# ASSESSMENT OF THE POTENTIAL FOR SPORT HUNTING OF GAMEBIRDS WITH SPECIAL EMPHASIS ON GUINEAFOWLS IN LAIKIPIA DISTRICT, KENYA

By

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# DECLARATION

## DECLARATION BY THE CANDIDATE

This thesis is my original work and has not been presented for a degree in any other University or any other award.

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ADHOLA ENOCK TITUS DATE

## DECLARATION BY SUPERVISORS

We confirm that the work reported in this thesis was carried out by the candidate under our supervision.

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# DEDICATION

To the loving memories of my Dad, Jack Omolo Oketch; and Brother, Daniel Omondi Omolo.

Fare thee well my loved ones till we meet again in that world so yonder, full of thunder and awesome wonder!

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## ABSTRACT

This study sought to investigate potential for rural communities in arid and semi-arid areas to derive economic benefit from hunting of gamebirds, specifically the guineafowls. In order to achieve this, it is important to have knowledge on guineafowl ecology and population dynamics; particularly how environmental conditions which vary in space and over time, influence their population dynamics. The study focussed on two sympatric species of guineafowl in Laikipia district, Kenya. They include; the Helmeted Guineafowl *Numida meleagris,* which is common in the moister parts of southern Laikipia, and Vulturine Guineafowl *Acryllium vulturinum,* which is more common in the drier northern reaches of the district. Their population dynamics, habitat preferences and breeding seasonality were compared in order to develop methods for monitoring their populations that are suitable for game bird management purposes. The study area comprised six sites arranged along a rainfall gradient in Laikipia district. Distance sampling technique was used to derive game bird densities within the study area both spatially and temporally. Game bird data was collected during five sample sessions conducted between September 2005 and April 2007 at each study site. Systat 9.0 statistical package was used to perform statistical analyses to test for relationships between guineafowl densities and factors perceived to limit their populations. Habitat was found to have a significant influence on guineafowl population dynamics. From the multi-wavelength data from Landsat imagery employed in this study, distributions of guineafowls across various habitats within Laikipia will be predictable. Both guineafowl species were observed to breed at least once every year after the long rains season. The birds were also observed to suspend breeding and thereby recruitment during periods marked by drought conditions. There was variation in recruitment rates, spatially and temporally within and between the study sites. The study concludes by recommending harvesting quotas for gamebirds occurring in Laikipia District.

# CHAPTER 1

## 1.0 INTRODUCTION

### 1.1 Wildlife conservation and its evolution in Africa

Across the savannas of Africa dramatic changes are occurring. Grasslands are being put under the plough, trees felled, the human population is increasing, and the wildlife decreasing. Pockets of wilderness survive or appear to survive as protected areas but even there, species richness of large mammals is decreasing. The fate of Africa’s unparalleled and spectacularly rich communities of large herbivores and their associated predators rests in the hands of man (Prins *et al.,* 2000).

A closer inspection of the problem outlined shows that wildlife can occur in two dramatically different situations, those inside and those outside protected areas. These latter areas are often used for livestock grazing or for arable cultivation. Under both these forms of land use, wildlife is often considered harmful, because it is thought to compete with livestock, to harbor diseases detrimental to livestock, or to cause crop damage. Frequently, wildlife poses a threat to the lives of people eking out an existence in or close to their habitat. Hence wildlife has no value outside the protected areas; it dwindles or disappears either through active persecution, loss of habitat, or competition with livestock (Soulé, 1986; Prins, 1992).

Post colonial wildlife conservation in Africa was based mainly on western approaches to wildlife management which were later found to be largely inappropriate and ineffective (Tisdell, 1989; Bothma, 1990).

A call for conservation strategies that are sustainable within the African context, including research needs and methods, is being made by many conservationists throughout the continent (Bothma, 1990; Kat *et al.,* 1990; Homewood and Rodgers, 1991; Eves, 1994). This conceptual evolution of strategies revolves around the issues of ownership of wildlife and the resulting costs and benefits to local communities. Whereas in the past local communities have often been seen as a problem and an obstacle to achieving wildlife conservation goals, it is now recognised that people are actually the solution to Africa's wildlife conservation goals (Lewis *et al.,* 1990).

Traditionally, wildlife was communally owned by many African societies (Mazrui, 1986). Although wildlife uses and needs varied among societies based on their agricultural or pastoral infrastructures, the people co-existed with wildlife sustainably (Meinertzhagen, 1983).

As influence from western cultures increased, the responsibility for and ownership of wildlife shifted toward a centralized position resulting in the removal of hunting rights and loss of wildlife as a resource. The European concept of hunting reserved the right for a privileged elite, removing the hunting component from traditional societies (Simon, 1962).

## 1.2 Economics of wildlife conservation

The economic perspective on ownership and utilization of wildlife is important for conservation purposes. It is defined as; the science concerned with the social administration or management of scarce resources in order to satisfy human desires for commodities to the maximum extent possible (Eves, 1994).

To undertake a wildlife conservation programme without the consideration of the human factor and its economic impact ignores one of the most significant components necessary for conservation success. As the majority of the world's human populations have societies based on market economies, it is necessary to consider the role natural resources play within a nation's economy and the potential for sustainable utilization of those resources (Tisdell, 1989).

It is important for conservationists to recognise that just as biological diversity within and among ecosystems provides balance and support for the continuation of those ecosystems, it is necessary for them to maintain a common vision and undertake the most appropriate methods to support that goal (af Ornäs, 1992; Jeroen *et al.,* 1994; Nikundiwe and Kabigumila, 2006).

The goal will be achieved and maintained in the longer term only through a diversity of strategies ranging from preservation to consumptive utilization of resources. Within this range is the community conservation component. It is also important to recognize that the inputs from economic and political concerns are as important in the development of a sustainability policy as from the ecologists and biologists in the field (Pelt, 1993; Eves, 1994).

### 1.3 Development of national parks and reserves

For many years, it has been the aim to separate wildlife from livestock and cultivation. In 1933, the Convention Relative to the Preservation of Flora and Fauna in their Natural State was signed in London; this convention called for the creation of national parks (Bonner, 1993). Large parks were to be areas where hunting would be prohibited and which would be set aside for perpetuity. Before then, reserves had been set aside for wildlife, for example, in South Africa (Stevenson-Hamilton, 1974), and some game hunters at the time thought that people and wildlife could co-exist; Meinertzhagen wrote, ‘In the view of the likelihood of a vast invasion by European settlers into Kenya, it seems that the larger game must disappear. One cannot have game and farms and I have suggested to the Game Ranger that he puts up a scheme for a very large area in the country unsuitable for white settlement where game can remain forever. There must be no risk of interference from an east African administration which cares nothing for game. The area might be some 12,000km$^2$ and possibly in Maasai country. The Maasai are good game preservers but are very wasteful of their grazing land. Moreover, both game and Maasai cattle can co-exist.’ (Meinertzhagen, 1983).

### 1.4 Are parks the best way to manage wildlife?

Since creation of national parks all over Africa, quite some wildlife has survived outside the protected areas. Yet, both in the parks and outside of them, wildlife is decreasing in high numbers in many African countries. Most areas with a protection status in Africa are too small to ensure the long-term survival of the majority of animal species that live in them notwithstanding, the often large to very large size of these protected areas (Prins, 1992).

This has implications for widespread conflict in policy on wildlife management which could be described as a conflict between the *preservationist* and the *conservationist* viewpoints. A practical preservationist’s point of view is that in the long term, wildlife will only have a place in protected areas, offering different forms of protection ranging from fencing to patrolling by armed rangers (Soulé *et al.,* 1979).

The conservationists would say wildlife is dependent on the attitude of the people living with it. Protected areas are too small by themselves and need dispersal areas or buffer zones (Prins, 1992). In these areas one has to come to a form of land use management in which the way of life of people and their livestock becomes integrated with wildlife management. Wildlife in the dispersal areas has to become a natural resource of direct benefit to people, just like grass, trees and livestock (af Ornäs, 1992). Once wildlife has become integrated into a people's way of life, the protected areas will be well protected at minimal costs and the wildlife will have a habitat larger than the confines of the protected areas necessary for its long-term survival (Prins *et al.,* 2000). Dispersal areas for wildlife can only work if there are financial attractions for the landholders and/or the entrepreneur in the tourist business to maintain and manage this special character of mixed land use (Eves, 1994; Jeroen *et al.,* 1994). Its future can only be guaranteed (or even realistically predicted) by detailed understanding and enlightened management (Begon *et al.,* 1990).

### 1.5 What are game birds?

These are birds that can be utilised by man in numbers for food, feathers and also shot for sport. The common attribute of all gamebirds is that they are sufficiently productive to withstand harvesting year after year (Adhola, 2007; Adhola *et al.,* 2007a). In Kenya there are about 79 species of game birds represented in six families. These include: Numididae (guineafowls); Phasianidae (quails & francolins); Pteroclidae (sandgrouses); Columbidae (pigeons & doves); Anatidae (ducks & geese) and Otididae (bustards) (Zimmerman *et al*., 1996). However, of the six families listed above, only three of them (numididae, phasianidae & pteroclidae) consisting of nine species are preferred by most hunters (Adhola *et al.,* 2007b).

### 1.6 History of gamebird sport hunting in Kenya

Sport hunting of game birds was re-introduced in 1984 after a general hunting ban in 1977. It went on until towards the end of 2005 when a moratorium was imposed by the Kenya Wildlife Service (KWS) following the birdflu (avian influenza) outbreak. The activity has since resumed following the lifting of the moratorium by the same KWS in September 2006. The KWS sets and collects license and booking fees and sets the shooting seasons (Eves, 1994; Adhola, 2007).

Shooting seasons are based on records of the reproductive status of the birds, their population size and distribution. This information in turn is obtained from a wide variety of sources but mainly from ornithologists and professional hunters (Eves, 1994; Adhola *et al.,* 2007c). Most of the country is divided into 'hunting blocks'. Hunting block booking fee is for residents and non-residents. This fee is payable to the KWS headquarters in Nairobi. In addition, there is an annual hunting license fee that is only paid by residents. Non-residents must be accompanied by a resident hunter on hunting trips. Funds are then remitted to the landowners at the end of every year. This form of sport hunting is only permissible outside the protected areas such as national parks and reserves (Eves, 1994; Adhola, 2007).

### 1.7 Economics of gamebird sport hunting

Game cropping schemes, mainly operated on an experimental basis, have tended to produce inconclusive or negative results in recent years and much work still needs to be done to establish the feasibility of economic wildlife cropping under varying conditions. Problems relating to the suitability for human consumption of meat containing parasites, killing, processing, marketing and the economics involved at every stage have still to be solved (Prins *et al.,* 2000).

There is considerable potential for rural communities to derive economic benefit from sport hunting of gamebirds, which is permitted in Kenya. There exists limits on the number of birds that can be shot per gun per day (shooting bag limits). There are also shooting seasons set to coincide with the non breeding season of the various gamebirds. Sport hunting has its scientific justification in the concept of 'doomed surplus'; the birds that are hunted were going to die of disease or old age anyway (Soulé *et al.,* 1979; Eves, 1994; Adhola, 2007).

All harvesting operations should have the basic aim of following the narrow path between overexploitation and underexploitation. In a continuously overexploited population, too many individuals are removed and ultimately the population is driven to extinction; in an underexploited population fewer individuals are removed than the population can bear, and a crop is therefore produced which may be smaller than necessary (Lamprey, 1972). Nevertheless, harvesting is usually a commercial undertaking and therefore economic factors must be taken into account. Current profits- which can be invested at a favourable rate of interest; are likely to be more valuable than future profits- which have to be waited for (Dixon, 1978). It therefore makes sense economically to overexploit a population since this increases current profits at the expense of future ones. Of course, this is ecologically shortsighted and unfuturistic; but profit is nonetheless an important factor that harvesters have to consider (Alers, 1943; Begon *et al.,* 1990).

### 1.8 Problem statement and justification

In many remote parts of Kenya, there are many game bird populations that are not harvested based on scientific knowledge; but through folklore or guesswork, with no management or restraint whatsoever. There is also a general lack of awareness on how to manage habitats to favour gamebirds (Urban *et al.,* 1986; del Hoyo *et al.,* 1994; Malan and Benn, 1999).

This becomes a serious concern from an ecological perspective, since it has been documented that the two main threats to the gamebird populations in the African continent; are habitat destruction and excessive hunting levels (Birdlife International, 2000; Dörgeloh, 2000; Fishpool and Evans, 2001). Laikipia district has one of the fastest growing human populations in Kenya, which, combined with land subdivision, has considerably increased pressure on the land (Ojwang, 2000). There is great need to diversify income sources for communities living in drylands that rely too heavily on traditional husbandry of livestock. In order for game birds to thrive on community land, habitat must be sufficient. This provides further motivation to manage or restore habitats. Game bird sport hunting therefore offers an alternative form of land use that is environmentally friendly. Under the Wildlife Conservation and Management Act, the Kenya Wildlife Service (KWS) has been mandated by the Kenyan government, to set and collect license and booking fees and to set the shooting seasons. Setup of shooting seasons is in turn based on records of the reproductive status of the birds, their population size and distribution. This information is availed by Ornithologists and professional hunters (Adhola, 2007).

The current game bird research in Laikipia therefore not only offers the opportunity to assess the limiting effects of bioclimatic and habitat factors on guineafowl populations; it will also form the basis of a game bird management initiative in Laikipia, to be later implemented on behalf of local communities by an ongoing partnership between the KWS, Mpala Research Centre, an institution dedicated to environmental research for management purposes, and the Laikipia Wildlife Forum, an institution with a strong reputation for extension services.

## 1.9 Null hypotheses

a.) Type of habitat has no effect on guineafowl population dynamics.

b.) Seasonality has no effect on guineafowl population dynamics.

## 1.10 Objectives

### 1.10.1 General objective

To facilitate an ecological framework for development of a gamebird harvesting scheme for both communal and private landowners in Laikipia district.

### 1.10.2 Specific objectives

a) To establish the effect of habitat associations on the population dynamics of Helmeted and Vulturine Guineafowls on private and communal lands in Laikipia district.

b) To establish the effect of seasonality on the population dynamics of Helmeted and Vulturine Guineafowls across a rainfall gradient in Laikipia district.

c) To develop a monitoring protocol for guineafowls and other game birds coexisting in the same habitats by using methods that are suitable for gamebird management purposes.

# CHAPTER 2

## 2.0 LITERATURE REVIEW

### 2.1 Guineafowl morphology

Guineafowl are endemic to Africa. They are large galliformes characterized by: bare heads and necks, often brightly coloured, most with feathers or a casque on crown; heads relatively small in comparison with body; bills short, stout and upper mandible arched; necks relatively long, bodies stout, thickset; wings short, rounded; tarsi short, stout, unspurred in most species, well adapted to running, walking and scratching; 3 forward and 1 hind toe; almost exclusively ground foragers, using feet and bill to excavate food items; plumage black, spotted and/or vermiculated with white; no obvious sexual dimorphism, although the males average larger than females, all appear sedentary. In Kenya, three species of Guineafowl are found, namely: Helmeted Guineafowl, Vulturine Guineafowl and Crested Guineafowl *Guttera puncherani* (Urban *et al.,* 1986; del Hoyo *et al.,* 1994).

### 2.2 Guineafowl social structure

All guineafowl species have highly terrestrial lifestyles. They are gregarious for most of the year, but when the breeding season approaches, the flocks disperse, so that only solitary individuals or pairs are seen, or the odd small group perhaps composed of non-breeders. The flocks are governed by a complex social structure, and research on the Helmeted Guineafowl has shown that, at least in this species, individuals can remain in the same flock over a period of several years (Stokes and Williams, 1971; Berry, 1972; Crowe, 1978a; Elbin, 1979; van Niekerk, 1979; Hastings, 1985).

## 2.3 Guineafowl and flock size

Flock size, outside the breeding season, varies quite considerably among guineafowl species; from the Black Guineafowl *Agelastes niger*, which normally forms groups of under ten individuals; to the Helmeted Guineafowl, which can gather in large flocks of over 200 birds, although this species usually occurs in much smaller flocks of 15-40 birds. The other species form flocks of intermediate size (Urban *et al.,* 1986).

There is no evidence to strictly suggest that flocks have strictly defined territories, and the ranges of two neighbouring groups can overlap to some extent. Nevertheless, if, for example, two flocks of White-breasted Guineafowl *Agelastes meleagrides* meet, a fierce fight is likely to ensue (del Hoyo *et al.,* 1994).

In contrast to this, several Helmeted Guineafowl flocks can coincide at drinking sites, particularly good feeding areas, preferred dusting sites, or roosts, but these flocks will only defend their own particular territories on rare occasions; for instance, when the population is exceptionally dense (Crowe, 1978a; Sibley and Monroe, 1990).

## 2.4 Guineafowl defence strategies

The various different species of guineafowl have to be constantly alert to the threat posed by their many potential predators, although there are different ways of dealing with such threats when they materialize. For instance, when a predator approaches a flock of White-breasted Guineafowl, they separate and scatter until the danger has passed, when they re-group with the help of a cheeping call (Berry, 1972; del Hoyo *et al.,* 1994).

In contrast to this passive strategy, a flock of Helmeted Guineafowl will sometimes perform communal defence against a predator. Guineafowl face a whole host of potential predators at the various stages of breeding. For instance, various monkeys and genets sometimes steal eggs. Wildcats are known to even kill adults at the nest (Urban *et al.,* 1986).

**2.5 Guineafowl and roost sites**

The evidence available suggests that all guineafowl species roost in trees at night, on the whole, communally. The Crested Guineafowl may roost in the same general area; the Plumed Guineafowl *Guttera plumifera* uses a different tree each night, whereas the Helmeted Guineafowl roost in the same traditional roosting sites over long periods. However, similar persistence has not been recorded for the other guineafowl species (del Hoyo *et al.,* 1994).

The White-breasted Guineafowl on the other hand seems simply to choose a roost site every evening in whatever area it happens to be at the end of the day, without there being the slightest evidence to suggest that such sites may be re-used (Urban *et al.,* 1986). On occasions when there may be no suitable roosting sites in the vicinity, the Helmeted Guineafowl, at least, will look for some sort of substitute, and this species has even been observed roosting on telegraph poles (Siegfried, 1965).

**2.6 Guineafowl acoustics**

Guineafowl are gregarious species that inhabit areas with vegetation that is thick enough to make visual contact between different members of a flock rather difficult. They overcome this problem by means of a full vocal repertoire, which enables a sufficient degree of communication to meet their ordinary needs (Zimmerman *et al.,* 1996).

For this reason, most activities have associated vocalizations, which can vary according to the different forms of behaviour involved. Apart from feeding and contact calls, other typical call types recorded in various species include those to signal alarm and others used in moments of aggression. There are some differences between the sexes in vocalizations. For example, females of both Vulturine and Helmeted Guineafowl have a "*buck-wheat*" call, which they most typically use during the breeding season on occasions when they are separated from their partners (Urban *et al.,* 1986; del Hoyo *et al.,* 1994).

**2.7 Guineafowl and foraging**

All species of guineafowl are sedentary, and their movements are limited to the local ones they perform daily over variable circuits, in search for food and water. Although they are mainly terrestrial, they are surprisingly mobile on their feet, and the area which they forage can vary quite considerably from one day to the next, when foraging success is low. Indeed, apart from the Helmeted Guineafowl, which is known to use traditional roosts, birds may start and end each day in quite different places. The long winding route followed daily by flocks of White-breasted Guineafowl, for example, takes them on average, over an area of about 0.9 $km^2$. The speed at which the birds move about is directly related to foraging success, varying from 10m/h to 203m/h, with an average of 115m/h (del Hoyo *et al.,* 1994).

In the Helmeted Guineafowl, it appears that larger flocks tend to cover greater distances daily than smaller ones, although the relative proximity of roosting and drinking sites are also major factors. In this species, home range has been found to average about 8.8 $km^2$, although it is actually extremely variable depending on the habitat type (Zimmerman *et al.,* 1996).

The evidence available suggests that all guineafowl are omnivorous opportunists. Their diet at any particular moment is dictated by the local abundance of the various different food types, with the result that their daily wanderings in search for food can vary considerably, in terms of both time and direction (del Hoyo *et al.,* 1994).

In general, it is essential for guineafowl to have access to some source of drinking water, which they tend to visit regularly. The exception, the Vulturine Guineafowl, of more arid zones, appears to be totally self sufficient in this department, and it does not even seem to take the opportunity to drink when it comes across standing water, even at the height of the dry season (Urban *et al.,* 1986).

All species feed almost exclusively on the ground, although the Crested Guineafowl has on occasions, been seen feeding on fruits in trees. Similarly, the Vulturine Guineafowl occasionally climbs into low trees or bushes to feed on fruits, for example of *Salvadora persica* and several species of *Commiphora* (del Hoyo *et al.,* 1994). The Helmeted Guineafowl often strips the seeds off grass, or crops such as sorghum and millet (Urban *et al.,* 1986). An interesting aspect of the Numididae (guineafowl family) is that, as well as being gregarious, they also associate with other species of birds or mammals, in order to improve their rate of foraging success. For instance, the Crested Guineafowl sometimes follows arboreal monkeys, feeding on the remains of food that the monkeys drop on the ground. The Helmeted Guineafowl regularly associates with a variety of other animal species. In many areas, it habitually feeds and drinks alongside baboons, and both species often try to steal bits of food from each other (Urban *et al.,* 1986; del Hoyo *et al.,* 1994; Zimmerman *et al.,* 1996).

## 2.8 Guineafowl status and conservation

Of the six species of guineafowl, one is currently classified as endangered; the White-breasted Guineafowl (Birdlife International, 2000). The species is an inhabitant of one of the richest African forests, the Upper Guinea Forest, which is famous for the large number of endemic forms it holds. This expanse of rain forest formerly spread over some 333,600 $km^2$, but it has suffered widespread devastation since the $19^{th}$ century, and now occupies under 13% of the original area. Worst still, the habitat that remains is heavily fragmented into rather small pockets, which are spread over five different countries. The other major problem that besets the species is excessive hunting pressure, in the form of both shooting and snaring. Such pressure has already led to some local extirpations and it threatens to bring about others in the not too distant future, especially in Liberia and Ghana (Collar and Stuart, 1985). While many species are capable of withstanding a moderate level of hunting pressure, when this is combined with habitat loss and fragmentation, such large species can be systematically wiped out from each small pocket of forest until they disappear from whole areas. The situation is made all the worse by the ready availability of guns and cheap cartridges throughout Sierra Leone, Liberia, Ivory Coast, Guinea and Ghana (Fishpool and Evans, 2001).

Apart from survey work and proposals for protection, one of the major steps towards the protection of the species involves the first significant studies of its biology and ecology. The key to the survival of the White-breasted Guineafowl seems to be very clear. If large tracts of primary forest can be preserved relatively undisturbed, with hunting pressure reduced to a minimum, the species is unlikely to disappear (del Hoyo *et al.,* 1994).

Both Helmeted and Vulturine Guineafowl are reckoned to have total populations numbering over a million individuals; and in the case of the helmeteds, there are likely to be many millions. Both species have been classified in the category of *"Least concern"* or *"LC"* by the International Union for Conservation of Nature and Natural Resources (IUCN). Populations of the very little known Black Guineafowl and also the Crested Guineafowl are both thought to be in the hundreds of thousands and that of Plumed Guineafowl in the tens of thousands. The White-breasted Guineafowl, probably numbers over 58,000 birds (Urban *et al.,* 1986).

The chief threats to the family as a whole seem to be habitat destruction and, in some cases, excessive hunting levels. Both factors are the most serious in the cases of forest species, and this is generally reflected in the population figures, as the species with the highest populations are those of open areas, while those of forest generally present much lower figures and are thought to be declining (Birdlife International, 2000; Fishpool and Evans, 2001).

Nevertheless, there are negative factors operating even on the Helmeted Guineafowl, the most serious of which is the increasing use of pesticides, which are likely to have adverse effects on the species in the long run (Urban *et al.,* 1986; Crowe and Ratcliffe, 2001a). The Moroccan race, *Sabyi,* of this species has declined drastically, for unknown reasons, and it may in fact, already be extinct (Collar and Stuart, 1985).

**2.9 Guineafowl and man**

The relationship of man with guineafowl goes way back into ancient times, mainly through the domestication of the Helmeted Guineafowl (Crowe and Ratcliffe, 2001b). Over the centuries, this species has probably been domesticated by several different peoples independently at different times. The earliest reference to guineafowl comes from murals of the fifth dynasty of Egypt in the Pyramid of *Wenis at Saqqara*, which date to about 2400 BC. The Phoenicians and Greeks are known to have kept domesticated guineafowl, the latter at least as early as about 400 BC. Only slightly later in the 4$^{th}$ century BC, the Moroccan race, *sabyi,* of the Helmeted Guineafowl was considered a sacred bird on one of the islands of the Aegean (Urban *et al.,* 1986).

The generic name *Numida,* which also gives the name to the family, refers to the ancient North African state of Numidia, and illustrates the fact that from the point of view of the Romans, the birds arrived from Numidia. The Romans regularly kept the helmeteds for food and carried it to all parts of their enormous empire. However it seems that with the fall of the Roman Empire, the species disappeared from Europe, and after this there was a long period in which it does not appear to feature in historical records, apart from an odd record of some captive birds in Athens in the 10$^{th}$ century AD. In the 15$^{th}$ and 16$^{th}$ centuries, the Portuguese explorers and navigators brought back individuals of the West African race, *galeata,* to Europe, and the species was regularly kept once again (Urban *et al.,* 1986; del Hoyo *et al.,* 1994). The repeated domestication of guineafowl over many centuries has led to its presence practically all over the world, usually in domestic form, but in many cases with feral populations too (del Hoyo *et al.,* 1994).

Such feral populations arose where a proportion of the domestic stock escaped and managed to establish more or less stable populations in the foreign habitat. This was the story, for example, on many islands in the West Indies such as Cuba, whither the species was brought in 1508 (Urban *et al.,* 1986).

Much of the importation of guineafowl to parts of Europe and especially America was effected by ships transporting slaves, and so many birds were imported that by the beginning of the $18^{th}$ century, feral populations had become established on most of the larger islands of the Caribbean. On the other side of the world, in Australia and New Zealand, there have been a multitude of instances over the years, at least since about the 1860's, of domestic birds escaping or being released, but they have invariably failed to become established, although in some areas, birds live on in the vicinity of farms in a semi-domesticated state (del Hoyo *et al.,* 1994).

### 2.10 Guineafowl feathers as ornaments

Guineafowl feathers have traditionally been highly prized as ornaments by chiefs and witch doctors of some tribes. In some areas, the birds were regarded as symbols of fertility, due to their profuse production of eggs, and these in turn, were used in rites of initiation for young girls or newly-weds, or other similar ceremonies. Although guineafowl feathers were also used as adornments for women's hats in Europe, and the eggs came to form a part of a few local traditions in central Europe (del Hoyo *et al.,* 1994).

### 2.11 Guineafowl as source of food

Man's main use of guineafowl has been as a source of food. Both the eggs and the flesh have been much appreciated by man since his first contact with them (Ayorinde and Ayeni, 1987). The major consequence of this has been the breeding of guineafowl, invariably, the Helmeted Guineafowl, on an industrial scale; and nowadays there are a great many farms dedicated to the production and commercialization of guineafowl (Ayeni and Ayanda, 1982). Proof of their wide culinary acceptance is supplied in the form of surprisingly large number of recipes specifically for guineafowl that exist all around the world (del Hoyo *et al.,* 1994; Downes, 1999).

### 2.12 Guineafowl meat and prevention of heart disease

Guineafowl meat appears more nutritive compared to other domestic poultry species according to Agwunobi and Ekpenyong (1990). It has been documented that guineafowl carcass contains more protein and ash compared to chicken. The fat content of guineafowl carcass is less than that of chickens. Due to the leanness of guineafowl carcass, it is highly recommended to consume guineafowl meat, seen as nutritionally more desirable in the human diet to help avoid heart disease (Ayorinde, 1991; Bonkoungou, 2005).

### 2.13 Guineafowl as biocontrol agents

The Helmeted Guineafowl has recently been put to a new rather revolutionary use in the USA, where it is now being employed in the control of infections spread by parasites, in this case, those that cause Lyme disease. The parasites are spread by deer ticks, and until recently all attempts to control them had failed, but the release of the guineafowl in the infected area has proved very effective (del Hoyo *et al.,* 1994).

## 2.14 Guineafowl conflicts with man

Within the natural ranges of the guineafowl, problems arise due to a conflict of interests between man and the birds. Once again, it is mainly the Helmeted Guineafowl that is implicated, as this is the species that occupies the most similar habitat, and most readily occurs in cultivation (Crowe and Ratcliffe, 2001a). While farmers tend to consider the birds a plague, it seems that they should readily be regarded as allies. While they will take a certain amount of some kinds of grain, the damage they cause to maize is virtually nil. At the same time they eat large quantities of destructive insects and also weeds, and thus collaborate significantly in the production of a healthy crop (del Hoyo *et al.,* 1994; Crowe and Ratcliffe, 2001b).

## 2.15 Guineafowl and habitats

Guineafowl populations are typically associated with a mosaic of habitats in a savanna landscape. Patterns of connectedness between habitats, defining structural continuity between landscape elements, strongly affect the distribution and abundance of species (Malan and Benn, 1999). Human-induced habitat change can influence gamebird abundance directly, for example, through loss of cover, or indirectly, via reduction of prey abundance (Martin, 1992). Land use change may also affect gamebird populations through its effects on density of nesting sites and roosts, and on birth rate and survival. For example, the effect of increased grazing and browsing may decrease cover for gamebirds, and increase disturbance (Baines, 1996; Tapper *et al.,* 1996). Laikipia District has one of the fastest growing human populations in Kenya, which, combined with land subdivision, has considerably increased pressure on the land (Ojwang, 2000). However, there is great potential to increase, through appropriate management practices, the area occupied by wildlife, including gamebirds, particularly on communally owned properties.

## 2.16 Guineafowl and land use and management practices

An understanding of the effects of current land use and management practices on productivity, and of species' responses to habitat disturbance, are critical for effective management strategies and conservation programs for threatened species (Bibby *et al.,* 1992; Hagan, 1993; Opdam *et al*., 1995). Gamebirds may benefit from agricultural practices, which provide food, sources of drinking water and roosting sites and from habitat restoration (Maphasa, 1996). Restoring the diversity and connectivity of suitable vegetation cover involves habitat and land management strategies at the conservancy level (Crowe and Ratcliffe, 2001a).

A great variety of habitat types and land uses exist in Laikipia, from natural (such as Mpala conservancy), to degraded (such as the group ranches that neighbour Mpala to the north-east). Reproduction in gamebirds is typically influenced by rainfall effects on the availability of insect and plant food (Pero, 1996). However, limiting effects of bioclimatic factors on gamebird populations are not well known in eastern Africa (Simiyu, 1998). A population is said to be limited in a density dependent manner if its growth rate is negatively related to the size of the population, and limited in a density-independent manner if its growth rate shows no relation to population size. A population is said to be regulated if its size varies, within narrow limits, around some equilibrium value (Ricklefs, 1973; Crowe and Siegfried, 1978).

Although starvation is uncommon and accounts for little mortality in birds (Rodenhouse, 1986), reduced clutch sizes or numbers of nesting attempts in response to food limitation are common (Martin, 1987). Management practices such as burning of fire-maintained grasslands and predator control programmes in stock farming areas may also limit the survival and reproduction of gamebirds (Mentis and Bigalke, 1979; Tapper *et al.,* 1996).

Creation of moderately fragmented habitats on a landscape scale is required for the resuscitation of Guineafowl populations (Crowe and Ratcliffe, 2001b).

**2.17 Guineafowl biology**

Very little is known about the breeding habits of most members of the Numididae, and in some cases the size and colour of the eggs constitute virtually the only information available (Brown and Britton, 1980). Thus details regarding courtship displays, the role of the sexes, the incubation period, overall levels of success, and so on, can only be interpolated tentatively from the best known species, the Helmeted Guineafowl (Urban *et al.,* 1986). The seasonality of breeding does not appear to follow particularly well set patterns; nevertheless, there do tend to be seasonal peaks which are apparently related to the rains (Crowe and Siegfried, 1978; Ayeni, 1980a; Ayeni, 1983).

An interesting case is that of the Crested Guineafowl, as its populations living in the vicinity of the equator, where there are two wet seasons in the year, nest all year round (del Hoyo *et al.,* 1994). The first signs of breeding can be in the form of an increased frequency and intensity of aggressive behaviour, in particular fights between rival males, and the splitting off from the flock of pairs that have been established (Skead, 1962; Berry, 1972). Male Helmeted Guineafowl can associate briefly with a series of different females, each in its own turn until, over the first four to six weeks. After this period, the pair stabilizes and then remains firm until the end of the breeding attempt. Courtship feeding is known to occur, at any rate and is particularly ritualised in the Helmeted, Crested and Vulturine Guineafowl. All three are monogamous, although males sometimes attempt to mate with other, unattended females (Angus and Wilson, 1964; Ayeni, 1980b; Ayeni, 1981).

Chicks, or keets, hatch synchronously, a common tendency in birds with nidifugous chicks, as it reduces the danger of predation. The Precocial chicks are led away from the nest almost immediately. Although, they are capable of feeding themselves, they still require the guidance and protection of their parents from time to time, and the male shares the task of chick-care with the female, at least in the Helmeted Guineafowl (Benson, 1963; Swank, 1977; Martin, 1992).

Once the breeding season draws to a close, the family group is merged into a much larger flock, consisting of other family groups and some non-breeding birds. Within this flock, the unity of the family group tends to persist, and the young birds remain in the company of their parents for at least two or three months more (Benson, 1961; Malan and Benn, 1999; Crowe and Ratcliffe, 2001b).

It has been calculated that, in an average population of Helmeted Guineafowl, during a normal breeding season, about 30% of the birds do not breed, although it is not known whether or not this percentage refers exclusively to immature birds (Benson, 1960; Mentis and Bigalke, 1979; Urban *et al.,* 1986).

These non-breeders hang about in flocks in the habitual feeding areas, and later join up with the breeders when they return with their young (del Hoyo *et al.,* 1994). Although flocks are fairly stable, each individual does not necessarily return to the same flock that it belonged to before the breeding season (Maphasa, 1996). The breeding biology of the Vulturine Guineafowl on the other hand has been studied only in captive birds (Grahame, 1969; Urban *et al.,* 1986; del Hoyo *et al.,* 1994).

In order to manage gamebird populations efficiently, different aspects of their ecology, such as specific habitat preferences and densities, need to be known (Mentis and Bigalke, 1979; Rodenhouse, 1986; Martin, 1987; Baines, 1996). Extensive literature surveys showed that no study on these aspects of gamebird ecology has been published for non-utilised, unmanaged Guineafowl populations in Eastern Africa (Opdam *et al*., 1995; Simiyu, 1998; Dörgeloh, 2000).

This study may form a baseline for establishment of a gamebird management regime for Laikipia region; besides, the perceptible returns of gamebird management will encourage landowners to implement sound conservation and management decisions to the overall benefit of biodiversity (Crowe and Pero, 1996; Prins *et al.,* 2000).

# CHAPTER 3

## 3.0 MATERIALS AND METHODS

### 3.1 Study area

The study area comprised six sites on four properties (Mpala Ranch, Olpejeta Sanctuary, Oljogi Sanctuary and Elkarama Ranch) arranged along a rainfall gradient in Laikipia district (36º53'E, 0º17'N). Three sites were located on Mpala (Mpala A, B & C) and only one site on each of Elkarama, Oljogi and Olpejeta ranches. Mpala is stocked with both wildlife and cattle for grazing. Wildlife that use Mpala are mainly resident except for elephant and buffalo that move in their seasonal search for pasture and water. The land is not fenced so animals move in and out of the ranch creating an interchange of wildlife with neighbouring ranches. Mpala as a whole comprises an area of 19,487 ha. Oljogi sanctuary (henceforth referred to as Pyramid) is a private wildlife reserve enclosed by an electric fence. It has a greater variety of wildlife than Mpala. The wildlife is strictly protected necessitating a very high road density for patrol purposes. This sites has an area of 3, 871 ha, excluding the main hilly region known as Pyramid. Olpejeta sanctuary (henceforth referred to as Sweetwaters) also has an electric fence and falls in the highest rainfall gradient among the study sites. It comprises an area of 9,716 ha. Elkarama ranch formed the last study site and has an area of 4,796 ha. It falls in the second highest rainfall gradient after Sweetwaters. These study sites were chosen because they have different habitat characteristics which are in turn influenced by the different rainfall gradients that they fall in. This allows one to relate gamebird densities to the differences in habitat and rainfall gradients. In addition the sites all have abundant gamebird diversity (Figure 1 shows study area).


*Figure 1. Map showing location of Laikipia District within Kenya and location of study sites within Laikipia District.*

**3.2 Vegetation descriptions and habitat mapping**

Throughout the Laikipia ecosystem, isolated glades occur within acacia bushland and woodland communities. The woody vegetation is dominated by acacia species (*Acacia brevispica, Acacia ethaica, Acacia mellifera, Acacia gerrardii and Acacia nilotica*) and includes shrubs *Croton dichogamus, Grewia* spp*.,* and *Rhus vulgaris.* The understory is dominated by grasses in the genera *Cynodon, Pennisetum, Digitaria* and *Sporobolus,* and by the herbs *Plectranthus* spp., *Pollichia* spp*., Portulaca* spp., and *Blepharis* spp., (Taiti, 1992).

Two major soil types underlie the Laikipia ecosystem; level soils of impeded drainage, especially deep clay 'black cotton' vertisols; and the red rocky friable soils that predominate on more sloping topographies. These soils support some of the most productive rangelands in East Africa. Both soil types are characterized by a landscape mosaic with numerous isolated 'glades'. These features are treeless, have high levels of mineral nutrients, and are preferentially used by wild and domestic herbivores (Young *et al.,* 1995). These glades are usually less than one hectare in area, but there are also some extensive areas/plains of glade vegetation**.** As in the red soils, glades on black cotton soils are higher in nutrients than are surrounding black cotton soils and are 'hot spots' of herbivore activity. Compared with those on the red soils, black cotton communities are relatively poor in species composition for some but not all groups (Young *et al.,* 1998).

The fauna of both birds and rodents are also far less rich on the black cotton soils than on the adjacent red soils. However, the species richness of large ungulate herbivores and carnivores is equally great on both soil types; not including the specialized habitats of rivers, rocky outcrops, and escarpments (Keesing, 1997; Young *et al.,* 1997; Sundaresan *et al*., 2007).

A well-equipped GIS facility at Mpala Research Center (MRC), with prodigious satellite image and aerial photo coverage, assisted with habitat and Geographic Information Systems (GIS) mapping for this project. This provided information on vegetation descriptions for each major habitat type in the study area, identified by the supervised classification of a *Landsat 7* image taken in February 2002 (Appendix II). Such descriptions consisted of the identity, density and biomass of dominant tree, bush and grass species in each habitat type using methods modified from James and Shurgart (1970) and Wiens and Rotenberry (1981).

### 3.3 Road transects

Due to the expansiveness of the study area coupled with the fact that wild and dangerous animals also occur in the same areas as the guineafowls, it was necessary to conduct gamebird counts from a vehicle being driven at a standard speed of 20km/hr. By using roads as transects, it was assumed that changes in abundance along roads reflected changes in abundance in the whole area; even if density was not the same between road areas and elsewhere. Thus, one can monitor dynamics over time along roads, assuming they represent overall changes, if not abundance. Through use of a Garmin 76 Global Positioning System (GPS), all accessible roads within the study area were tracked before being overlaid onto a map of the study area using *Arc*GIS 9.1 (ESRI, 2005) software. It was not possible to have a standard transect size length due to differences in terrain and vegetation structure within the study sites (Appendix I). Five transects per site were then selected using a stratified random design approach. Each transect was then sampled once in a day for three consecutive days; robust density estimates was achieved by averaging densities obtained from the three replicates.

### 3.4 Bird census

Gamebird transect counts were conducted in all study sites from September 2005 to January 2006. From April 2006 onwards, data were not recorded for Sweetwaters and Elkarama study sites due to budgetary limitations. The sampling regime was instead modified by increasing the sampling intensity for sites within Mpala and Pyramid; this process was repeated for each of the subsequent sampling sessions during the period between April 2006 and April 2007. Distance sampling technique by Buckland *et al.,* (1993) was used to measure guineafowl densities. This method depends on the following four critical assumptions being met: (1) Birds are detected at their initial location prior to any natural movement or movement in response to observer's presence; (2) all birds at zero distance are detected; (3) all sightings are independent and (4) all measurements of distance are accurate. The time of sampling was standardized for all sites and was done in the late afternoons (3.00 pm to 6.00 pm), times when guineafowls were expected to be congregated while feeding, working their way towards roosting areas (Crowe, 2000). At each guineafowl sighting, the GPS waypoint/co-ordinates of the observer's position at the time of the sighting was recorded. An optical rangefinder (Bushnell Yardage Pro with an x6 magnification and a +/-1 metre accuracy) was then used to measure the distance to the birds, and a compass to record the angle of sighting from the road. Sightings beyond fifty metres were recorded for mapping purposes but truncated during the analyses for density estimates as recommended by Buckland *et al.,* (1993). The location of sighting was then *snapped back* to the road through use of GIS to measure the perpendicular distance from the road. Identification of the different stages of development such as chick, juvenile, immature, sub-adult or adult stages was based on observer's experience and also following field notes from Zimmerman *et al.,* (1996).

Censuses were carried out immediately prior to the breeding season to get an index of adult bird numbers, and subsequently after every two months following the breeding season to estimate the survival of adults and the number of first year birds.

### 3.5 Habitat preference

There was no need to collect fine resolution vegetation data on habitat homogeneity/heterogeneity since guineafowl are known to respond to habitat heterogeneity at a landscape scale (Malan and Benn, 1999; Crowe and Ratcliffe, 2001a). Consequently, *Landsat imagery* was considered appropriate for that purpose. During each sampling session, the GPS coordinates were recorded for each flock sighted. A matching 'measure' of habitat was determined as the mean for each of the 6 wavebands comprising each of the 9 pixels from the *Landsat* image surrounding each GPS sighting location. In addition, an equal number of random points within the study area was selected using GIS, and the vegetation characteristics at each point determined both on the ground, and as waveband means from the *Landsat* image. Thus, there was two multivariate data sets (ground-based and pixel-based) describing preferred habitat and 'random' habitat for *each* of the two species.

### 3.6 Population structure

This was assessed by recording the number of individuals in each flock (cluster sampling). The ratio of juveniles to adults was used as a measure of productivity. This was further monitored during the study period to assess whether this varied within and between seasons. Timing of breeding for gamebirds was deduced from behaviour indicative of different stages of breeding e.g. pairing and number of juveniles in a flock. Juveniles were distinguished from adults by size differences and plumage development.

### 3.7 Monitoring protocol

Population dynamics of the two sympatric guineafowl species along with other gamebirds (largely francolin species) was monitored during each sample session (five sample sessions were conducted for the entire study). Sites in which the birds consistently bred every year were identified as potential sources. Sites in which first year birds predominate (identified morphologically as having brown eyes for vulturines-adult bird has red eyes ; and, lacking red in casque for helmeteds-adult has red at the tip of its casque) were identified as sink areas/dispersal areas for excess birds that have been displaced from the main population 'source' by dominant mature birds. Source-sink dynamics is a theoretical model used by ecologists to describe how variation in habitat quality may affect the population growth or decline of organisms (Watkinson and Sutherland, 1995; Tittler *et al*., 2006). With the monitoring protocol in place, recommendations were then put forward to landowners on when it is safe to harvest surplus birds including information on number of gun days and shooting bag limits.

### 3.8 Data analysis

Bird data were grouped per species and per site for each of the five data collection sessions during fieldwork and analysed through *Distance 5* sampling software to derive densities. *Systat 9.0* (SPSS, 1999) software was then used to present density and abundance outputs in the form of graphical presentations, pie charts and tables. This was to determine whether any variations occurred within and between species due to differences in habitat or amount of rainfall received in a particular site. The GPS coordinates of the waypoint for each game bird sighting during each session of data collection were recorded; and overlaid through *AcrGis 9.1* (ESRI, 2005) software onto a habitat map comprising the whole study area. This was to reveal the gamebird distributions and frequency of occurrence per study site.

Shannon-Wiener diversity index was used to measure diversity of gamebird species within each study site. It is calculated as:

Diversity Index $H' = \sum p_i . \ln(p_i)$

Where *H'* is the information content of sample/index of species diversity, $p_i$ is the proportion of species *i* expressed as a proportion of the total number of individuals of all species, ln is the natural logarithm, and $\sum$ represents the total $p_i.\ln(p_i)$ for all species. Shannon-Wiener index is based on information theory, as a measure of information content or uncertainty. This index is dependent upon species richness (S), and evenness (number of individuals in each species). Within an ecological context, it is the amount of uncertainty associated with the identity of a randomly selected individual. If a community has low species diversity and is largely dominated by one species, the identity of a randomly selected individual has a low degree of uncertainty and the associated *H'* will be low. In a community with high species richness and evenness, there is a large degree of uncertainty associated with the identity of a randomly selected individual or species and therefore the associated value of *H'* will be high. A community with only one species has no uncertainty in it, and therefore $H' = 0$. The value of *H'* increases with S but rarely exceeds $H' = 5.0$ (Bibby *et al.,* 1992).

The proportions of juvenile birds within populations of game birds (recruitment rate) was tabulated and analysed through the data analysis tool/component of *Microsoft Excel* and used as a measure of productivity. Productivity/recruitment rate of a given population is measured by its increase in size, mainly due to younger members being added to the population through birth. The productivity of each gamebird population within each study site was recorded during each of the five sampling sessions of fieldwork.

Generalised Linear Models (GLM) was used to fit habitat-bird density models using the *Systat 9.0* software. GLMs are an extension of the classical linear or multiple regression models where model coefficients are estimated by a maximum likelihood ratio (ML) algorithm or some variant of it, instead of the classical Ordinary Least Squares (OLS). GLMs are increasingly used in ecology to summarise the relationships between species distributions and environmental variables (Guisan *et al.,* 2002; Omolo, 2006).

A post hoc test at P = 0.05 (Tukey's HSD) was then computed to confirm the significance of ANOVA tests. The following steps are followed when computing the Tukey test: (1) rank the sample means in order of increasing magnitude; (2) calculate the standard error (S.E.) using the formula, S.E. $=\sqrt{S^2/r}$ (Where $S^2$ = error Mean square in the ANOVA, while $r$ = the number of replicates; (3) tabulate pairwise comparisons and obtain the computed $q$ by dividing the difference between the paired means by the standard error.

If the calculated $q$ is equal to or greater than the critical $q$ at $q_{\alpha,\gamma,k}$ (Where $\alpha$ = the level of confidence ,$\gamma$ = error degrees of freedom and $k$ = number of treatments), then the null hypothesis is rejected.

# CHAPTER 4

## 4.0 RESULTS

### 4.1 Analyses of effect of habitat associations on guineafowl population dynamics

Guineafowl densities were derived using Distance Sampling Software (Version 5) and ANOVA tests performed using *Systat9.0* statistical software. The following results were observed in each study site (Table 1 at P = 0.05 Tukey's HSD): in Mpala A, mean Helmeted Guineafowl densities were significantly higher than those of the Vulturine Guineafowl and the Yellow-necked Spurfowl.

There was no significant difference between mean vulturine and spurfowl densities in Mpala A; in Mpala B, helmeted, vulturine and spurfowl mean densities significantly differed, with vulturines being the dominant species; in Mpala C, mean vulturine densities were significantly higher than those of helmeteds and spurfowls. However, the mean helmeted and spurfowl densities were not significantly different in Mpala C; in Pyramid, even though the mean helmeted and vulturine guineafowl densities did not significantly differ from each other; they both had significantly higher densities than those of the spurfowls.

A Shannon-Wiener analysis performed showed Pyramid scoring the highest diversity index (H') for all sites followed in decreasing order by Mpala A, Mpala B and Mpala C. The higher the index, the higher the magnitude of gamebird diversity in a site; consequently, Pyramid was the richest site in terms of gamebird diversity followed by Mpala A, Mpala B and lastly, Mpala C (Table 2).

Vulturine Guineafowls were not observed in two study sites (Sweetwaters and Elkarama ranches) and since the focus of this research was to compare the population dynamics of two guineafowl species (vulturine & helmeted) in relation to habitat type; and mainly due to budgetary limitations, sampling effort was thereby concentrated on the four sites that had both guineafowl species. These included; Mpala A, B & C and Pyramid.

However, for every guineafowl or francolin spotted during the entire study duration whether in Elkarama or Sweetwaters, the waypoints for its GPS location was recorded and overlaid onto a GIS map to show their spatial distributions across all study sites. The game bird distributions across study sites seemed non uniform, with clustered sub-populations occurring in certain regions only, within each study site (Figure 2).

*Table 1. Mean (±S.E.) bird densities per square kilometer in each site. Means represent averages over five sampling sessions. Within each site, means marked with different letters are significantly different at P= 0.05 (Tukey's HSD).*

| Gamebird species | Site | | | |
|---|---|---|---|---|
| | Mpala A | Mpala B | Mpala C | Pyramid |
| Helmeted Guineafowl | $8 \pm 1.5^{a}$ | $10 \pm 4.3^{b}$ | $2 \pm 0.5^{b}$ | $12 \pm 4.6^{a}$ |
| Vulturine Guineafowl | $2 \pm 0.7^{b}$ | $41 \pm 10.6^{a}$ | $35 \pm 11.2^{a}$ | $8 \pm 4.8^{a}$ |
| Yellow-necked Spurfowl | $3 \pm 1.8^{b}$ | $1 \pm 0.6^{c}$ | $3 \pm 1.4^{b}$ | $4 \pm 0.8^{b}$ |

*Table 2. Game bird diversity index for each study site.*

| Study site | Shannon-Wiener diversity index (H') |
|---|---|
| Mpala A | 0.379 |
| Mpala B | 0.291 |
| Mpala C | 0.233 |
| Pyramid | 0.508 |

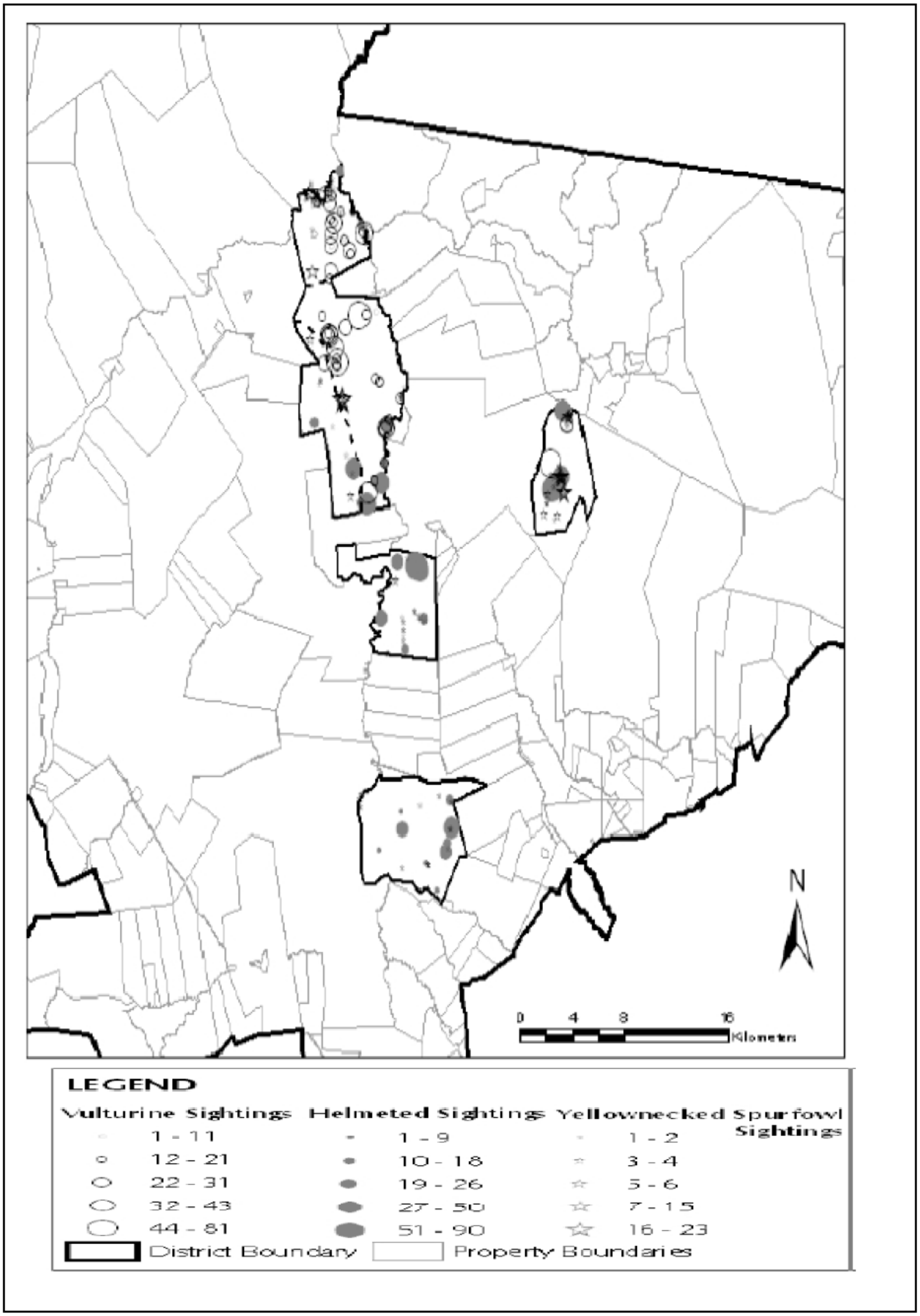


*Figure 2. Map of study area highlighting the properties on which vulturine (open circles), helmeted (closed circles) and Yellow-necked Spurfowl densities (open stars) have been censused from September 2005 to April 2007.*

**4.2 Analysis of effect of rainfall on guineafowl population dynamics**

General linear models (GLM) was used to derive habitat-bird density models for data obtained during the five sampling sessions. Consequently, both rainfall and guineafowl density data for the entire study duration was modelled to reveal if any relationships existed between guineafowl densities for each site and the rainfall recorded (Figures 3a,b,c & d).

In Mpala A (Figure 3a), the Helmeted Guineafowl densities seemed to increase despite the sharp decline in amount of rainfall between September 2005 and January 2006. As rainfall continued to increase between January and April 2006, the guineafowl densities continued to increase before reaching a peak in density during March/April 2006. Between March 2006 to October 2006, the helmeted densities seemed to decrease despite further increase in amount of rainfall. As amounts of rainfall decreased between October 2006 to April 2007, the helmeted densities also continued to decline.

The Vulturine Guineafowl densities seemed to increase with increase in rainfall before recording a peak in density during March/April in 2006. The peak in vulturine densities was followed by a drop to a minimum low in August/October2006, despite this being the period that recorded the highest rainfall. Finally, the vulturine densities seemed to increase as rainfall decreased between the period August 2006 and April 2007.

In Mpala B (Figure 3b), both species of guineafowl recorded their highest peaks in density during August/October 2006; the duration with the highest recorded rainfall. Both species of guineafowl seemed to record increases in density with increases in amount of rainfall and vice versa.

In Mpala C (Figure 3c), Helmeted Guineafowls recorded very low densities irrespective of the rainfall patterns. Vulturine Guineafowls on the other hand recorded the highest peak in densities in January 2006; the period with the lowest amount of rainfall. From January 2006 to April 2006, vulturine densities decreased as amount of rainfall increased during the same period. Between April 2006 to October 2008, the vulturines recorded a plateau in densities despite this period recording the highest amount of rainfall. The vulturine densities then increased further despite the decrease in rainfall between the period August 2006 and April 2007.

In Pyramid (Figure 3d), the Helmeted Guineafowl densities seemed to decrease with decrease in rainfall between September 2005 to January 2006. Their densities, however, continued to decrease further despite the increase in amount of rainfall between January 2006 to October 2006. In contrast, during the period between October 2006 to April 2007, helmeteds recorded an increase in densities as the amount of rainfall decreased.

The vulturines recorded the highest peak in density in January 2006, the period with the lowest rainfall. Between January and April 2006, the vulturine densities decreased as amount of rainfall increased. Between April 2006 and October 2008, the vulturines recorded a plateau in densities despite this period recording the highest amount of rainfall. Unlike Mpala C, the vulturine densities in Pyramid seemed to decrease with decreases in amount of rainfall between the period August 2006 and April 2007.

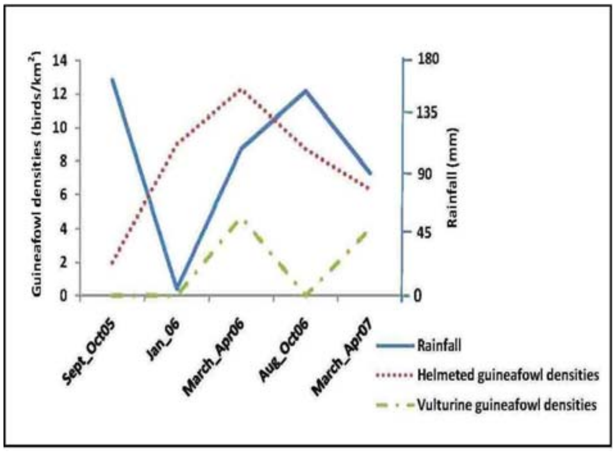


*Figure 3a. Relationship between guineafowl densities and rainfall in Mpala A.*

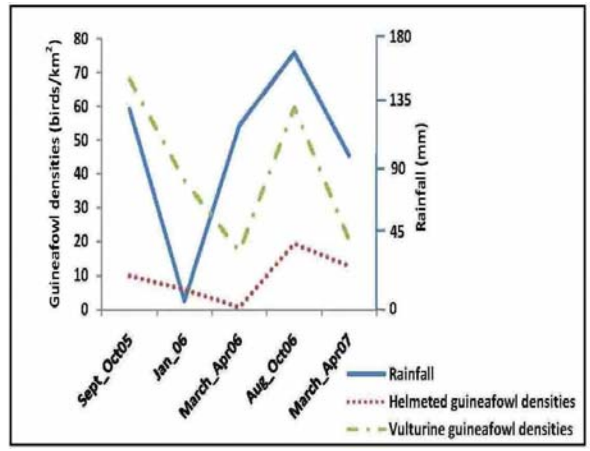


*Figure 3b. Relationship between guineafowl densities and rainfall in Mpala B.*

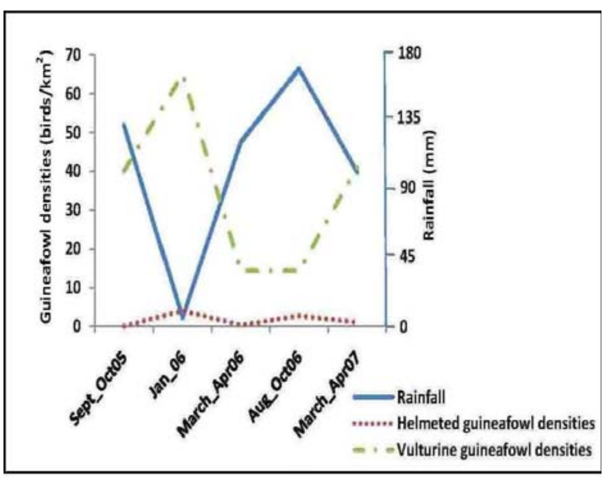


*Figure 3c. Relationship between guineafowl densities and rainfall in Mpala C.*

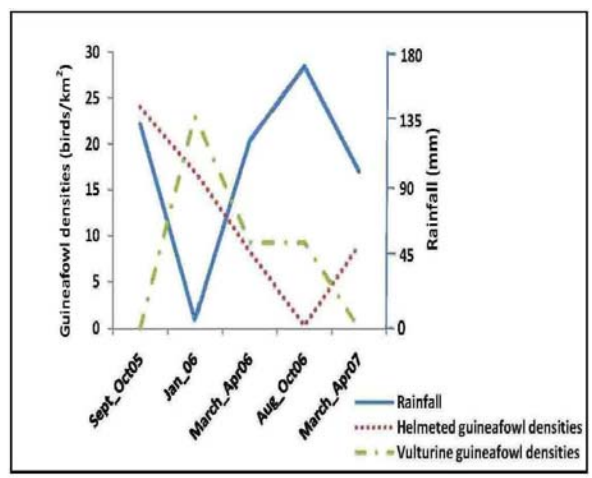


*Figure 3d. Relationship between guineafowl densities and rainfall in Pyramid.*

## 4.3 Analysis of recruitment rate as a measure of guineafowl productivity

No recruitment was observed for gamebird species in all study sites during the sampling session of March_April 2006. During the August_October sampling session, there was no recruitment observed for all gamebird species within the study sites with the exception of Mpala B. Recruitment rates for gamebird species within Mpala A were recorded during the last sampling session only (March_April 2007). The highest recruitment rates for each gamebird species was recorded during the final sampling session of March_April 2007.

During all sampling sessions, helmeted recruitment rates were observed not to exceed 20%. Vulturines on the other hand recorded a higher recruitment rate than the helmeteds at 30% in Mpala B and C during the final sampling session (Table 3). Recruitment/productivity was observed to coincide with durations preceded by substantial rainfall. Consequently, both species of guineafowl were observed to breed at least once in a year mainly after the long rains.

*Table 3. Recruitment rates (%) of game bird populations within each study site with the dash (-) indicating absence of that species during that particular sampling period.*

| Mpala A | | | | | |
|---|---|---|---|---|---|
| Gamebird species | Sept_Nov05 | Jan_06 | Mar_Apr06 | Aug_Oct06 | Mar_Apr07 |
| Helmeted Guineafowl | 0 | 0 | 0 | 0 | 20 |
| Vulturine Guineafowl | - | - | 0 | - | 10 |
| Yellow-necked Spurfowl | 0 | - | - | 0 | 10 |
| **Mpala B** | | | | | |
| Gamebird species | Sept_Nov05 | Jan_06 | Mar_Apr06 | Aug_Oct06 | Mar_Apr07 |
| Helmeted Guineafowl | 0 | 10 | 0 | 10 | 20 |
| Vulturine Guineafowl | 0 | 10 | 0 | 20 | 30 |
| Yellow-necked Spurfowl | 0 | - | 0 | 0 | 30 |
| **Mpala C** | | | | | |
| Gamebird species | Sept_Nov05 | Jan_06 | Mar_Apr06 | Aug_Oct06 | Mar_Apr07 |
| Helmeted Guineafowl | - | 0 | 0 | 0 | 20 |
| Vulturine Guineafowl | 10 | 20 | 0 | 0 | 30 |
| Yellow-necked Spurfowl | 0 | 0 | 0 | 0 | 20 |
| **Pyramid** | | | | | |
| Gamebird species | Sept_Nov05 | Jan_06 | Mar_Apr06 | Aug_Oct06 | Mar_Apr07 |
| Helmeted Guineafowl | 20 | 10 | 0 | 0 | 20 |
| Vulturine Guineafowl | - | 20 | 0 | 0 | - |
| Yellow-necked Spurfowl | 30 | 0 | 0 | 0 | 20 |

# CHAPTER 5

## 5.0. DISCUSSION

### 5.1 Habitat and guineafowl abundance

Habitat was identified as having a significant effect on game bird populations (Table 1). These findings are supported by Lack (1954) who identified habitat quality and quantity as primary limiting factors that influence bird populations. Savannah habitats predominate the Laikipia landscape ecosystem. Ayeni (1980a) investigated the chemical properties of soil samples from the major sites which were intensively utilised by guineafowl; results showed that guineafowl habitat is characterized by high variability in pH and mineral levels. These findings are consistent with the fact that the mineral characteristics and pH values vary in the soil according to the nature of the parent rock materials, moisture gradient, location of sites. The ability of the bird to tolerate variabilities in the chemical characteristics of the sites which it investigates in the course of its normal life enhances survival and accounts for its widespread distribution throughout the savannah habitats.

Based on the results of this study, it will be possible to predict guineafowl occurrences and distributions across various rainfall gradients and habitat types within Laikipia, through Landsat imagery and remote sensing technology.

Studies on game birds in Europe have shown that species such as Grey Patridge *Perdix perdix* Rands (1986) and Black Grouse *Tetrao tetrix* Baines (1996), have high specific nest site habitat requirements, which may be a factor important for their survival. The optimum environment of a species usually coincides with most productive types in the range of habitats occupied by a species (Folse, 1982; Rands, 1988).

Four major habitat types (Figures 1 & 2 and Table 1) were evident in the study area: (1) Acacia woodland predominated by rocky outcrops; soil type here is the black cotton soil (Mpala A); (2) Closed canopy vegetation interspersed by open patches of grassland; soil type-red soil (Mpala B); (3) Open acacia woodland; soil type- red soil (Mpala C); and (4) Mixture of closed canopy vegetation and open acacia woodland interspersed by large patches of grassland. Two soil types evident in the latter were black cotton and red soil (Pyramid).

The following observations were made when the above habitat type descriptions were linked up with results from Table 1: Helmeted Guineafowl recorded their lowest densities in Mpala C (habitat type 3) and highest densities in Pyramid (habitat type 4) while Vulturines recorded their lowest densities in Mpala A (habitat type1) and highest densities in Mpala B (habitat type 2). While a significant difference in densities was observed for both guineafowl species in Mpala A, B and C (helmeteds recording higher densities than vulturines in Mpala A; and vulturines recording higher densities than the helmeteds in Mpala B and C), no significant difference in densities of the two guineafowl species was observed in Pyramid.

It therefore implies that helmeteds tend to fare better than vulturines in areas where habitat type 1 predominates, while vulturines tend to fare much better than helmeteds in habitat types 2 and 3. In contrast, in habitat type 4, no guineafowl species seemed to have an advantage over the other (co-dominance).

It is also worth of note that it is Pyramid with habitat type 4 that scored the highest index for gamebird diversity in comparison to the 3 other habitat types according to a Shannon-Wiener diversity index (Table 2).

Glades (open patches of grassland) were observed to occur albeit in varying proportions in all study sites; it is therefore evident that seasonal balance of available grassland has important consequences for guineafowl who require cover for nesting, refuge from predators and for protection from the elements.

The non-uniform distribution of guineafowl sub-populations across study sites (Figure 2) could be explained by Wiens (1977) competition theory, which predicts that; populations will track variations in resources by adjusting population sizes or modes of resource utilization. Göransson *et al.,* (1991) support the Wien's competition theory by stating that animals are rarely distributed at random over the landscape, but rather according to the occurrence of essential resources.

However, as natural and anthropogenic forces change the availability of habitats, the proportion of individuals of a given species in any particular habitat may be altered (Pulliam and Danielson, 1991). Most theories of optimal foraging (e.g. Myers *et al.,* 1981) predict that individuals should specialize on the most productive habitat patches or restrict their diet to the optimal prey types when resources become more abundant. Observations from this study resonate well with arguments put forward by Malan and Benn (1999) and Crowe and Ratcliffe (2001a) that guineafowls thrive under a mosaic of habitats on a landscape scale.

**5.2 Seasonality and guineafowl abundance**

Due to Laikipia's leeward position North West of the Mt. Kenya massif, it is comparatively dry despite its location on the Equator. The spatial distribution and the temporal viability of rainfall though are strongly influenced by the Mt. Kenya and the Aberdares range. Along the foot zones of the massifs, the annual mean rainfall can go up to over 1100 mm, but decreases towards the central and northern areas of Laikipia.

Precipitations also vary greatly in terms of time and amount along the same gradient. The rains primarily fall in two seasons; the main wet season occurs during April-May, often accounting for 80% of total annual rainfall, while a second wet season occurs later in the year in October-November (Ojwang, 2000; Taylor *et al.,* 2005).

Rainfall seemed to have indirect effects on game bird densities (Figures 3a, b, c & d; and analysis of effect of rainfall on guineafowl population dynamics in section 4.3). Guineafowls were observed not to be uniformly distributed across the study sites (Figure 2); sub-populations apparently clustered around areas with drinking water. If there is a relatively high frequency of rainfall during a particular year, existing sub-populations will breed successfully utilizing the abundant ripe grass seeds and high protein arthropod food that becomes available (Ayeni, 1983; Berry and Crowe, 1985).

Furthermore, new areas of suitable habitat will arise around temporary water. Many of these new areas are colonized by emigrants, probably mainly juveniles, from areas with more persistent water. If, in the subsequent year(s) the frequency of rainfall becomes relatively low, ephemeral water will dry up, and the sub-populations that utilised this resource must seek out other areas with drinking water. Immigrants are resisted, usually successfully by guineafowl resident at areas with more persistent water (Liversidge, 1966).

However, social disturbances by potential immigrants, plus competition for mates between resident males, lead to an increase of energy expenditure in agonistic behaviour; and may hinder male-female pairing and reduce feeding efficiency of resident birds (Crowe, 1978b).

Since breeding in female birds in general and rapid growth of young guineafowl in particular, seem to depend on the acquisition of high protein food (Davis, 1943; Jones and Ward, 1976), any factor which decreases the effective consumption of arthropods can depress breeding success.

Thus, in a poor-food-quality situation, those few females which pair successfully may not have the necessary protein reserves to lay and incubate successfully; and those few keets that hatch may suffer heavy mortality ultimately, due to nutritional deficiency mostly likely caused by lack of rain (Crowe and Siegfried, 1978).

Therefore, rainfall and its indirect effects (improved vegetation cover providing abundant shade and litter for nesting sites; access to drinking water; and availability of plant and arthropod food) could be limiting factors to game bird populations.

Periods marked by decreases in game bird densities that accompany increases in rainfall (Figures 3c & d), could be attributed to low reproductive success due to mis-timed breeding; and the adverse effects of rainfall on downy young (e.g. hypothermia). Cold, wet conditions may also make the guineafowl sluggish and therefore more easily caught by natural predators. During this study, guineafowl were observed to prefer relatively dry, open grassland, and avoided dense wet grass.

Since guineafowl will readily abandon nests and young under adverse conditions, and also since pairing is strongly correlated with frequency of rainfall (Crowe and Siegfried, 1978), the timing of pairing therefore becomes critical.

If pairing occurs at the right time, the female can build up the necessary reserves for incubation (she incubates the eggs alone); and keets hatch when conditions are essential for their survival (e.g. food quality/quantity, cover etc.) are optimal. In contrast, high rainfall and subsequent pairing may result in increased nesting failure and/or keet mortality.

Despite its indirect effects on guineafowl populations, frequency of rain is still arguably a good predictor of game bird populations. Odum (1971) states that a population can be limited by a physical factor, such as rainfall, which fluctuates markedly and unpredictably. Ojwang (2000) and Taylor *et al.,* (2005) have demonstrated that rainfall in Laikipia is highly variable and unpredictable. Simiyu (1998) surmised that game bird populations in East Africa are limited in a density independent manner, primarily by unpredictable rainfall. Skead (1962) and Mentis *et al.,* (1975) have speculated that poor breeding success may be due to the negative effects of low rainfall on the availability of high protein insect food, an important component in the diet of breeding guineafowl.

### 5.3 Game bird monitoring, recruitment rates, density estimates and quota allocation

The methodological framework adopted in this study is simple, robust and replicable. Through it, one can monitor annual variation in guineafowl densities in a particular management unit/ranch in Laikipia. Recruitment rates (rates at which young are reproduced) seemed variable across study sites and across seasons. Recruitment is observed to coincide with durations preceded by abundant rainfall (Berry and Crowe, 1985).

Both species of guineafowl were observed to breed at least once every year. Table 3 reveals sampling sessions that showed no recruitment of young and this could be attributed to failure of rains.

It was observed that whenever recruitment occurred in the game bird populations, its range was between 10 - 30 % of the adult population (Table 3). This is not unexpected due to the unpredictability of the environmental conditions in the East African region (Brown and Britton, 1980).

For safety purposes (to minimise disturbance and prevent over-harvesting) and also based on the results of this study, harvesting quotas (percentage of individuals to be cropped from the population) for gamebirds occurring in Laikipia should be pegged at 10% (this is the minimum annual recruitment rate for each guineafowl species) of the total population estimates. It should take place once a year and only after the long rains, preferably in August with the precise timing set to maximise the offtake of first-year birds, most of whom die or disperse.

The end of the long rains in Laikipia occurs towards the end of May each year (if the long rains are consistently punctual in subsequent years). The breeding period is expected to commence towards the end of the long rains; by August the adult birds are expected to have fully bred and reproduced their young. However, no harvesting should take place during seasons of failed rains as the birds are not expected to have bred during such times.

Monitoring of the game bird populations is recommended to take place at least three times a year in the months of January, August and December. This captures well any dynamics in the gamebird population structure, helps to determine annual breeding success by recording and comparing the number and proportion of juvenile birds in a given population; and allows for flexibility whereby, hunting quotas can be varied depending on the prevailing environmental conditions that may be limiting to the local game bird populations in each management unit/ranch.

Flexibility of the hunting quotas implies that during years in which high recruitment has been observed, the hunting quota could be slightly adjusted upwards to match the influx in population estimates. It is advisable to allow for safety nets, by pegging each hunting quota to a slightly lower percentage than the current recruitment rate. This allows for recovery of the harvested population and ensures sustainability of the entire process.

Game bird monitoring also ensures that red flags are raised in good time in cases where decreases in populations are recorded; such warnings should lead to cessation of any harvesting activity to allow the game bird populations to recover.

# CHAPTER 6

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

The following observations were made at the conclusion of the study:

1. Habitat has an influence on guineafowl population dynamics; distributions of guineafowls will be predictable through multi-wavelength data from Landsat imagery.

2. Rainfall is potentially a reliable predictor of guineafowl populations in Laikipia. Both Guineafowl species breed at least once every year after the long rains season. The birds also suspend breeding (and thereby recruitment) during periods marked by long dry spells/drought conditions.

3. The methodological framework adopted in this study is simple, robust and replicable. Through it, one can monitor annual variation in guineafowl densities in a particular management unit/ranch in Laikipia.

## 6.2 Recommendations

The following are recommendations based upon the study findings:

a.) The game bird population monitoring framework designed in this study should be done at least three times a year during the months of January, August and December. This captures well any dynamics in the game bird population structure and allows for flexibility whereby, hunting quotas can be varied depending on the prevailing environmental conditions that may be limiting to the local game bird populations in each management unit/ranch.

b.) Harvesting quotas for game birds occurring in Laikipia should be pegged at 10% of the total population estimates, should take place once yearly and only after the long rains, preferably in August.

c.) The harvesting activity should be halted in years marked by drought/failed rains as the birds are expected not to have bred.

d.) Training workshops for community members should be conducted to the level of being competent enough to independently carry out game bird monitoring schemes for the gamebird populations occurring in their properties.

## 6.3 Further research

Road transects even though effective for censusing guineafowl populations, did not prove effective for sampling populations of other game birds. The census data gathered for such species during the surveys were inadequate for analysis using the Distance software. The species included: Lichtenstein's Sandgrouse *Pterocles lichtensteinii;* Four-banded Sandgrouse *Pterocles quadricinctus;* Crested Francolin *Francolinus sephaena;* Hildebrandt's Francolin *Francolinus hildebrandti* and Shelley's Francolin *Francolinus shelleyi*. Game bird research conducted elsewhere indicates that, census for Sandgrouse populations are effective when conducted at water points (Simiyu, 1998; Little *et al.,* 1993; Lloyd *et al.,* 2001a; Lloyd *et al.,* 2001b).

Further studies should therefore be conducted to determine the time budgets (times when birds conduct particular activities during the course of a day) or water point visitation times (frequency/number of times especially during morning or evening hours of each day when birds congregate at particular watering locations to drink water) for the game bird populations that could not be adequately censused using road transects.

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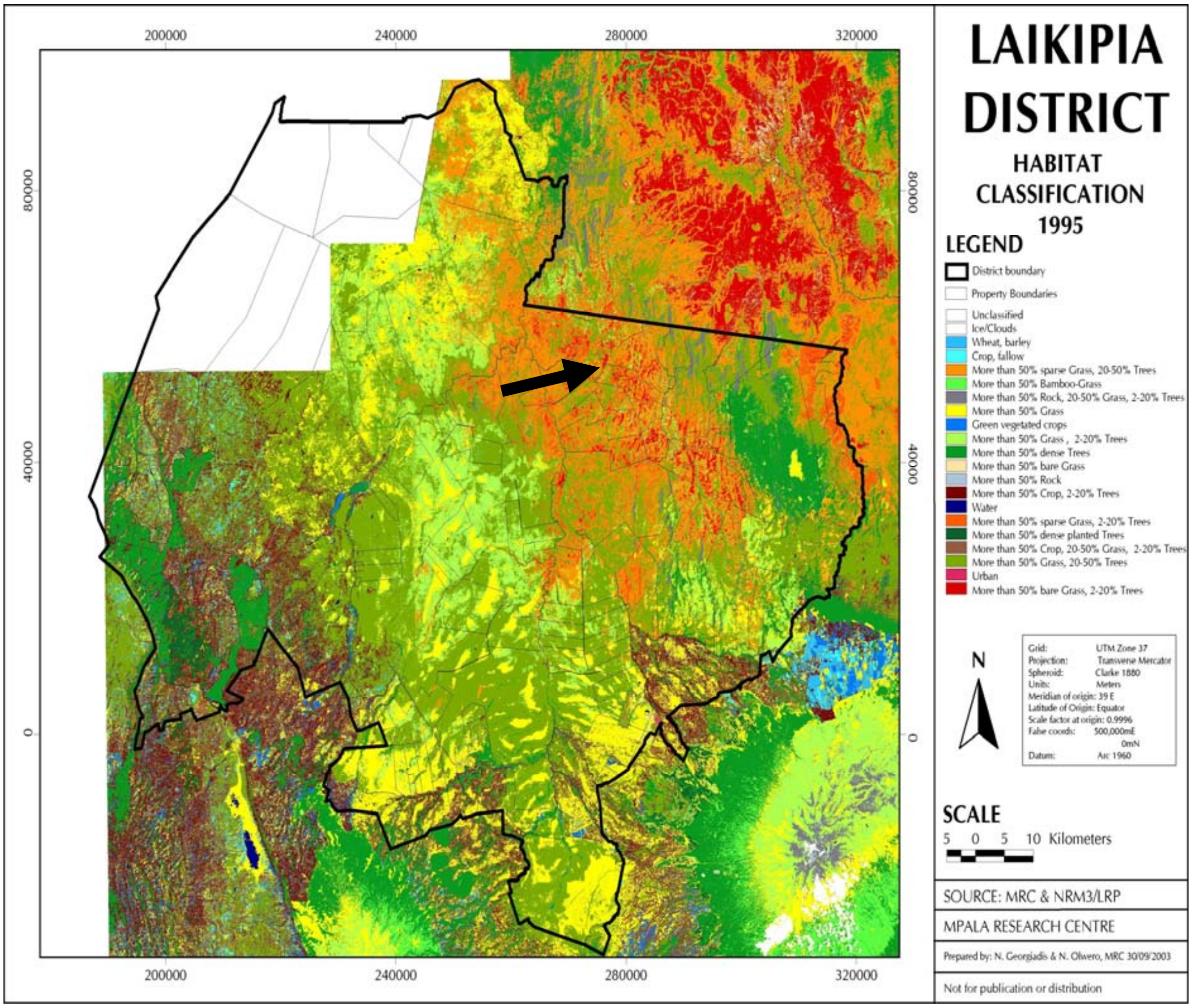
**Appendix I.** *Transect lengths within each study site in the study area.*

| Study site | Area (ha) | Transect | Length (km) |
|---|---|---|---|
| Mpala A | 4,806 | T1 | 3.5 |
| | | T2 | 6 |
| | | T3 | 4 |
| | | T4 | 5.5 |
| | | T5 | 4 |
| Mpala B | 10,031 | T6 | 3.5 |
| | | T7 | 13 |
| | | T8 | 5.3 |
| | | T9 | 12 |
| | | T10 | 10.1 |
| Mpala C | 4,650 | T11 | 6 |
| | | T12 | 10.1 |
| | | T13 | 8.5 |
| | | T14 | 6.5 |
| | | T15 | 7.1 |
| Oljogi Sanctuary | 3,871 | T1 | 3.9 |
| | | T2 | 4.7 |
| | | T3 | 5.1 |
| | | T4 | 3.2 |
| | | T5 | 9.7 |
| Elkarama | 4,795 | T1 | 6.3 |
| | | T2 | 4.2 |
| | | T3 | 3.1 |
| | | T4 | 2.9 |
| | | T5 | 8.4 |
| Olpejeta Sanctuary | 9,716 | T1 | 6 |
| | | T2 | 16.5 |
| | | T3 | 9.2 |
| | | T4 | 4.5 |
| | | T5 | 9.1 |




**Appendix II.** *Thumbnail of a supervised habitat classification by P. Niederer based on a 1995 Landsat TM image. MRC has just completed a similar classification of two Landsat 7 images covering Laikipia District from February 2002. (location of MRC is arrowed).*

**Appendix III.** *Species list of gamebirds (along with raptors known to predate on them highlighted in bold) spotted within study area.*

| Species | Family | Scientific name |
|---|---|---|
| Egyptian Goose | Anatidae | *Alopochen aegyptiacus* |
| Hottentot Teal | Anatidae | *Anas hottentota* |
| Knob-billed Duck | Anatidae | *Sarkidiornis melanotos* **am** |
| Red-billed Teal | Anatidae | *Anas erythrorhyncha* |
| **Augur Buzzard** | Accipitridae | *Buteo augur* |
| **Black Kite** | Accipitridae | *Milvus migrans* **am, pm** |
| **Eastern Pale Chanting Goshawk** | Accipitridae | *Melierax poliopterus* |
| **Martial Eagle** | Accipitridae | *Polemaetus bellicosus* |
| **African Harrier Hawk** | Accipitridae | *Polyboroides typus* |
| **Steppe Eagle** | Accipitridae | *Aquila nipalensis* **pm** |
| **Tawny Eagle** | Accipitridae | *Aquila rapax* |
| **Verreaux's Eagle** | Accipitridae | *Aquila verreauxii* |
| **Lanner Falcon** | Falconidae | *Falco biarmicus* |
| **Peregrine Falcon** | Falconidae | *Falco peregrinus* **pm** |
| Crested Francolin | Phasianidae | *Francolinus sephaena* |
| Harlequin Quail | Phasianidae | *Coturnix delegorguei* **am** |
| Shelley's Francolin | Phasianidae | *Francolinus shelleyi* |
| Hildebrandt's Francolin | Phasianidae | *Francolinus hildebrandti* |
| Yellow-necked Spurfowl | Phasianidae | *Francolinus leucoscepus* |
| Helmeted Guineafowl | Numididae | *Numida meleagris* |
| Vulturine Guineafowl | Numididae | *Acryllium vulturinum* |
| Black-bellied Bustard | Otididae | *Eupodotis melanogaster* |
| Crested Bustard | Otididae | *Eupodotis ruficrista* |
| Hartlaub's Bustard | Otididae | *Eupodotis hartlaubii* |
| Kori Bustard | Otididae | *Ardeotis kori* |
| White-bellied Bustard | Otididae | *Eupodotis senegalensis* |
| Lichtenstein's Sandgrouse | Pteroclidae | *Pterocles lichtensteinii* |
| Four-banded Sandgrouse | Pteroclidae | *Pterocles quadricinctus* |
| African Green Pigeon | Columbidae | *Treron calva* |
| African Mourning Dove | Columbidae | *Streptopelia decipiens* |
| Dusky Turtle-Dove | Columbidae | *Streptopelia lugens* |
| Emerald-spotted Wood Dove | Columbidae | *Turtur chalcospilos* |
| Laughing Dove | Columbidae | *Streptopelia senegalensis* |
| Namaqua Dove | Columbidae | *Oena capensis* |
| Tambourine Dove | Columbidae | *Turtur tympanistria* |
| Red-eyed Dove | Columbidae | *Streptopelia semitorquata* |
| Ring-necked Dove | Columbidae | *Streptopelia capicola* |
| Speckled Pigeon | Columbidae | *Columba guinea* |

***Key: am= afrotropical migrant*** ***pm = palearctic migrant***