threat to the health of the birds (Dei *et al.*, 2014).

2.6 Attempts to address problems of Guinea fowl production

The possibilities of improving the productivity of the Guinea fowls are considerable and are being actively pursued in Ghana (Payne, 1990). Guinea fowls have a lot of potentials of enhancing the living standards of rural people. In view of these potentials of the Guinea fowl, a lot of experiments were being carried out in most parts of the world. Some of this experiments include:

2.6.1 Housing

An improved housing system for rural poultry was developed in Burkina Faso (Saunders, 1984). The house was a round compartment of three metres in diameter with two or more windows. In Zimbabwe, a run is attached to the poultry house and the term fowl-run in local poultry is commonly used (Kitalyi, 1998). In Ghana, a lot of experiments have been conducted towards addressing housing problem of Guinea fowls.

These experiments includes; raising Guinea fowls on the intensive housing system (Teye *et al*., 2001a, and 2001b; Adjetey, 2006; Dei *et al*., 2009; Dei *et al*., 2010; Agbolosu *et al*., 2012a and 2012b; Adjetey *et al*., 2014). Although, these experiments were not conducted purposively on housing, the housing system used in conducting the experiments had a positive impact on the results obtained by this authors.

2.6.2 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.,* 2006b). In an experiment to define the caging density of laying Guinea fowl, Nahashon *et al.* (2006b) concluded that laying Guinea fowls 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). The Department of Environmental, Food and Rural Affairs (2010) also recommends 2.5 kg live weight per m^2 for Guinea fowls. Table 8 shows stocking densities of Guinea fowls at different ages.

Table 8: Maximum stocking densities of Guinea fowls

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)

2.6.3 Feeding and watering of Guinea fowl

2.6.3.1 Feed and feeding of Guinea fowls

The nutrient requirements of the Guinea fowl have been assumed to be the same as that of the chicken (Koney, 1993) 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.*, 2007b). 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 crumble (Darre, 2007; Jacob and Pescatore, 2011).

It is recommended that they should be given only mash or crumbles instead of pelleted feed (Darre, 2007). In an attempt to solve the feed and feeding problems of the Guinea fowl, different levels of feeding trials were conducted at the different phases of growth in order to establish feeding standards for Guinea fowls. This include the brooding, growing and the laying phases (Teye *et al.*, 2001b; Teye *et al.*, 2003; Dei *et al.*, 2009). Also, works were done on non-conventional feedstuffs for feeding Guinea fowls in order to minimize the cost of feeding (Sadick, 2008; Mohammed, 2013; Dei *et al.*, 2015).

2.6.3.2 Feeding of guinea keets

USDA (1976) suggested that guinea keets could be fed much the same as turkey poults. Similarly, Smith (1990) suggested that Guinea keets can be raised on a broiler starter diet and at the same stocking density as broilers. Nsoso *et al.* (2006b) fed keets with commercial chick starter mash and had a good results.

USDA (1976) reported that Guinea keets require high protein which makes them grow faster. Dei and Karbo (2004) added 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 24-26% protein ration similar to turkey starter or game bird 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. 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.* (1975) 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 grey 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) suggested that 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, oyster shell, dicalcium phosphate, common salt, vitamins and mineral premixes (Teye and Gyawu, 2002).

A study undertaken by Abdul-Moomin (2010), to determine the effect of dietary protein on the growth performance of Guinea fowl during the brooding phase showed a slow growth pattern but had a positive effect on the survivability of the keets, thus mortality was generally low (7.58, 5.31, 5.78 and 6.06%) among all the four tested diets (22%, 23% 24% and 25% CP) respectively.

2.6.3.3 Feeding of grower guinea fowls

Guinea fowl have their highest protein requirements between 5 and 10 weeks of age (Sales and Du Preez, 1997). Oke *et al*. (2003) fed a grower diet containing 20.01% CP 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 observed that diet containing 16% CP and 2750 kcal/kg ME was 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% CP 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).

A work was done by Teye *et al.* (2001b), to determine a suitable protein level for grower phase II of exotic birds under the Guinea savanna climatic conditions. A diet containing three levels of crude protein (150, 160 and 170 g/kg) was used and was concluded that, 160 g/kg crude protein was adequate in the grower phase II diet for the exotic ISA ESSOR birds under the Guinea climatic conditions. A similar study was undertaken to determine the energy requirement of 8-week-old exotic ISA ESSOR Guinea fowl grower phase II in a hot Savanna climate (Teye *et al.*, 2003). Three levels of metabolisable energy (10.88, 11.30 and 11.72 MJ/kg with equal crude protein of 160 g/kg were fed to the birds. The study suggested that 10.88 MJ/kg dry matter ME should be recommended for the period 8-15 weeks of age for ISA ESSOR production in the hot Savanna climate.

Tindan (2010), studied the effect of wet feeding on growth performance of local Guinea fowl with diet formulated to contain 21% CP and 12.4 MJ/Kg metabolisable energy. The results indicated that, the birds fed on the wet diet ate slightly lower amount of feed compared to the birds on the dry feed but converted the feed (FCE) better which resulted in higher growth performance than the control birds.

Agbolosu *et al*. (2012a), studied the performance characteristics of growing indigenous Guinea fowls from Upper East, Upper West and Northern regions of Ghana. The Guinea fowls from a varying environment were fed with the same diet which contained 20% CP and 2800 Kcal/kg to determine growth performance as well as their survivability rates. From the study, birds from Upper East ate less but had better body weight, higher survival rate and performed averagely better in terms of egg production than those from Upper West and Northern regions. Although performance of birds from Northern region was not much different from those from Upper East, they performed slightly better in terms of feed intake and egg numbers. Birds from Upper West performed poorly and this was attributed to poor adoptation of the environment during the experimental period. Generally the performance traits of birds from the various regions varied and this can provide the basis for which they could be classified into varieties.

A work was done by Adjetey *et al*. (2014) to determine the protein requirements for growing indigenous Guinea fowls (*Numida meleagris*) in the Humid Tropical Zone of Ghana. The birds were fed with diets containing four different levels of CP (160, 180, 200 and 220 g/kg) with a common ME of 12.30 MJ/kg from 9-27 weeks of age. It was therefore concluded that 160 g/kg 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 could save cost, since the higher protein levels are associated with higher production costs.

2.6.3.4 Feeding of laying guinea fowls

The laying performance of Guinea fowls 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% CP 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 of guinea fowls fed layer (26-52 weeks of age) diet containing 17.5% crude protein and 2650 kcal/kg ME. The mature body weight when the highest egg production was obtained was 1274 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. Nahashon *et al.* (2006a) fed layers a 16.5% crude protein laying ration when they researched into the effect of cage density on the performance of laying Guinea hens.

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 on 14% CP and 12% CP dropped theirs at 166 and 175 days respectively. Considering other parameters they concluded that, it was most economical to produce a dozen eggs on the 16% crude protein diet.

2.6.3.5 The use of non-conventional feedstuff for feeding guinea fowls

Rhule *et al*. (2003) reported that the high cost and scarcity or seasonal variation of conventional feedstuffs such as maize and soya bean place a major constraint on the poultry industry. They added that as a result of competition between human and poultry for conventional feedstuffs, for example maize and fishmeal there is the need to focus attention on non-conventional feedstuffs such as copra cake, cocoa pod husk, palm kernel cake, false yam seeds and tubers, mango kernel, cereal grains and other alternative but equally good sources of feeding materials. Agro-industrial by-products (AIBPS) are reported to be cheap, readily available, as a source of fat soluble vitamin and not used for human consumption (Okai *et al*., 1984).

Hutagalung *et al.* (1977) indicated that AIBPS have been considered to be a worthy substitute with a considerable potential. They said one of such groups of AIBPS is the oil seed cakes such as palm kernel cake, copra cake and soybean cake and as a result of the comparatively high residue oil in such seeds, they have been reported to be a satisfactory and economic substitute for high energy as well as protein feedstuff.

Sumani (2001) conducted an experiment on sheanut cake (SNC) as a feed component for exotic Guinea fowl and indicated that the inclusion of 5% SNC in the diet of the Guinea fowl had no adverse effects on growth performance and that the inclusion of SNC at 5% also reduced the cost of feed.

Conventional feedstuff such as groundnut cake could be replaced with non-conventional feedstuff such as African locust beans (*Pakia filicodia*) (Oluyemi and Roberts, 1979) and melon seeds (Kekeocha, 1984). Traditionally, palm oil and palm oil slurry are used in the diets of poultry to supply vitamins A and D and reduce the dustiness of feed (Nelson, 1993).

Sadick (2008) conducted an experiment to determine the effect of baobab (*Adansonia digitata*) leaf meal (BLM) on the growth performance and mortality of Guinea fowls. The tested leaf meal was included up to 2% and did not had a negative effect on the growth performance and survivability of the birds. This indicates that baobab leaf meal is a potential non-conventional feedstuff for feeding Guinea fowl. A similar work was done by Zakaria, (2008) to determine the effect of baobab leaf meal (BLM) on egg lay, fertility and hatchability of Guinea fowl eggs. The leaf meal was included in the diets up to 2% but did not yield good result which suggests that the BLM is not suitable for feeding of Guinea fowls at the laying phase.

A boiled mango kernel meal (BMKM) was used as a non-conventional feedstuff in feeding indigenous Guinea fowls at varying levels of 0%, 10%, 15% and 20% to determine their growth rate (Amoah, 2012). This work indicated that, inclusion of the BMKM at 10% had no adverse effect on the growth performance of the Guinea fowls during the growing phase and was economical compared to the control diet. A similar work done by Iddrisu (2012), to determine the effect of BMKM (0%, 10%, 15% and 20%) on the carcass characteristics of indigenous Guinea fowls revealed that, inclusion of these products at 20% had no any negative effect on the carcass characteristics of the Guinea fowl meat as well as it sensory characteristics and could be used as a substitute for maize at 20% (Agbolosu *et al.*, 2014).

An experiment conducted at the Department of Animal Science, UDS, to determine the effect of Soaked False Yam (*Icacina oliviformis*) Seed meal (SFYSM) on the growth performance of local Guinea fowls at the varying levels of 0%, 5%, 10% and 15% as a substitute for maize yielded a positive result and did not have noticeable health effect on the birds (Bosomah, 2013). However, the SFYSM can be used as a non-conventional feedstuff for feeding Guinea fowls during the growing phase, replacing maize up to 15% (Bosomah, 2013). . Tumbulto, (2013) also worked on the effect of Boiled False Yam (*Icacina oliviformis*) Seed meal (BFYSM) on the growth performance of Guinea fowls at varying levels of 0%, 5%, 10% and 15%. The tested material was used as a substitute for maize at the various levels mentioned above. The results of this work was not different from that of Bosomah, (2013) indicating that the false yam seed is a potential non-conventional feedstuff for feeding Guinea fowls. Processing methods such as soaking and boiling of the seed removes or reduces its toxic substance that enhances its palatability (Dei *et al.*, 2015).

Mohammed (2013), used pito mash as a substitute for maize up to 20% to assess it effect on the growth performance of Guinea fowls. The work yielded a favourable result in terms of growth performance of the birds and was economical to use compared to the control diet. Kụbkomawa *et al.* (2013), completely replaced maize with Dried Cassava Alabo Meal (DCAM) in feeding Guinea fowls. The experiment was in two phases, starter and grower phases. The results indicated that feed intake of the control group was significantly higher than the DCAM group whereas the DCAM group recorded significantly heavier final body weights gain. The results of feed conversion ratio revealed that, the control group had significantly lower feed conversion ratio compared to the DCAM group at the starter stage. This could be due to the fact that, the tested diet (DCAM) might contained certain nutritional properties that were favourable to the keets which as well improved on their growth performance than the control diet (Kubkomawa, *et al.*, 2013). The results at the grower stage was not different from that of the starter stage. This confirmed that DCAM could replace maize up to 100% without any adverse effect on the growth performance of Guinea fowl (Kubkomawa, *et al.*, 2013). Also, the cost of producing the DCAM based diet was expensive compared to the control diet but due to the efficiency of utilization of the tested diet by the birds, it costs less to produce 1kg of Guinea fowl keet using DCAM (Kubkomaawa *et al.*, 2013).

Nobo *et al.* (2012) undertook a study to investigate the effect of feeding varying levels of Phane meal (*Imbrasia belina*) as a protein source on feed intake, body weight, average daily gain, feed conversion ratio and carcass characteristics of guinea fowl under the intensive system of production up to 13 weeks of age. Dietary inclusion levels of Phane meal were 4.5%, 9% and 13.5% while control diet contained 3% fishmeal. The results showed that feed intake (FI) increased significantly ($p<0.05$) with age. Dietary treatment did not affect FI. There was no significant difference for ADG among treatments, however, Guinea fowl fed control diet had higher ADG (0.0138±0.0003 kg) and lower FCR (3.83) than birds on 4.5% Phane diet which had FCR of 4.09. Body weight increased significantly ($p<0.05$)

with age. However, dietary treatment had no significant effect on BW at week 13 (slaughter age). Birds on control diet had significantly higher carcass dressed weight compared to other treatments. Female and male birds fed control diet had significantly higher dressing percentage (75.82±2.99 and 74.10±2.99%, respectively) compared to other treatments but dressing percentage of female and male birds on 4.5% Phane diet did not differ. These results suggested that Phane meal can be included in Guinea fowl diets up to 4.5% without affecting growth (Nobo *et al*., 2012).

2.6.3.6 Watering guinea fowls

Water is an essential component of poultry production in the humid tropics (Baffour-Awuah *et al*., 2005) and should be provided adequately to enhance its metabolic activities in birds. Watering must be adequate (Avornyo *et al*., 2007) and it should be ensured that Guinea fowls have access to cool clean water (Avornyo *et al*., 2007; 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). A study carried out at the Animal Science Department, UDS, to determine the effect of water restriction on the performance of Guinea fowl in the northern region of Ghana (Ansu, 2008) revealed that, water restriction had a negative effect on the growth performance of the birds. This implies that regular supply of clean water to Guinea fowls could go a long way in improving their body weight as well as enhancing their laying performance.

2.6.4 Health-care 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) (Karbo *et al.,* 2002; Nwagu and Alawa, 1995). 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. The losses can be prevented by improving the management practices at the farmer level. While in confinement, the keets need to be provided with the required space, warmth, lighting, feed, medication and water (Avornyo *et al*., 2007).

A work done by Teye *et al*. (2001a) and Dei *et al*. (2009) experienced a low mortality rate of day-old keets with the intensive brooding system. These authors recorded a mortality of 10.6 and 9.8% respectively and therefore attributed it to effective management practices under the artificial brooding system.

2.6.4.1 Guinea fowls medication

Avornyo *et al*. (2007) suggested the following as a means of reducing the high mortality rates in Guinea fowls. They are;

- Giving of 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).

Apiiga (2007) described some signs and symptoms of ill-health in Guinea fowls as

Apiiga (2007) described some signs and symptoms of ill-health in Guinea fowls as reduced or no appetite, dull plumage/ruffled plumage, pale and flat wattles/comb, dull face pigmentation, dry vent (small and round), diarrhoea, bad gait, difficulty in breathing, loss of weight and lagging behind contemporaries.

Apiiga (2007) also suggested that the 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:

- Vaccinate against Newcastle Disease (NCD) two weeks after the keets have been hatched.
- Use Coccidiostat (Powder type).
- Use antibiotics to prevent diarrhoea, salmonellosis etc.
- Prevent fowl pox and Gumboro disease by vaccination.
- For ectoparasites, use acaricides to prevent lice, mites and fleas (Apiiga, 2007).

In an experiment, Teye and Gyawu (2002) used these health management guide (Table 9) and had a reduced mortality in their work and thus recommended it for Guinea fowls producers.

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Table 9: 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)

2.6.5 Breeding of Guinea fowl

Most wild Guinea fowls 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 (Murton and Westwood, 1977). The sub-humid tropical pearl Guinea hens 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 hinders large-scale or commercial guinea fowl production (Aire *et al.*, 1979). Laate (1974) and Anamoh (1975) identified two breeding seasons in Ghana, the major season occurs during the rainy season between May-July and the minor season from October-December.

Most Guinea fowls start laying from the month of 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). Konlan *et al.* (2011) argued that Guinea hens (pearl) are capable of laying fertile eggs throughout the year when given adequate supplementary feeds with the provision of water *ad libitum*. Bell and Smith (2010) also reported that the Guinea fowl starts to lay in spring with increasing day light and continue to lay for about nine months and can be extended by using artificial lightening. In addition, in captivity, the laying period of Guinea fowls can be increased by increasing day length to between two to five hours in the dry season and providing plenty of water (Apiiga, 2007). Laying is sometimes interrupted during the breeding period for a few weeks when the daily photoperiod (day length) is shorter than 12 hours (Hien, 2002). It has been demonstrated that a short daily photoperiod of less than 12 hours has a negative influence on the laying rate (Bonkoungou, 2005). Ayorinde (1990) and Biswas (1999) indicated that the Guinea fowl starts to lay at the age of 7-8 months and may be delayed to a year in the wild. It appears that weather is the major controlling factor when it comes to Guinea fowl laying period (Maganga and Haule, 1994). The peak of laying season declines with the onset of the dry season (Kwari, 1984).

A study carried out in the Department of Animal Science, UDS, to assess the effect of 24-hour photoperiod on egg laying performance of the local Guinea fowl showed a profound beneficial effect on their laying performance during the non-breeding period (Dei *et al.*, 2010). This indicate that the laying performance of the local Guinea fowl can be enhance even in the dry season through the provision of light for 24-hours.

2.6.6 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 (Koney, 1993). 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 egg 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 (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).

2.6.7 Sexing guinea fowls

One of the major setback in Guinea fowl breeding is the identification of the sex of the young birds because both sexes look alike very much (Teye *et al.*, 2000). The ability to determine the sex of Guinea fowls could aid the local breeder, farmer and fancy bird show-persons to appropriately house and feed both genders (eHow, 2008). Selected flocks for breeding purposes often turn out to be all male or just few females (Biswas, 1999; Osman, 2006).

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 (Platt, 1997; Teye and Gyawu, 2002; Bell and Smith, 2003; Guinea fowl International Association, 2009). However, when keets are gently handled from about the fourth week of age, it is possible to identify a rudimentary phallus in the males, which distinguishes them from the females (Teye *et al.*, 2000). 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).

calling at about nine weeks as only the females have a two note sound while the male birds produce a single note. Nevertheless, females can also produce a single call (Teye and Gyawu, 2002; Guinea fowl International Association, 2009). 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 shown on Table 10.

Table 10: Indicators of sex determination of guinea fowls

Stages of development	Indicator	Sex
Eggs	Eggs with narrow end more pointed	Male
	Eggs with narrow ends 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	High body frame Pronounced and more concave wattles More protruding helmet Monosyllabic sound like "kir ke ke ke ke"	Male
	Lesser body frame Less pronounced and flatter wattles Less protruding helmet Bisyllabic sound like "chekwen chekwen"	Female

Source: Avornyo *et al*. (2007)

2.6.8 Brooding of keets

Keets are fragile, nervous, easily panic and vulnerable to predation, accidents and adverse conditions especially direct exposure to rainfall and extremes or temperature. It is therefore important to protect these birds against unsatisfactory conditions. They may therefore be brooded in an area where they are provided with optimal conditions of temperature, ventilation and supplied with the right type of feed and water. Koney (1993) reported that before putting the day-old keets in the brooder house, the rooms should be properly cleaned and disinfected at least 2-3 weeks earlier.

Bell and Smith (1994) stated that, all types of poultry brooder houses are suitable for keets and operate between 37ºC and 37.5ºC from day-old and reduced by 4ºC each week to down to 29ºC. Similarly, Teye and Gyawu (2002) also reported that, brooding temperature for the first four weeks of keets should vary from 38ºC in week one to 32ºC in week four with 2ºC reduction per week. The required temperature can be provided by using 100-150 watt white incandescent bulb, coal pot and hurricane lamps (Teye and Gyawu, 2002) and explained that, it is important to ensure that lamps did not give too much smoke when using them as that would be detrimental to the keets and care should also be taken with the use of lamps because of the danger of outbreak of fire. Koney (1993) advised that, during brooding, farmers should regularly check the behaviour of the keets and adjust the temperature accordingly. Koney (1993) further explained that large fluctuations in brooder house temperature will lead to stress on the keets and energy being used by keets to control temperature will have a negative effect on feed conversion efficiency.

2.6.9 Pinioning

This involves the removal of a portion of the wings (Young, 1948; Williamson and Russell, 1971). This involves the amputation of the tip of the wing from which the flight feathers grow by severing between the second and the third metacarpal bones. This procedure also renders birds permanently incapable of flight.

Several studies have been undertaken at the Department of Animal Science, UDS, to determine the effects of pinioning on the performance of the local Guinea fowl as well as to assess their behaviours.

Dei and Nsowah (2009) reported that the pinioned birds had a better feed conversion efficiency compared to their counterpart of non-pinioned birds, probably due to the less muscular activities. Amidu (2012) also reported that, pinioning had no adverse effect on growth weight and laying performance of the Guinea fowls. Koduah (2012) reported that, pinioning had no adverse effect on the growth performance of day-old keets. It was also noted that, pinioning had a positive effect on the behaviour of the Guinea fowls. The pinioned birds in general were calm, less flight, less noisy, more accommodating of human presence, less aggressiveness, tamed compared to the non-pinioned birds (Dei and Nsowah, 2009; Fuseini, 2011; Amidu, 2012; Koduah, 2012).

2.7 Inference from Literature Review

The Guinea fowl is one of the most prevalent poultry species found in almost every household in the northern part of Ghana (Dei and Karbo, 2004). It derives its name the Guinea Coast of West Africa (Teye and Gyawu, 2002; Dei and Karbo, 2004; Jacob and Pescatore, 2011). Though, it was originated from Africa precisely West Africa, its production is still at its rudimentary stage (Saina, 2001; Dougnon *et al.,* 2012). However, it is still raised on small scale basis under the traditional system of management with a local hen or a Guinea hen brooding on the eggs to hatch and taking care of the keets (Dondofema, 2000; Smith, 2000; Saina, 2001) and are characterized by low productivity due to the poor management practices under the free-range system of production (Annor *et al.*, 2012).

The Guinea fowl plays a very important roles in the livelihood of the rural people of northern Ghana (Karbo and Bruce, 2000). Some of these roles include income generation for guinea fowl farmers which leads to poverty reduction (Zakari, 2007) especially in the lean season where there is shortage of food. The income generated from these birds are sometimes used to purchase farm inputs for crops production as well as food stuff to bridge food and nutritional gabs in the lean season (Karbo and Bruce, 2000). It provides manure for enriching soils that have been exhausted for good yield of crops (Teye and Gyawu, 2002). It is also a source of food in the form meat and eggs with less fat containing essential fatty acids and less cholesterol as well as high protein level compared to the chicken (Biswas, 1999; Darre, 2007). Despite all these benefits, there are challenges that militate against the industry. Some of these challenges include feed and feeding (Buamah, 1992), inadequate funds (Alidu, 2003), diseases and healthcare (Koney, 2004), predation and theft (Karbo *et al.*, 2002), poor management practices (Koney, 1993), unavailable improved breeding Stock (Koney, 1993), heat stress (Smith, 1990), irregular supply of eggs and day-old-keets.

It is in light of its importance that there is the need to research into its production in order to intensify production on sustainable basis.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area and period of study

The study was conducted in the Nadowli District of the Upper West Region of Ghana. Five communities were selected from the district for the study. The communities selected were among the geo-tagged project communities of Africa RISING Project. The selected communities were Goriyiri, Goli, Gyilli, Papu and Nator-Douri. The Nadowli District is bounded to the north by the Jirapa District, to the south by the Wa Municipality, to the West by Burkina Faso and to the East by the East Sissala District. The Nadowli District is 40 km to Wa, the regional capital of the Upper West Region. The District lies between latitudes 10.8' 28' and 9.8' 18' north and longitudes 2.7' 10' and 1.9' 10' west. The mean annual temperature is 32°C and a monthly mean temperature ranging from 36°C in March and 27°C in August. Rainfall is mono-modal which occurs from May to September with a mean annual rainfall of 110 cm and is unevenly distributed (MoFA, 2010). The study was conducted from November, 2014 to May, 2015.

3.2 Selection of Farmers

Five (5) communities were involved in the project in the Nadowli District of Upper West Region of Ghana. 50-68 farmers per community were involved in the project. In all, three hundred and fourteen farmers were involved in the project in the District. All the five (5) selected communities were used for the study.

Ten (10) farmers were selected from each community using the purposive sampling method. In all, fifty (50) farmers were selected for the study. The selected farmers were among the tagged farmers of Africa RISING Project.

3.2.1 Criteria for Selection of Farmers

The criteria used in the selection of the farmers include;

(1) Must be willing to work hard to contribute to the success of the project

(2) Should have some experience in guinea fowl rearing

(3) Should have hens that are ready to brood

(4) Should have a good night shelter (house) for the guinea keets

3.3 Procurement of Guinea fowl eggs for incubation

A total number of three thousand eight hundred and sixty (3,860) Guinea fowl eggs were purchased from Nyankpala and its environs as well as the Poultry Unit of the Department of Animal Science, UDS, Tamale.

3.3.1 Incubation of Guinea fowl eggs on-station

Three thousand one hundred and ten Guinea fowl eggs (3,110) were incubated artificially in four batches at the Animal Research Institute (ARI) and University for Development Studies (UDS), both in Nyankpala.

One thousand one hundred and fifty (1150) eggs was incubated at the Animal Research Institute (ARI), Tamale. Three batches (600, 600 and 760 eggs) were incubated at the Poultry Unit of the Department of Animal Science, UDS, Tamale. The manual electrical incubators made of wood were used at both centres.

The eggs were candled on the 14th and 21st day of every incubation period to determine the fertility of the eggs as well as breaking of the eggs at the end of every incubation period to determine dead in shell.

3.3.2 Incubation of Guinea fowl eggs on-farm

Farmers were supplied with seven hundred and fifty Guinea fowl eggs (750) to be hatched using the natural method. Each farmer was supplied with fifteen eggs. The local domestic chickens (hen) were used for the incubation of the eggs. The hens were first observed until they were ready to brood before the eggs were set under them.

3.4 Brooding of the Guinea keets on-farm

The day-old keets hatched using the natural method by the farmers were subjected to the natural brooding system. Under the natural brooding system, the hatched keets/chicks are allow to roam about with their foster mother in search for food and return to sleep in their coops in the night. Similarly, the keets were allowed to roam with their foster mother to scavenge for their own food. They were allowed to go out at the 3rd day after hatching. The day-old keets were mainly fed with termites as supplementary feed mostly in the morning and evening with occasional provision of crushed cereal grains by farmers. Water was made available for the keets *ad libitum*. They were housed at night in coops with their foster mothers. The keets were brooded up to 9 weeks under the semi-intensive system of production by farmers.

3.5 Management of keets on-station

3.5.1 Brooding of Guinea keets

The hatched Guinea keets were brooded in a dry clean deep litter brooder house at the Poultry Unit of the Animal Science Department, UDS, Tamale. Feed and water were provided *ad libitum* throughout the brooding period. Light was provided 24 hours throughout to enable them feed in the night as well as provide heat for the keets. Coal pots were also used to supplement heat when the house was too cold. The initial temperature in the brooder was 35°C which was gradually reduced to 29°C. The necessary medication schedules were administered appropriately (Table 12 and 13). The keets were brooded up to 9 and 12 weeks of age before supplying them to farmers. The keets were brooded up to 9 weeks of age because, there is high mortality of keets from the day one of hatching to the 8th week of age (Karbo *et al.,* 2002; Nwagu and Alawa, 1995) under the traditional management system of production, therefore, the need to extend the brooding period. The other batch was raised up to 12 weeks of age for the purpose of comparison, thus, to ascertain the survivability rate between them.

3.5.2 Feeding of Guinea keets

Guinea keets starter mash was formulated using ingredients such as maize, soybean meal, wheat bran and fishmeal. Maize was obtained from the Tamale market whereas the soybean meal, wheat bran meal and fishmeal were obtained from

Kumasi. The composition of the starter mash is shown in Table 11. The formulated diet contained 22% crude protein and 12.5 MJ/Kg Metabolizable energy (Table 11).

Table 11: The starter mash formula for the Guinea keets

Ingredients	Percentage (%)
Maize meal	60
Wheat bran meal	6
Soybean meal	17
Fishmeal	14
Oyster shell	1.5
Dicalcium Phosphate	1.0
Premix	0.3
Salt	0.2
Calculated nutrient analysis (g/kg)	
Crude Protein	22
ME (MJ/Kg)	12.5

Composition of layer premix per kg: Vitamin A 8,000,000 IU; Vitamin D_3 15,000,000 IU; Vitamin E 2,500 mg; Vitamin K 1,000 mg; Vitamin B_2 2,000 mg; Vitamin B_{12} 5 mg; Folic acid 500 mg; Nicotinic acid 8,000 mg; Calcium panthotenate 2,000 mg; Choline cloruro 50,000 mg; Magnesium (as mono-hydrate sulphate magnesium) 50,000 mg; Copper (as penta-hydrate sulphate copper) 4,500 mg; Cobalt (as hepta-hydrate sulphate cobalt) 100 mg; Zinc (as zinc oxide) 4,000 mg; Iodine (as potassium iodine) 1000 mg and Selenium (as sodium selenium) 100 mg. Antioxidant (as butylated hydroxytoluene) 10,000 mg. Calcium carbonate 25 kg.

3.5.3 Health-care

The brooder house was kept dry and clean to avoid Pneumonia and other infectious diseases. Watering troughs were washed every day and clean water provided daily. A footbath was provided at the entrance of the house to prevent an introduction of diseases. Entrance into the brooder house by strangers were restricted to prevent the introduction of diseases. However, recommended preventative measures usually employed in conventional poultry production in the zone were put in place to prevent the occurrence of diseases such as Newcastle, Coccidiosis, Fowl pox, Gumboro and worm infestation.

Table 12: Medication schedule for the 12 weeks old Guinea keets

Age (Day)	Medication	Mode of application
1st	Glucose	Oral
7th – 9th	Coccidiostat	Oral
14th – 16th	Oxydoxyl	Oral
21st – 26th	Penstrep	Oral
28th	Vitamins	Oral
35th	Dewormer	Oral
38th – 44th	Penstrep	Oral
45th	Vitamins	Oral
52nd – 56th	Penstrep	Oral
60th	Vitamins	Oral
70th	Dewormer	Oral
80th	Dewormer	Oral

Table 13: Medication schedule for the 9 weeks old Guinea keets

Age (Day)	Medication	Mode of application
1st	Glucose + Vitamins	Oral
3rd – 7th	Penstrep	Oral
9th	Vitamins	Oral
14th	Newcastle Vaccination	Oral
18th – 22nd	Coccidiostat	Oral
23rd	Vitamins	Oral
24th – 28th	Penstrep	Oral
38th	Dewormer	Oral
47th – 49th	Penstrep	Oral
50th	Vitamins	Oral
55th – 57th	Coccidiostat	Oral
62nd	Dewormer	Oral

3.6 Experimental birds and design

The Randomized Complete Block Design (RCBD) was used in conducting the experiment and each selected community served as a block. The local breed of the helmeted Guinea fowl (*Numida meleagris*) was used for the experiment.

Four hundred (400) young Guinea fowls comprising of 200 nine-week old and 200 twelve-week old were assigned to farmers in Goli and Goriyiri communities in the Nadowli District of the Upper West of Ghana.

Twenty (20) farmers received young Guinea fowls and eggs while thirty (30) farmers received only Guinea fowl eggs.

Ten (10) farmers from each community were supplied with 20 young guinea fowls each, while 127 birds brooded by the farmers served as the control birds with each farmer having between 6 and 8 birds.

The experimental treatments were as follows:

T_0 - control treatment (9 weeks of age), that is the keets that were hatched and brooded by farmers

T_9 - keets supplied to farmers at 9 weeks of age

T_{12} - keets supplied to farmers at 12 weeks of age

3.7 Management of experimental birds on-farm

The semi-intensive system of production was used. This is the system of production practiced by the farmers.

3.7.1 Housing

The experimental birds were housed only in the night. Although, the houses for the birds were not up to standard they were kept clean always by the farmers. Housing the birds at night was meant to tame them in order to have easy access to them when the need arise.

3.7.2 Feeding

The birds were allowed to scavenge for their own food in the range. Supplementary feed was given to the birds in the morning and in the evening when they returned to sleep. The main feed for the birds was cereal grains such as maize, sorghum, rice and millet. These supplementary feedstuffs were obtained from farmers own farms but occasional purchases from the market and neighbours were made in time of shortage.

3.7.3 Watering

Water was provided in clean locally made clay pots as well as improvised containers. The sources of water for the birds were obtained from borehole, rivers and streams. The water was made available *ad libitum* for the birds.

3.7.4 Health-care

Anti-biotics were given to the birds to boost their immune systems. Drugs such as Penstrep and Levasol (dewormer) were given to the birds. The Penstrep was given to the birds during brooding and growth phases. It was given in their 2nd, 4th and 6th weeks during brooding and 12th and 16th week during the growth phase. The dewormer was given in their 8th, 14th and 20th weeks of age.

3.8 Data Collection

The parameters measured were egg hatchability, initial live-weight gain, final live-weight gain, live-weight gain, mortality and economics of production.

3.8.1 Hatchability of eggs

Proper cleaning, disinfection and fumigation were carried out before setting of eggs. The eggs were turned manually through 90° in the incubator. On the 14th and 21st

days of incubation the eggs were candled to identify and remove infertile eggs. The remaining fertile eggs were kept back in the incubator. The records kept were percentage hatchability of eggs set and percentage of unhatched eggs of eggs set.

1) Percentage hatchability of eggs set

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

2) Percentage of unhatched eggs of eggs set

% unhatched of eggs set is calculated as: $\frac{\text{Total no. of eggs unhatched}}{\text{Total number of eggs set}} \times 100$

3.8.2 Live Weight gain

The experimental birds were weighed with their individual body weights taken weekly by catching them into an empty locally manufactured basket. The local basket was placed on a measuring scale. The weight of the basket was nullified by calibrating the scale to zero with the empty basket still on it. The birds were put into the local basket and the weight recorded. The mean weight per bird per farmer were obtained by dividing the total weight by the total number of birds per farmer. The kitchen type of scale was used in weighing the birds.

The live-weight gain was determined by subtracting the initial live-weight of the birds from the weight obtained in the first week and subsequently at the end of every week. The weekly weight differences were divided by the number of birds per farmer to obtain weights gain per bird per week. Weekly weight gain per bird was then divided by the number of days in a week and multiplied by 1000 to get the weight gain per bird per day in grammes.

The final live-weight gain was determined at the end of the experiment. The final live-weight gain of these birds were taken when they were twenty-six (26) weeks of age. It was obtained by dividing the weights of the 26th week by the total number of birds per farmer.

3.8.3 Mortality

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

$$\text{Mortality} = \frac{\text{Number of deaths}}{\text{Number of birds housed}} \times 100$$

3.9 Economic evaluation

An estimated cost of production of the Guinea fowls in each treatment was calculated. These included the cost of on-farm brooding of keets, cost of eggs supplied to farmers, cost per keet supplied to farmer, cost of transporting eggs and keets to farmers, cost of medication per farmer, total cost of production per farmer, cost price per bird in each treatment, income from the birds per farmer in each treatment and gross margin per farmer.

3.9.1 Costs of production

The cost price per egg was multiplied by the number of eggs supplied to each farmer while the cost price per keet of the birds brooded artificially was determined by dividing the total cost of brooding by the total number of keets alive. The cost price per keet was then multiplied by the number of keets supplied to each farmer.

The cost of on-farm brooding of keets includes cost of obtaining termites, estimated cost of supplementary feed used as well as the cost of medication. The cost of obtaining termites was determined by using the minimum working hours per day and the minimum daily wage per person per day. The amount obtained was then multiplied by the number of days used in brooding the keets. The cost of the supplementary feed was estimated based on the amount of feed given to the birds per day. The amount obtained was then multiplied by the number of days that the keets were brooded. The cost of medication was determined by dividing the cost of medicine distributed to farmers during the brooding phase. A similar calculation was done with regards to feeding and medication at the growth phase.

The cost of transporting eggs and keets to farmers was determined by dividing the cost of transporting eggs from Tamale to the Nadowli District by the number of farmers who were supplied with the eggs. Similarly, the cost of transporting the keets from Tamale to the Nadowli District was divided by the number of farmers who were supplied with the keets.

The total cost of production was determined by adding all cost items involved in raising the birds from day one to the 26^{th} week of age.

3.9.2 Income

This was determined by the help of traders who deal in guinea fowls. The prices were estimated based on the size and weight of the birds. This was calculated by multiplying the selling price per bird by the total number of birds alive per farmer.

3.9.3 Gross margin

The total cost of production (TC) was subtracted from the total revenue (TR) obtained from the birds to determine the gross margin (GM) per farmer.

3.10 Data Analysis

The data collected on the hatchability of the eggs was calculated as follows:

$$\%\ \text{Hatchability of eggs set} = \frac{\text{Total keets hatched}}{\text{Total number of eggs set}} \times 100$$

$$\%\ \text{unhatched eggs set is calculated as: } \frac{\text{Total no. of eggs unhatched}}{\text{Total number of eggs set}} \times 100$$

The data collected on the growth and mortality at the growth stage were subjected to the Analysis of Variance (ANOVA) using GenStat, 4^{th} version while the mortality at the brooding stage was calculated in percentages. Significant differences between treatment means were separated using the least significant difference (LSD) and values were considered significant at $P<0.05$.

Data on economics of production were also calculated as follows:

Cost price of eggs per farmer = Cost price per egg x number of eggs per farmer

$$\text{Cost price per keet brooded artificially} = \frac{\text{Total cost of brooding}}{\text{No. of keets alive}}$$

Total cost of keets supplied per farmer = Cost price per keet x No. of keets per farmer

Transportation cost of eggs per farmer = $\frac{\text{Transportation cost}}{\text{No. of farmers}}$

Transportation cost of keets per farmer = $\frac{\text{Transportation cost}}{\text{No. of farmers}}$

Cost of medication per farmer = $\frac{\text{Cost of drug}}{\text{No. of farmers}}$

Total cost of feeding of birds = cost of feed per bird per day x No. of days that the birds were fed

(TC) = $C_e + C_k + C_t + C_{te} + C_f + C_m + C_l$ where TC = total cost, C_e = cost of eggs, C_k = cost of transportation of keets, C_{te} = cost of transportation of eggs, C_f = cost of supplementary feeding, C_m = cost of medication and C_l = cost of labour

Income = CP per bird x No. of birds per farmer where CP = cost price

GM = TR – TC where GM = gross margin, TR = total revenue and TC = total cost of production.

CHAPTER FOUR

4.0 RESULTS

4.1 Hatchability of Guinea fowl eggs

Table 14 and 15 show the results of the hatchability of incubated Guinea fowl eggs using the artificial incubator and brooding hens respectively.

The hatchability rate of the eggs was generally low in both methods of incubation. The hatchability rate at the on-farm level (natural method) was slightly higher (Table 15) than that of the artificial method of incubation (Table 14). Higher percentage (%) of the eggs were plain eggs which contriouted to the lower hatchability (Table 14). Other factors that contributed to the low hatchability included dead in shell and eggs that were formed but could not developed (Table 14).

Table 14: Hatchability of Guinea fowl eggs using the manual incubator

Batch number	No. of eggs incubated	No. of eggs hatched	No. of eggs unhatched			Percent hatchability
			Infertile (candling)	Dead in shell	Unform ed eggs	
1	1150	482	493	82	93	41.9
2	600	228	301	40	31	38.0
3	600	121	446	10	23	20.2
4	760	70	593	52	45	9.2
Overall	3110	901	1,833	184	192	27.3

Table 15: Hatchability of Guinea fowl eggs using the local chicken (natural incubation method)

Community	No. of eggs incubated	No. of eggs hatched	
		No.	%
Goriyiri	150	18	12
Goli	150	36	24
Papu	150	95	63.3
Gyilli	150	39	26
Natodori	150	45	30
Total	750	233	-
Mean %	-	-	31.1

Table 16 shows the mortality of the Guinea keets brooded using the artificial method. The keets raised up to 9 weeks of age recorded a lower mortality rate compared to the keets brooded up to 12 weeks of age (Table 17).

Table 16: Mortality of Guinea keets brooded artificially to 9 and 12 weeks of age

Treatment	No. of keets hatched	Mortality	
		No.	%
T_9	419	58	13.8
T_{12}	482	93	19.3

Table 18 shows the mortality of Guinea keets hatched and brooded up to 9 weeks of age by farmers at the various communities using the semi-intensive system of production. The results indicate that farmers in the Papu community had a higher number of keets than the other communities while the farmers in Goriyiri had the lowest number of keets. The mortality of the Guinea keets per farmer was in ranges as follows: 27.3-100% in Goli, 0-60% in Papu, 44.4-100 % in Gyilli, 38.5-66.7% in Nato-Dori and 100% in Goriyiri. Similarly, farmers in the Papu community had the highest survivability rate, followed by the Nato-Dori community with the Gyilli and Goli communities having the lowest survivability rates while the farmers in Goriyiri lost all their keets (Table 17).

Table 17: Mortality of Guinea keets during on-farm brooding (1-9 weeks of age)

Community	No. of keets hatched	No. of keets dead	Mortality (%)
Goriyiri	18	18	100
Goli	36	21	58.3
Papu	95	26	27.4
Gyilli	39	22	56.4
Nato-Dori	45	19	42.2
Total	233	106	56.9

4.2 Growth performance

Table 18 shows growth parameters and mortalities of the Guinea fowls during the growing phase.

Table 18: Effect of farmer management on growth and mortality of Guinea fowl (9-26 weeks of age)

Parameters	T_0	T_9	T_{12}	S.E.D	P-value
Mean initial live-weight	194.5[a]	335.2[b]	332.9[b]	1.31	<0.001
Mean daily live-weight gain (g/b/d)	4.0[a]	5.5[b]	5.3[b]	0.08	<0.001
Mean final live-weight at 26 weeks (g/bird)	790[a]	887.6[b]	853.3[b]	12.4	<0.001
Mortality (%)	32.3[a]	25.5[b]	24.5[b]	4.49	<0.001

T_0 (control) – naturally brooded birds, T_9 and T_{12} (birds artificially brooded up to 9 and 12 weeks of age respectfully), S.E.D = Standard Error of Difference, P- probability, Means with the same superscripts in a row are not significantly different (P>0.05).

4.2.1 Mean initial live-weight gain

There were significant (P<0.05) differences between the control birds and their counterparts in T_9 and T_{12} in terms of their mean initial live-weight. There was no significant (P>0.05) difference between T_9 and T_{12} (Table 18). This was due to the fact that, the T_{12} birds faced a health problems which affected their growth performance during brooding stage

4.2.2 Mean daily live-weight gain

There were significant (P<0.05) differences between the control birds and their counterparts in T_9 and T_{12} in terms of their mean daily weight gain (Table 18). There was no significant (P>0.05) difference between the birds in T_9 and T_{12} (Table 18).

However, the daily weight gain of the birds in T_9 was slightly lower than that of the birds in T_{12} with the control birds (T_0) having the lowest mean daily weight gain (Table 18).

4.2.3 Growth pattern

Figure 1 shows the growth patterns of guinea fowls brooded under natural and artificial systems. Generally, the birds in all the treatments were consistent in their growth rates (Figure 1). The growth rates of the control birds was at slower pace than the others (T_9 and T_{12}) because of their relatively low initial live-weight.

At 26 weeks of age, there was no significant ($P>0.05$) difference between T_9 and T_{12} but there was a significant ($P<0.05$) difference between the control birds and the birds in T_9 and T_{12} (Table 18). Birds in T_9 and T_{12} had a similar final live-weight. However, the birds in T_9 were slightly heavier than their counterparts in T_{12}. Comparatively the control birds had lower ($P<0.05$) final live-weight compared to the birds in T_9 and T_{12} (Table 18).

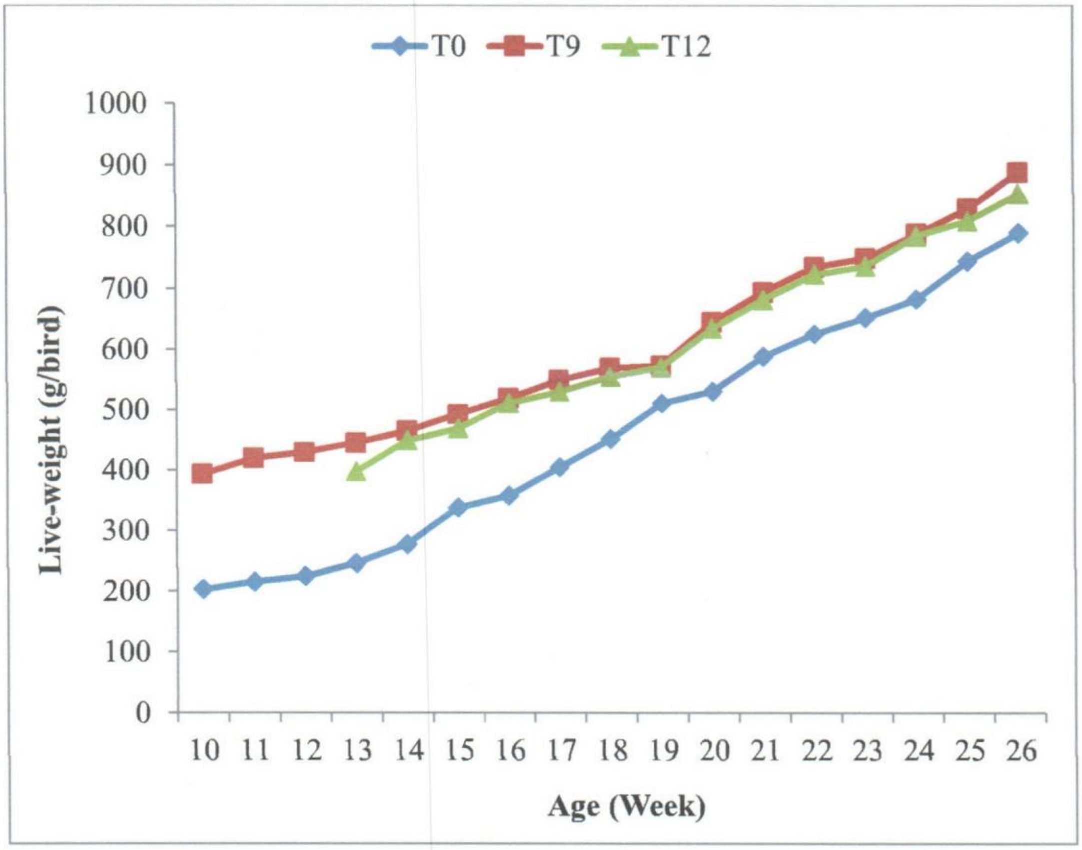

Figure 1: Growth patterns of guinea fowls naturally and artificially brooded (9-26 weeks of age)

4.2.4 Mortality

The mortality rate of the control birds was higher ($P<0.05$) than those of the birds in T_9 and T_{12} (Table 18). The mortality rates between T_9 and T_{12} were similar ($P>0.05$) but birds in T_9 recorded a slightly higher mortality than those of the birds in T_{12} in numerical terms (Table 18).

4.3 Economics of production

There were differences in the estimated gross margin made per farmer between the control birds and those that were in T_9 and T_{12}. Also, there was a difference in the gross margin made per farmer between the birds in T_9 and T_{12} (Table 19). The gross margin obtained from the control birds were lower than that of the birds in T_9 or T_{12}. Similarly, the T_9 birds has a higher gross margin than the T_{12} birds (Table 19). The gross margin of the birds in T_9 and T_{12} was 53.4-67.3 % higher than the control birds. Also, the gross margin of the birds in T_9 was 9.1% higher than those that were in T_{12}.

Table 19: Economic evaluation of Guinea fowls under the semi-intensive system of production

Variables	Treatments		
	T_0	T_9	T_{12}
	Gh¢	Gh¢	Gh¢
Brooding cost per farmer	49.10	n.a.	n.a.
Medication per farmer	5.00	5.00	5.00
Cost of eggs per farmer	7.50	n.a.	n.a.
Cost of keets per farmer	n.a.	100.00	120.00
Transportation cost per farmer	6.58	32.90	32.90
Cost of feeding birds per farmer	35.70	59.50	59.50
Total cost per farmer	103.88	197.40	206.90
Selling price per bird	17.00	18.00	18.00
Total revenue	1,462.00	2,682.00	2,718.00
Total revenue per farmer	146.20	268.20	271.80
Gross margin per farmer	42.32	70.80	64.90

n.a. = not applicable, 750 eggs supplied to farmers, 233 keets hatched, 127 survived after natural brooding, 200 nine weeks old keets supplied to farmers, 200 twelve weeks old keets supplied to farmers, At 26 weeks old 86 birds survived out of 127, 149 survived out of 200 nine weeks old birds and 151 survived out of the 200 twelve weeks old birds

CHAPTER FIVE

5.0 DISCUSSION

5.1 Hatchability of Guinea Fowl Eggs

The hatchability rates of the eggs set under the natural and artificial systems were generally low. This could be as a result of poor fertility of the eggs. The hatchability rate of these eggs fell below the average hatchability rate of 60% as reported by Koney (1993).

Poor fertility of Guinea fowl eggs has been attributed to factors such as wrong mating ratio, poor nutrition of breeders, age of breeders, wrong time of egg collection and health problem as well as genetic disorders (Oluyemi and Roberts, 1979; Payne, 1990). The eggs were bought from different Guinea fowl farmers in Nyankpala and its environs. These farmers practice the extensive/semi-intensive system which might have not taken into consideration the male to female mating ratio and therefore could contribute to the poor fertility of the eggs produced by these fowls. Thus, the possibility of the Guinea hens being more than the Guinea cocks in a breeding stock could contribute to poor fertility of the eggs as reported by Nwagu and Alawa (1995). The recommended mating ratio for Guinea fowls is one male to five or eight females (Nwagu *et al.*, 1997; Bell and Smith, 2003; Apiiga, 2007; Avornyo *et al.*, 2007). In this, study, it was observed that eggs purchased from the Poultry Unit of the Department of Animal Science, UDS, where sex ratio was 1:2 gave better hatchability values.

Another factor that might have contributed to the poor fertility of these eggs could be the storage period. The eggs were stored for more than 14 days due to the difficulty in getting the eggs in large quantities at a go. The internal qualities of Guinea fowl decreases or deteriorates with the increase in storage time (Song *et al.*, 2000). Thus, changes in the interior or internal qualities of the egg might have affected its fertility due to long storage time (Shaibu, 2008) which resulted in the low hatchability.

The poor fertility could also be as a result of high temperature during the study period. High temperatures (above 30°C) can reduce egg fertility (Kekeocha, 1984). The temperature in the Northern part of Ghana is usually higher in the dry season (SARI, 2001). The Nadowli District, where the eggs were incubated has a temperature range of 32-36°C and hence could have negative effect on the incubated eggs. Due to this problem, Smith (1990) suggested that eggs meant for hatching should not be stored for more than 7 days and should be maintained at a temperature range of 10-14°C and a relative humidity of 75-85%. This, however, can only be achieved if farmers keep relatively large flocks so that sufficient quantity of eggs can be collected within a week for incubation.

5.2 Growth Performance

The poor performance of the control birds (T_0) during the growth phase could be due to the manner in which the birds were brooded. The improved management practices under the artificial brooding system enhanced the growth performance of the birds in T_9 and T_{12}. The better performance of the keets under the artificial brooding system than their counterpart on the natural brooding system showed that adequate feeding and proper care had a positive effect on their growth. The control birds during the brooding phase were poorly fed by the farmers; whereas those brooded artificially received complete diets and fed *ad libitum*. The control birds were given termites and crushed cereal grains in addition to whatever they scavenged in the range. Teye *et al.* (2001a) and Dei *et al.* (2009) reported that proper care has a positive impact on growth performance of guinea keets.

Although the performance of the birds brooded artificially was good during the starter phase, their performance during the growth phase was generally lower than expected (Table 18). Guinea fowls at 26 weeks of age were expected to weigh about 1.2 kg/bird (Annor *et al.*, 2012), but the birds in this experiment recorded live-weights of 26-29% below that. This could be as a result of the inadequate feeding and poor nutrition at the farmer level. In this study, the birds scavenged for their own feed on the range though often supplemented with handful of grains by the farmers. Moreover, the experiment was conducted in the dry season when shortage of feed on the range or food in the barns of farmers was usually experienced. Thus, their feed intake was inadequate and imbalanced in terms of essential nutrients such as protein and vitamins as reported by Dei and Karbo (2004). Also energy obtained from the feed consumed by the birds were used in walking for long distances in search of food as well as used in controlling of heat stress posed by the adverse environmental conditions such as high temperature and flying around (Bowlin and Wilkelski, 2008; Henry *et al.*, 2005) instead of converting it into growth.

Brooding birds intensively up to 9 weeks of age was more beneficial than raising them up to 12 weeks of age since both groups exhibited similar live-weights at the end of the study (Figure 1). This would save extra cost in terms of labour and feeding the birds beyond 9 weeks of age. Also, judging from the high mortality (27.4-100%) farmers incurred during brooding, it is advisable to purchase artificially brooded birds.

5.3 Survivability

Survivability of Guinea keets at the brooding stage is very important to the development of the Guinea fowl industry in northern Ghana. A mortality ranging from 27.4 to 100% (Table 17) was recorded during the brooding phase of the keets raised by farmers under the semi-intensive system of production while that of the artificial brooding was 13.8% and 19.3% (Table 16). The causes of these mortalities reported by farmers were accidents, predation, missing and unknown causes. This was due to the fact that the keets were exposed to those factors since the guinea keets were allowed to move freely with their foster mother in searching for feed. Similar causes of mortalities were reported by Dei and Karbo (2004) in their studies in Ghana.

The mortality rates of birds brooded artificially up to 9 and 12 weeks of age were significantly lower ($P<0.05$) than that of the control birds during the growth phase (Table 18). The causes of death of birds during the growth phase were also attributed by farmers to predation, missing, accidents and unknown causes. Reduction in the mortality rates of the artificially brooded birds was 21-24% compared to the control birds. This indicates that taking good care of day-old keets under the artificial brooding system before rearing on the semi-intensive system could enhance the survivability and sustainability of the Guinea fowl industry in northern Ghana. This also suggests that proper care of Guinea fowls by way of feeding and health-care during the brooding stage could improve their survival rate under the semi-intensive system of production.

Another factor that might have contributed to the lower mortality of the artificially brooded birds could be the age at which the birds were exposed to farmer management. Probably, the birds at nine or twelve weeks of age might have formed a strong immune system against diseases and the adverse environmental factors that are worrisome to them at the keets stage (0-8 weeks old) (Karbo *et al.,* 2002; Nwagu and Alawa, 1995).

It was also observed at the beginning when the birds were sent to farmers that, the birds remained indoor even when they were allowed to go out. This indicates that, the intensive system of brooding rendered them docile. This attribute enabled the farmers to feed them easily. This might have contributed in the reduction of the mortality during the growth stage due to the problems of theft, missing, accidents and predation.

Although, there was no significant difference between the artificially brooded birds up to 9 and 12 weeks of age, the 9 weeks old birds had a slightly higher mortality rate compared to the 12 weeks old birds (Table 18). This could be attributed to the differences in the management practices of the farmers in each community. Though there were slight differences in the management practices of the farmers per community, there was a general improvement in their management practices which resulted in high survivability of the Guinea fowls.

5.4 Economic considerations

The birds in T_9 and T_{12} yielded a higher income than the control birds which increased between 53.4 and 67.3% per farmer. This was as a result of the more number of birds that survived to maturity (Table 19). This indicate that rural poultry production is profitable and serve as a means of reducing poverty (Karbo and Bruce, 2000; Teye and Gyawu, 2002).

Generally the cost of production for the control birds was lower than the birds in T_9 and T_{12} (Table 19). This was due to the fact that the birds were mainly scavenging on their own which drastically reduced the cost of feeding (Koney, 2004). On the other hand, the higher cost of production of the birds in T_9 and T_{12} was mainly due to the intensive brooding and transportation costs. However, raising keets intensively up to 9 and 12 weeks of age before rearing on-farm was more beneficial. Even though the general cost of production for the control birds was lower, the cost of feeding the control birds was higher than those in T_9 and T_{12} from week 9 to 26 (Table 19). This could be due to wastage of feed by the birds during feeding. It could also be that the consumption rate of the control birds was higher because of the energy loses due to roaming or moving to long distances in search for feed (Bowlin and Wilkelski, 2008; Henry *et al.*, 2005). Again, it could be that other species such as chicken and ducks as well as wild birds might have been taking part of their feed since the feed is usually thrown on ground. Comparatively, the control birds were less in number than their counterparts in T_9 and T_{12} and if given the same quantity of feed, the rate of feed that would be consumed by the control birds would be higher than their counterparts in T_9 and T_{12}. On the hand, the birds in T_9 and T_{12}

consumed less feed due to their calm nature which made it economically beneficial than the control birds.

Although, the birds in T_{12} had a higher income than those that were in T_9 (Table 19), the birds in T_9 had about 9.1% increase in gross margin than the birds in T_{12}. The difference in the income between the birds in T_9 and T_{12} was as a result of the difference in the mortality rates between them (Table 19). Also, the cost of production for the birds in T_{12} was higher than that of the birds in T_9 (Table 19) which could be attributed to the difference in the brooding duration between them. The extra three weeks of brooding of the T_{12} birds incurred extra cost which lead to a higher cost per keet compared to their counterparts in T_9. Generally, it was more economical to raise guinea keets intensively up to 9 weeks of age before rearing under the semi-intensive system of production.

5.5 Implications of the findings for sustainable production of Guinea fowl

It was observed that supply of Guinea fowl eggs to rural farmers for hatching ensured accessibility to eggs for sustainable production. However, hatching of guinea fowl eggs on-farm has a number of limitations associated with the natural method of incubation. For example, a farmer can only set a few number of eggs (10-12) per hen. Therefore, to hatch a large number of eggs, the farmer must have more hens. This implies that supply of Guinea fowl eggs to rural farmers for hatching might not be a reliable proposition for improving Guinea fowl production.

Also, egg incubation conditions at farmer level are not quite favourable for hatching eggs.

The study shows clearly that on-station hatching and brooding of Guinea keets up to 9 and 12 weeks of age before supplying to farmers to rear under the semi-intensive system enhanced their growth performance. Therefore, Guinea fowl production can be improved through regular supply of artificially brooded birds to rural farmers for rearing. This can be done by supporting small scale producers or institutions to produce keets for sale to farmers.

Overall, it is economically viable to supply keets to farmers. Therefore interventions to sustain Guinea fowl production should encourage production of keets for sale to farmers.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusions

- The growth performance of Guinea keets supplied to farmers at 9 and 12 weeks of age was better than that of keets hatched and brooded by farmers.
- The supply of keets at 9 and 12 weeks of age reduced mortality at growth stage as well as eliminated high keet mortality experienced by farmers during the brooding stage.
- It is more economical for farmers to buy keets brooded intensively up to 9 weeks of age for rearing. There must be a brooding source for this to happen.

6.2 Recommendations

1. There is the need to support Guinea fowl production at the rural level in northern Ghana through the establishment of breeding stocks, hatcheries and brooding facility by the government/private sector to ensure regular and reliable supply of keets to farmers.
2. Business minded people could also go into the production of day-old keets or by raising them intensively up to 9 weeks old before selling to farmers.

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