STATUS AND HABITAT CHOICE OF TURNER'S EREMOMELA, *Eremomela turneri* (Van Someren 1920) IN SOUTH NANDI FOREST RESERVE -KENYA

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DEDICATION

To My long suffering mother, my elder brother, my wife, my son and my four little daughters for their tolerance and understanding and to the ideal of a clean environment for them and for all of the poor suffering people of the Earth.

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ABSTRACT

This study was carried out on Turner’s Eremomela, *Eremomela turneri,* a globally Vulnerable bird species of mid-altitude forests. The nominate race *turneri*, is known only from South Nandi and Kakamega forests in western Kenya. Prior to the present study, there was very little documented about the ecology of this species particularly its recent status.

The main objective of the study was to estimate the population of Turner’s Eremomela in South Nandi Forest as well as to determine the factors best explaining its presence, distribution and habitat choice. The forest was stratified by altitude into three blocks where detailed eremomela counts and vegetation sampling were carried out. Vegetation parameters predicted to be important for its survival and hence occurrence in the forest were measured.

The population of Turner’s Eremomela was estimated to be 13,900 with an overall density of 1.06 eremomelas ha $^{-1}$. The eremomela foraged in groups of two to eight birds and predominantly in groups of four which accounted for 55.2% of all the sightings. There were no significant differences between the blocks in the group sizes. The estimated density of groups was 0.27 ha $^{-1}$.

E. turneri utilised seven of the more than sixty tree species occurring in the forest. 74.1% of all the sightings were in *Croton megalocarpus,* while only 8.5% of trees recorded in vegetation sampling plots were *C. megalocarpus*. This indicate that the bird had a very strong preference for this tree species. The spatial distribution of the bird within the forest was mainly influenced by maximum canopy height and percentage canopy cover. The means of these parameters were higher in the eremomela-occupied than in the eremomela-unoccupied areas.

The eremomela exhibited a high degree of micro-habitat selection. This was strongly influenced by percentage canopy cover, tree density, maximum canopy height and average canopy height. Index of tree dispersion and the number of tree with height < 10 m were negative predictors.

A logistic regression model selected maximum canopy height, percentage canopy cover and index of tree dispersion (distance) as the best positive predictors of the presence of *E. turneri* at macro-habitat level. Maximum canopy height was the strongest predictor while index of tree dispersion (based on dbh) and minimum canopy height were negative predictors. The same model selected percentage canopy cover, the number of trees with diameter at breast height (dbh) of 10-35cm and maximum canopy height as the best positive predictors of the presence of the bird at micro-habitat level. Percentage canopy cover was the strongest predictor while index of tree dispersion (dbh) and the number of trees with height <10 m were negative predictors. The number of trees encountered with dbh > 10 cm, number of trees with height of 11-20 m and number of *Croton megalocarpus* and *Celtis africana* were selected by a normal multiple regression model as the factors important in influencing the density of the bird in the forest.

The factors important for the survival of *E. turneri* in S. Nandi Forest, particularly canopy cover, canopy height, tree height and the abundance of *C .megalocarpus* have been changed by logging among other forest uses. This has resulted

in loss and fragmentation of the bird's optimal habitats. Presently, these optimal habitats occur as patches or 'islands' within a matrix of degraded forest. This in turn has affected the spatial distribution of the bird in the forest with a bias towards the low altitude areas (block L) which is less disturbed.

Though South Nandi Forest appears to be the world's stronghold of this race *turneri*, forest encroachment and the present logging (concentrating on *C. megelocarpus*) are a serious threat to the bird's continued survival. A comprehensive conservation and management plan for the forest is urgently needed.

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CHAPTER ONE

1.0 INTRODUCTION AND LITERATURE REVIEW

1.1 BACKGROUND

Turner's Eremomela, *Eremomela turneri* (Van Someren 1920) is a bird species of mid-altitude forests in eastern Africa, with a scattered and fragmented range (Collar and Stuart, 1985, Collar *et al*, 1994). A taxon is said to be Vulnerable when it is facing a high risk of extinction in the wild in the medium-term future i.e 10% chance of extinction in 100 years (Collar *et al*, 1994). Turner's Eremomela is listed as a globally Vulnerable species (Collar *et al*, 1994). The nominate race *turneri* is found only in Kakamega and South Nandi forests in western Kenya, at the eastern fringe of forests of the so-called the central Refugium (Stuart, 1985).

The sub-species *kalindie* is found in eastern Zaire, with and old record from southwestern Uganda. This Ugandan record was a bird collected in 1911 in Nyondo forest near Kanyonsha, east of the Ruthshuru valley in the south westernmost part of the country near the Zaire border (Chaplin 1953). In Zaire, birds have been noted in small groups of 10-15 (Prigogine, 1958). Zairian specimens have been collected at Mazali, Abyaloze, Kolima and Kailo between 1950 and 1958 (Collar and Stuart, 1985). In Kakamega forest, the eremomela are usually seen in groups of 3-6, commonly feeding alongside Buff-throated Apalis, *Apalis rufogularis.* In this forest they are sympatric with the globally threatened Chapin's Flycatcher, *Muscicapa lendu* (Zimmerman, 1972).

Turner’s Eremomela is a small (length, 84-88 mm) grey-backed warbler of the forest treetops. They forage in the canopy or sub-canopy and often with mixed flocks. Its food consists of caterpillars and other insects. The adult has a black band across the lower throat, broad black eye lines and a chestnut forehead patch extending back over the eyes. The chin and throat are creamy white, the breast to belly, greyish. The bill is black, eyes, brown and feet pale pinkish (Zimmermann, *et al*, 1996). Turner’s Eremomela was once considered sub-species of the Brown-crowned Eremomela, *E. badiceps* until the two were found to be sympatric around Kailo in eastern Zaire (Prigogine 1958). The two are very similar except that the chestnut patch in *E. badiceps* is confined to the forehead only.

The bird’s call is a high-pitched call with rapid series of 8-10 notes, only slightly fluctuating in pitch:- *titititititi-tititIti* followed by a slightly louder *sisi-cheek* or *weet-su-sweet*. Begging young give a chattering *it-it-eet-chi-chit.* The juveniles are olive with faint rufous wash on the forehead, pale yellow below with only suggestions of the breast band (Zimmermann *et al*. 1996).

The type specimen was collected in 1915 along the Yala river in western Kenya (Van Someren, 1920). Subsequent Kenyan records have been from 1500-1700 m in Kakamega forest (Tennet, 1965, Ripley and Bond, 1971, Zimmerman, 1972, Britton, 1980), through which the Yala river passes. In 1982, a small party of birds was seen in the nearby South Nandi forest (Collar and Stuart, 1985). Recent surveys have confirmed their presence in this forest (e.g. Waiyaki, 1998).

1.2 STATUS OF AVIFAUNA

Our knowledge of the numbers, distribution, status and ecology of forest species is so poor that the true dimension of this problem are only beginning to emerge (Whitmore and Sayer, 1992).

The Twentieth world conference of the International Council for Bird Preservation was held at Hamilton, New Zealand in November, 1990. With conservation as their focus, delegates provided evidence of why there is generally a continuing decline in bird populations and species diversity (Noon and Young, 1991). The general themes that emerged emphasized the significance of the loss and fragmentation of habitat through human activity. Most changes of status cannot be attributed to a single factor but are the expression of several factors working simultaneously or sequentially and often synergistically.

There is little doubt that the rate of species extinction has grown during the course of this century. For instance, 60 bird species are known to have become extinct between 1900 and 1950 (Reid and Miller, 1989).

A total of 1,030 bird species were considered threatened with global extinction in 1988 (Collar and Andrew 1988). This figure increased to 1,111 species (11% of the world's avifauna) in 1994 (Collar *et al*. 1994). Of these 1,111 threatened bird species, four (0.4%) are identified as Extinct in the Wild, 168 (15%) as Critical, 235 (21%) as Endangered and 704 (63%) as Vulnerable (Collar *et al*. 1994).

Given that the three categories are characterized by the different probabilities of extinction (50% chance in five years for Critical, 20% in 20years for Endangered, 10% in 100years for Vulnerable), it is possible to calculate the number and rate of avian species extinctions over the next 100 years assuming no action is taken on their behalf and making no allowance for new species entering the lists.

From this, it emerges that over 400 bird species are likely to die out in the next 100 years, but far more disturbing is the anticipation that 200 will disappear in the next 20 years, 100 of them in the next 5-10 years (Collar *et al*. 1994)

The commonest way in which bird species have been judged to be at risk is by their possessing a declining population numbering less than 10,000 mature individuals. No fewer than 764 species out of the 1,111 (about 70%) are believed to exhibit this characteristic (Collar *et al*. 1994).

The small and isolated populations of birds are the ones susceptible to extinction via inbreeding depression and a variety of random causes. Arguably, the rate of extinction may be low to begin with, but latter accelerates as populations are reduced to critically low levels. But in at least some situations, birds may persist for numerous generations at very low population levels (Dowsett-Lemaire, 1983).

In one recent model, extinction rates is predicted at 15% of the world's bird species (1350 species) between the mid 1980s and 2015 (Simberloff, 1986). Another school of thought postulates that over a fifth of all bird species give some cause for concern in terms of global extinction (Collar *et al*. 1994). However, as a result of conservation action, relatively few of these species are likely to become extinct by 2015, though many will be maintained in a precarious position.

1.3 FACTORS AFFECTING THE STATUS OF AVIFAUNA

1.3.1 Habitat disturbance and fragmentation

Disturbance to the forest can be grouped into three classes; 1) disturbance altering the structure of the forest e.g due to windthrow, logging and land clearing activities; 2) those that alter the species composition of the forest e.g due to the introduction of new species of animals and plants and clearing; 3) those that alter the long term climate in which the forest grows e.g due to climatic change.

Recent studies have shown that in Southeast Asia, 68 percent of the original habitats for wildlife have been lost and in sub-Saharan Africa, the figure stands at 65 percent (MacKinnon and MacKinnon, 1986a). This loss of habitat through conversion to other habitat types is the greatest threat to bird species survival and the maintenance of their diversity

In forested countries of Africa, protected areas have been found to contain 70-90 percent of the national bird faunas (Sayer and Stuart, 1989). Unfortunately, very little of these rain forest areas can be considered to be under effective management at present; perhaps less than 1 percent (Poore, 1989).

The wanton destruction of forests in Kenya today has led to habitat disturbance leading to habitat loss and fragmentation. Unfortunately, this is taking place in a background of poor silvicultural management and poor policy implementation on the conservation and protection of these forests. The result has been the shrinking of these forests over the years. The overall outcome is small, fragmented and isolated pockets of forests or ‘island habitats’.

Whatever the actual quantitative relations, in qualitative terms, smaller forests generally possess fewer species than larger ones. Smaller forests too will contain smaller populations of particular species and this in turn will tend to lead to genetic drift, inbreeding depression and loss of genetic diversity (Whitmore and Sayer, 1992). Consequently, a bird population may fall below a critical threshold or become locally extinct because of greater vulnerability to physical disturbance of small populations in small areas.

The small less mobile species are more prone to population reductions in heavily damaged forests. The patchy distribution of resources may affect ranging patterns, breeding success and even gene flow, unless these species are able to re-occupy the regenerating forests and restore an even dispersion of individuals.

There are few data available for Africa on the effects of disturbance and fragmentation. It appears however, that it is the forest specialists that suffer most. Some forest interior species are particularly vulnerable to fragmentation as they are unable to disperse over large open areas (Newmark, 1991). This is mainly because habitat fragmentation not only reduces the area available to species but also extends the amount of edge and increases the chances of population isolation.

The increased extent of ‘edge habitat’ associated with habitat fragmentation is disadvantageous to birds especially where this reduces the extent of core habitat as it leads to concomitant increase of a zone liable to disturbance especially from human activity.

In a more general context, the impact that habitat alteration has on bird life depends on what has been lost and what has been substituted on the area involved. It also depends on the spatial relationships that exist in the new landscape including the extent of connectivity and fragmentation.

The major threats to the continued survival of forest birds and the ecosystem as a whole are man induced (Dowsett, 1985). Their effects may show up first as a reduction in the densities rather than the complete disappearance of a species (Bennun and Waiyaki, 1992a).

1.3.2 Logging

Commercial logging in tropical rainforests can take different forms, almost all of, which involve the removal of selected trees rather than the clear felling of whole stands.

Tree loss through windthrow is much higher in logged forests. The uneven nature of the canopy increases wind turbulence to which shallow rooted remnant old trees are particularly susceptible.

The distribution of trees become more patchy following intense logging (Johns, 1986b), which may necessitate changes in ranging and foraging behaviour among birds. The species that cannot readily adapt will be placed in a competitive disadvantage.

Removal of marketable trees is however, only a minor consequence of logging. The cut trees are generally the large emergents and their felling cause considerable damage to other layers of the forest. For instance, an emergent tree of >2.5 m girth will destroy around 0.02 ha on falling (Dawkins, 1959).

The overall impact of logging operations is dependent on two main factors; the number of trees removed and the care taken in so doing. A third factor is of considerable importance to the forest-dwelling animals, namely, the extent to which timber trees are important as food sources for particular species.

Responses to the changed conditions of habitat and food supply brought about by logging can be varied. The extend of dietary specialization may be important in birds specialized to exploit food sources that are less common following logging. Logically they also become less common. A reliance upon particular features of micro-climate or physical environmental characteristics that are changed by logging may also have a deleterious effect.

Logging activity affects the nature of bird community. Kavanagh, *et al*, (1985) for example, found few bird species and individuals on logged compared to unlogged coupes and while bird life recovered as vegetation regenerated, only 78 percent of the original bird numbers were found four years after felling.

In general, birds in a recently logged forest may face three problems concerning food source trees; 1) fewer trees, 2) a different spatial distribution of trees and 3) different patterns of format and leaf production. If a bird is specialized to exploit such a tree species, then it may be eradicated also.

1.4 HABITAT CHOICE

1.4.1 Factors influencing habitat choice

Perhaps, no other taxonomic group has and presumably exercises the potential for habitat selection that birds do. The uniqueness of the birds with respect to habitat choice was discussed by Hilden (1965) who distinguished between and summarized the ultimate and the proximate factors involved in the choice.

The proximate stimuli for choice of habitat might be structural features of the landscape, foraging or nesting opportunities or the presence of other species. Such factors might operate independently, hierarchically as a system of sequential decisions or overrides or synergistically in a complex fashion or ‘gestalt’.

Habitat selection by whatever process and of whatever specific aspect, results in species sets co-occupying a particular habitat type. Some species may occur there because they can forage successfully in the canopy; others because the lack of ground cover is conducive to their litter-scratching activities. Thus within a habitat, there are many opportunities for species to select different parts of the vegetation or different structural niches in which to center their activities. Among others, segregation by tree species or foliage type, or by foraging height in the vegetation are obvious possibilities.

Much of the current theory and information concerning bird habitat selection and community structure are derived from the studies of temperate forest birds (e.g Lack, 1933, MacArthur, 1958, Hilden, 1965 and James, 1971). These forests offer a wide range of habitats that differ in extent, physical structure and availability to birds over both space and time.

Specific resources of the habitat on one hand and aspects of a bird's ecology, morphology or behavior on the other may be tightly coupled as reciprocal selective influence and may justify the term co-evolution.

In previous studies, it was found out that birds preferentially select certain tree species for foraging (Holmes, 1984). This choice seemed to be influenced by the unique morphological and behavioral traits of the individual bird species that allow them to differentially exploit arthropods among various foliage structures exhibited by forest trees (Robinson and Holmes, 1982).

The evolution of habitat preference is determined and determines the bird's morphological structure and behavioural functions, its ability to obtain food and shelter successfully in the habitat. Thus at certain times, particular features of the habitat may predominate and other times they may be overridden by yet other features. It is against this background of variations of critical resources in time and space that habitat choice studies must be conducted.

Habitats that are intrinsically less suitable for example in terms of their food resources may be tolerable if population densities there are lower than in prime habitats. This is the basis of the model of Fretwel and Lucas (1969) in which habitats are ranked according to their intrinsic suitability to a species *de facto, h*abitat quality declines as bird density increases to a threshold at which the next best habitat begins to fill up.

There has been a variety of theoretical approaches to habitat selection problems beginning with studies such as those of Levins and Culver (1971) and Horn and MacAthur (1972), which showed that the outcome of the existence between competing species is quite different where habitats occur in mosaics of partially isolated patches.

Fretwel and Lucas (1969) initiated a somewhat different approach to the theory of habitat selection by modeling the effects of intra-specific populational pressure on the sequential occupancy of habitats ranked by their intrinsic quality or suitability. The suitability of a particular habitat (also called optimality) affects the breeding performance and population dynamics of each species as well as the dispersion of individuals within a species' range (O'Connor and Fuller, 1986). Therefore, the study of a bird's habitat consists essentially of trying to ascertain the most consistent features of its environment that could be used to describe its range. Habitat is important too in assessing the effects of human activity on bird populations.

1.4.2 The role of vegetation structure in habitat choice

Many studies have been conducted on the association of particular bird species with habitats along environmental gradient. Most of these studies have demonstrated strong correlation between bird species and certain habitat features, with major emphasis on vegetation structure (MacArthur and MacArthur, 1961; James, 1971; James and Warmer, 1982 and Whitcomb *et al,* 1981).

Clearly, habitat structure, as it is measured can mean or translate into very different resources for different sorts of birds; foraging sites, nesting sites and protection from predators are the possibilities. Thus, forests rich in tree species and those with high canopies hold most bird species (James and Warmer, (1982). On the other hand, bird species diversity correlates strongly with vegetation height diversity (MacArthur, *et al,* 1962). Structurally complex vegetation types buffer the effects of seasonality such that resources become predictable (Karr, 1976).

If habitat underpins population performance, then there is need to record the habitats in which the population under study live. It will then be possible to relate performance at individual sites to habitat- a powerful way of identifying factors that may determine the success of a population. For instance, most small birds apparently distinguish habitats based on structural characteristics. Thus, in Patagonian Mocking birds, Gochfield (1978) found that *Mumus triarus* avoided low desert scrub and increased in density with vegetation height.

1.5 PROBLEM, RATIONALE AND JUSTIFICATION OF THE STUDY

Although Kakamega and South Nandi forests have similarities to those of the southern and western Uganda, they are biogeographically unique, with a number of birds found nowhere else in east Africa, and among the key forests for bird conservation in Africa (Collar and Stuart, 1985)

The two forests lie in one of the most densely populated parts of Kenya and are presently under severe threats from a variety of causes. For instance, upon its gazettement in 1936, South Nandi forest covered an area of 24,441 ha. Two substantial excisions took place in 1951 and 1968. A further 1,542 ha has recently been excised from the southwest corner of the forest for settlement of people displaced because of the proposed establishment of

Bonjoge National Reserve. The total forest area now stands at around 19,502 ha, of which the closed canopy forest covers only 13,200 ha (or 66%). The remaining 6,300 ha is classified as either; non-forest, other forest associations or plantations, (KIFCON, 1993). In the later category, an estimated 2,000 ha have been converted from forest to tea plantations or (over a large area) open unplanted land under the Nyayo Tea Zone Programme, (KIFCON, 1993).

Over the last decade (and particularly since the Kenya Indigenous Forest Conservation Programme ceased its work in 1993), considerable encroachment, illegal felling, charcoaling, intensive cattle grazing and forest clearance for agriculture have led to severe degradation of large areas (e.g Waiyaki 1998). More recently, South Nandi has been (and is being) ravaged by mechanized logging, licensed by the Forest Department despite a Presidential ban on cutting of indigenous trees.

Further, the highest basal area value measured in S. Nandi was 37 m^2 ha^{-1}, but the low average indicating that the forest is poorly stocked. While considering the “cut-off” *logging index* of 1,500 it was found that only 9% of the productive areas is at present adequately stocked to allow further consideration of logging as a management option (KIFCON, 1993). Results from recent inventories in other tropical regions indicate that the basal area in the unlogged and fully stocked forest will be in excess of 30 m^2 ha^{-1} and may be as high as 55 m^2 ha^{-1} (Korsgaard, 1992; Alder, 1991).

Croton megalocarpus constitutes about 50% of the indigenous hardwood in the forest. Harvesting has concentrated on this species, which is used as a source of peeler logs by the plywood industry (KIFCON, 1993). This species is known to be used by the *Eremomela turner*i when foraging (Waiyaki, 1998).

It is not known how Turner's Eremomela is affected by these changes. As mentioned earlier, *E. turneri* is listed as a globally Vulnerable species (Collar *et al*. 1994). Prior to the present study there was virtually nothing recorded about the species' ecology and especially its recent status. A recent survey in South Nandi found that the bird was present in relatively high numbers (Waiyaki, 1998), suggesting that South Nandi may be the stronghold for this species in Kenya, and thus a key site for its survival.

This study aimed at assessing the distribution and abundance of the eremomela in South Nandi, in particular its habitat preferences. The results will allow us to understand better if, and how forest degradation poses a threat to its survival, and recommend strategies for its conservation. Unlike its close neighbour, Kakamega Forest, South Nandi has been very little studied in the past, and for this reason, too it was appropriate to base this project here.

1.6 OBJECTIVES

The long-term goal of this study is to provide information useful for the conservation of *E. turneri*, with a specific reference to the South Nandi population and its habitats.

The study has the following objectives:

(i) to determine the distribution of Turner's Eremomela in South Nandi forest, in relation to forest types, history of disturbance and altitude;

(ii) to estimate the overall population size and density of the eremomela in South Nandi;

(iii) to determine the detailed habitat characteristics associated with the presence of the eremomela in South Nandi Forest;

(iv) to determine tree species preference of the eremomela in South Nandi;

1.7 LITERATURE REVIEW

Presumably, since man started foraging for animals and plants in the bush, he has realized that different organisms live in different places and that different birds are found in different habitats.

To know one's bird, one must know its habitat. The habitat, of a bird can be described as the geographical and vegetation features that occur within the area in which it lives. A species can only occupy those parts of the earth's surface where its minimum requirements are satisfied.

In fact individual bird species may cue on specific structural features such as cactus in Somora desert (Tomoff, 1974) or certain tree species in the wood forest (Holmes and Robinson, 1981) where insectivorous birds prefer yellow birch and avoid belch and maple. Previous studies demonstrated the importance of species-specific effects of plants on the foraging behaviour of insectivorous birds (Holmes and Robinson, 1981).

Many studies have been conducted on the associations of particular bird species with habitats along environmental gradient (e.g James, 1971) and in habitats with either similar or contrasting physical characteristics (Sabo and Holmes, 1983). Most of these studies have demonstrated strong correlation between bird species and certain habitat features (MacArthur and MacArthur, 1961 and James, 1971). These largely correlated approaches have proven useful in describing and predicting certain bird-habitat associations.

Modern studies of habitat selection were closely tied to questions about the taxonomy of congeneric species and indeed were first approached from that point of view. However, an ecological approach was developed by Lack (1933), who watched the colonization of Pine plantations on the Breckland Heath, Southern England, by species apparently drawn to appropriate ‘ancestral’ habitats through ‘psychological’ factors. A latter analysis of the woodland birds (Lack and Venables, 1939) confirmed that while some species had strong preference for habitats with particular features such as conifers broadleaf forests and abundance of nest holes or taller trees, others in certain circumstances were quite flexible. Hill *et al,* (1990) showed how bird density in natural pinewood increase in response not only to canopy closure and increasing tree height, but also to the number of dead wood on the ground.

Although the impact of woodland type and structure on birds is inevitably complex (Avery and Leslie, 1990, Simms, 1971 and Yapp, 1962), there are two common goals when sampling avian habitat structure.

The first one is to measure features of the habitat that will allow accurate determination of the species' habitat requirements (habitat parameters) believed to be at least proximally related to a species' survivorship and reproductive success in that habitat and are selected for measurement. The second, is to make accurate predictions of species' response to habitat change and to anticipate possible detrimental effects to a species population from various land-use practices. The second goal is contingent upon having achieved the first.

The sampling protocol that is followed is based on a multivariate approach to habitat selection, specifically on the niche concept as formalized by Hutchinson (1957). The rationale for employing these techniques is the belief that a species response to habitat structure is not univariate i.e the suitability of a habitat patch to an individual bird is a function of several interrelated habitat parameters whose combined effect (in match sense) determines the habitat suitability.

The suitability of a particular habitat (also called optimality) affects the breeding performance and population dynamics of each species' range (O’Connor and Fuller, 1986). Habitat too is important in assessing the effects of human activity on bird populations.

Thus, the common goal of habitat selection studies is to understand the distribution of birds. The spatial coincidence between the distribution of birds and environmental variables provide evidence of what determines this distribution, provided that it is assessed using appropriate statistical techniques. Equally, change in distribution can be related to the environmental factors to test the hypotheses about the causes of the changes.

Any changes the forest is subjected to will have considerable repercussions on birds. Therefore, habitat studies are crucial. The impact of habitat loss and fragmentation on Vulnerable species was shown by Bibby (1978) in his study of the Dartford Warbler, *Sylivia undata*. The woodland tends to support greater numbers and greatest diversity of birds and certainly the decline and dilution of such woodlands has adversely affected some species.

The major threats to the continued survival of forest birds and the ecosystem as a whole are man induced, (Dowsett, 1985). In Kenya, the obvious threat facing the forest birds is habitat degradation (Fanshawe and Bennun, 1991).

On a global scale, 25% (448 million ha) of the tropical forests have already been destroyed at a rate of 7.3 million ha/year for agriculture and a further 4.4 million ha being degraded through selective logging and ecologically inappropriate afforestation (WRI/IIED, 1988, Sec.25). The impact of habitat disturbance and subsequently habitat loss and fragmentation on the continued survival of forest birds has been explicitly discussed in section 1.2.

Thus, several processes that influence avian distribution and abundance operate locally i.e within areas the size of individual territories. Psychological processes for example affect habitat selection (Hilden, 1965) and are explicit in the ‘niche-gestalt’ model of habitat selection (James, 1971, Whitmore, 1975, Collins *et al*, 1982, James *et al*, 1984). This paradigm stresses that individuals respond independently of other species to gross structural features of the habitat (e.g vegetation height and density in various layers).

Therefore, to achieve the goal of sampling vegetation structure to gain insights of habitat selection as well as distribution and population censusing, simple and objective systems for their description and recording are needed. Systems using point counts or line transects to asses bird populations are being further explored by B.T.O -The British Trust for Ornithology, (Baille and Merchant, 1992). Crick (1992) has produced such a system for B.T.O schemes which employs a coding system for habitat characteristics which promotes full standardization, increases objectivity and aids computerization of the data. The system is based mainly on the vegetation structure of habitats which has been shown to play an important role in determination of bird community structure (Wiens, 1989). Bibby *et al* (1992) have recently presented a full account of methods for censusing bird populations.

Apart from measuring foliage profile there have been several suggestions on how habitat structure might be measured (e.g James and Shugart, 1970, Fox, 1979) with emphasis on measures of vegetation density in both vertical and horizontal directions.

CHAPTER TWO

2.0 STUDY AREA, METHODS AND DATA ANALYSIS

2.1 STUDY AREA

The study was carried out in South Nandi Forest Reserve in Nandi District, (see Figure 1). The South Nandi Forest lies within the Kakamega-Nandi forest complex. It is one of the last surviving relics of the Guineo-congolian tropical rain forests in Kenya (Dean and Trump, 1983)

2.1.1 Gazettement details and administration

South Nandi Forest Reserve was originally gazetted in 1936 as a Trust Forest with an original area of 24,441 ha. The current area of the forest is around 19,500 ha. In 1964, it was declared a Central Forest. The forest is under the management of the Forestry Department in the Ministry of Environment and Natural Resources, administered from the Nandi District Forest Office in Kapsabet.

South Nandi Forest Reserve was declared a ‘protected catchment area’ under the Water Act (Cap 372 Laws of Kenya), in a Gazette Notice 83 of 12/1/65 (together with Mt. Elgon and Kikuyu Escarpment Forest).

2.1.2 Topography, soils and climate

South Nandi forest is situated to the west of Kapsabet and to the south of the Kapsabet/Kaimosi road. The altitude ranges from 1700m in the N. W, where the forest adjoins Kaimosi Tea Estate, to 2,000 m in the east. The Kimondi and Sirwa rivers merge within the forest to form the Yala River, which subsequently flows through Kakamega forest and drains into Lake Victoria.

The gently undulating upland terrain is underlain by granitic and basement complex rocks from which are derived well drained, extremely deep, dark, reddish-brown, friable clay soils with thick humic nitosols and moderate to high natural fertility.

Mean annual rainfall is of the order 1600 mm to 1900 mm with peaks in April or May and August or September. Mean annual temperatures are in the range 17^{o} C to 20^{o} C with mean maxima and minima of around 25^{o} C and 16^{o} C, respectively. An absolute minimum temperature of 3.9^{o} C has been recorded at Kapsabet.

2.1.3 Vegetation and fauna

Beentje (1990) classified S. Nandi forest (together with Kakamega forest, to which it is often considered an extension), as Tropical Rainforest although he notes that it is less diverse than Kakamega forest because of its higher altitude. It occupies a transitional position between the lowland forests that stretch across Africa from Zaire basin to western Kenya and the Afro-montane forests of the Kenyan highlands. Thirty tree species (of the more than 60 species) in this forest have been listed by various authors as being of economic importance.

A mammal survey carried out in November 1993 (Gathua, 1993) reported that there were two ‘Red Data Book’ species, classified as V±ulnerable in S. Nandi forest:- Leopard, *Panthera pardus* and Giant forest Hog, *Hylochoerus meinertzhagen*, both at very low population densities. Three diurnal primates were recorded; Blue Monkey, *Cercophitecus mitis*, Black and White Colobus Monkey, *Colobus abyssinicus* and Olive Baboon, *Papio anubis*. The Bushbuck, *Tragelaphus scriptus* is the largest of the antelopes found in S. Nandi. Others are the Blue Duicker, *Cephalophus monticola* and the Red Duicker, *C. natalensis*.

A total of 226 species of birds comprising of 75 forest specialists have been recorded from the Kakamega and Nandi forests (Lewis and Pomeroy, 1989). This represents the highest number for both these categories in any forest of Kenya. Furthermore, these two forests are the homes of the globally Vulnerable *E. turneri* and (in Kakamega forest) the globally *M. lendu.*

2.1.4 Forest utilization and threats

Forest use by adjacent communities is high and includes grazing (especially in land cleared, but never planted by the Nyayo Tea Zone Development Authority), honey gathering, charcoal burning, pitsawing and harvesting of poles, firewood and medicinal plants.

There has been considerable recent licenced logging of the forest by Rai ply of Eldoret. Evidence of extensive hunting and trapping was found during the mammal survey (KIFCON, 1993).

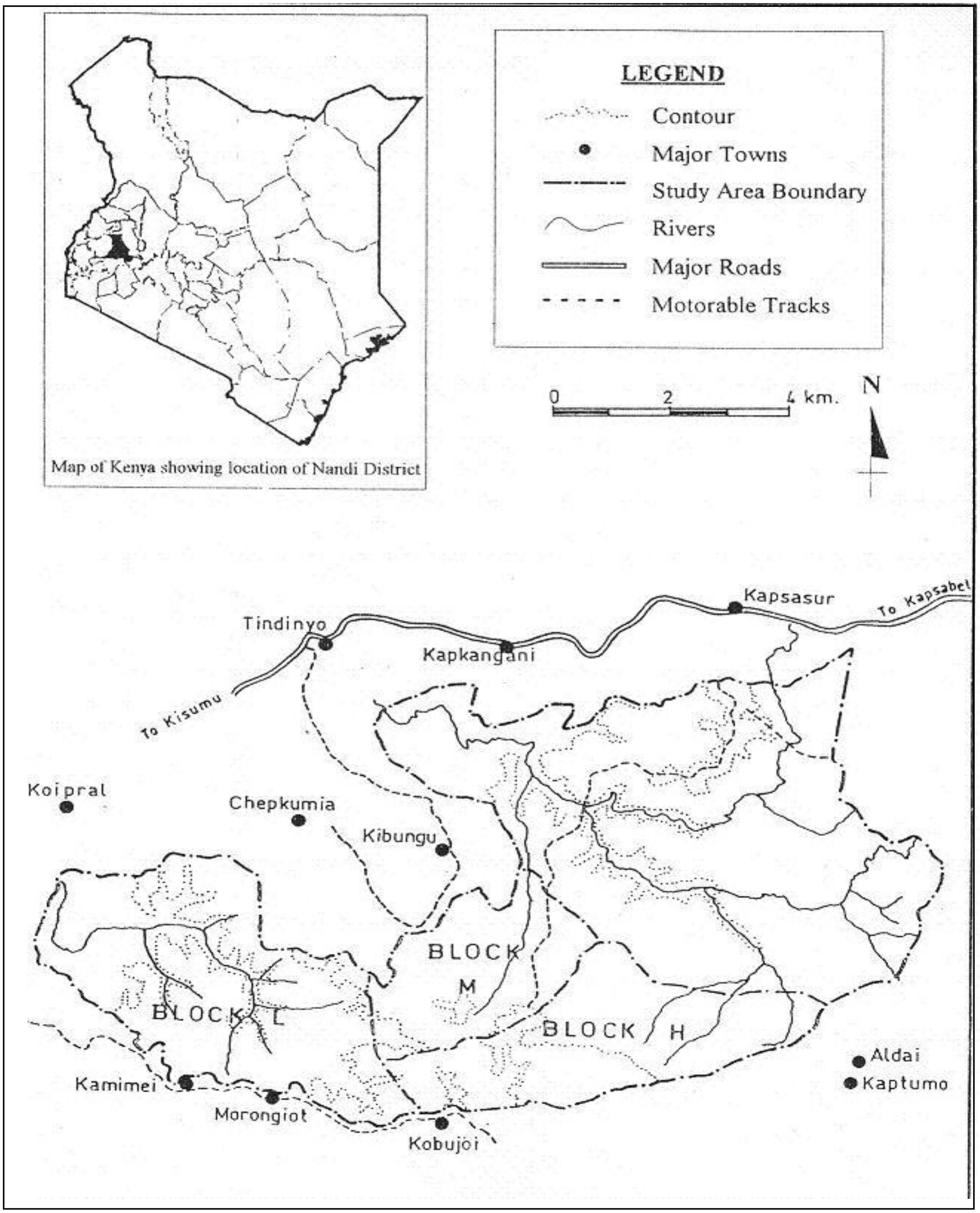


Figure 1: Map of South Nandi Forest showing the location of the study Blocks.

2.2 METHODS

2.2.1 Preliminary survey and research design

A preliminary survey of the study area was carried out for one month (September 1996). This entailed making a number walks in the forest coupled with repeated observations on the eremomela.

The survey was to serve the following four purposes: - First, to locate and map out the existing trails in the forest for use as transects in the study. Second, to identify the tree species preferred by the eremomela. Third, to familiarize the observer(s) with the study species e.g its calls, groupings, general habits, associations with other bird species etc. Fourth, to stratify the forest into three blocks along an altitudinal gradient. The survey also served as a crucial training session for the research assistants on the various aspects of the study.

At the end of the survey, most of the existing trails in the forest had been located, numbered and mapped. Six of these trails from each block were randomly selected using lottery to be used as transects. The length of each transect was 1000 meters. The blocks were coded as; L (1820-1900 m a.s.l), M (1900-1980 m a.s.l) and H (1980-2040 m a.s.l) for low, medium and high altitude respectively (Figure 1). The northernmost part of the forest was not covered in the sampling because of the distance from the base (Kobujoi). Furthermore, most areas of this part of the forest were similar in altitude to those in blocks M and H as described above. To simplify the logistics, the transects in each block were grouped into two clusters of three transects. One cluster was covered during a day's work of eremomela counts and (partial) vegetation survey (i.e vegetation survey at the eremomela-location sites).

2.2.2 Eremomela counts.

Eremomela counts started at 0730 hrs. Counts were conducted using the method described by Morrisson (1986). This entailed walking along the transect slowly, making frequent stops to look and listen for eremomelas. Although the eremomela calls are not loud, with practice we could detect them reliably 50 m or more away. Generally, the detectability of the eremomela calls was affected by wind conditions, distance of the birds from the transect, calls from other birds and noises from mammals e.g. the Black and White Colobus Monkeys. On the other hand, sighting was affected by canopy density and cover. On sighting or hearing the species, the observer(s) moved off the transect to the tree that they were in. An accurate count of the group size was then made while they were foraging among the foliage. Alternatively, counts were made when the birds flew from one tree to another. This was necessary when the eremomela were foraging in a bird party or when the foliage was very dense. The tree species on which the eremomelas were located was identified and its height estimated and recorded. These trees were used as centers for the circular plots defining the eremomela-location sites as explained in section 2.2.3.1. In addition, the perpendicular distance of the tree from the transect and the distance along the transect were measured and recorded. These perpendicular distances (y_i) were measured following the method described by Lake *et al* (1993). Once a transect was completed, the next one on the same cluster was started as soon as possible.

Each transect was counted five times during the period of study. Counts were performed in rotation within clusters, between the clusters and between the blocks. Thus each transect had an equal chance of starting at the 0730 hr commencing time, to minimize time-of-day bias.

After the five rounds of eremomela counts, it had become evident that within each 1,000m transect there were areas used by the eremomelas and others that were not. These are referred to as ‘eremomela-present’ and ‘eremomela-absent’ habitats respectively. The eremomela-present habitats constituted the areas within each transect belt where the eremomelas were recorded. These eremomela-present and eremomela-absent areas were mapped out for each transect line. Each transect was then marked at 40 metre intervals i.e. 25 points in total, each of which fell in either an eremomela-present or absent area. Any point falling on a boundary zone was excluded. Vegetation surveys were carried out as follows:-

2.2.3 Vegetation sampling

To identify the habitat factors important in determining presence and density of Turner’s Eremomela in the forest, several approaches were adopted based on a hierarchy of habitat preference referred to here as ‘levels’. The sampling protocol used in this aspect of the study was adapted from Hutchinson (1957) multivariate approach to habitat selection, specifically on the niche concept.

Vegetation sampling was carried out at two broad levels viz.; one transect-based and the other is plot-based. The transect-based sampling was carried out in the eremomela-present and absent areas. Short (40 m) vegetation transects were used and resulting data were used for macro-habitat choice assessment. Plot-based sampling was carried out in the eremomela-location sites, eremomela-present and eremomela-absent areas using 0.04 ha circular plots as described in the subsequent sections below. Data from eremomela-present and absent plots were used for macro-habitat choice assessment (i.e for additional parameters not included in transect-based sampling). Data from the eremomela-location and eremomela-present plots were used for micro-habitat choice assessment.

2.2.3.1 Vegetation sampling at the eremomela-location sites

For the purposes of this study, eremomela-location sites are the exact points defined by the trees on which the Eremomelas were sighted during the counts. Each tree in which the eremomela was sighted was considered the centre of a 0.04 ha (11.3 m radius) plot (James and Shugart 1970). Within each plot, vegetation parameters were measured as described in section 2.2.3.3 below.

2.2.3.2 Transect-based vegetation sampling

From each point marked along each transect as described in section 2.2.2 above, a short **vegetation transect**, 40 metres long and two metres wide was laid perpendicular to the survey transect. To decide whether the first vegetation transect was to be cut to the right or left of the main 1,000-m transect, a coin was tossed; heads for right and tails for left. Thereafter, the subsequent transects were marked in an alternating manner. This was done to minimize bias.

Along these vegetation transects, all the trees encountered having dbh >10 cm were counted and their heights measured and recorded. In addition, the seven tree species utilized by the eremomela were counted and their heights estimated and recorded. The objective of carrying out this sampling was to obtain data important for providing background information about the general structure of the forest.

By providing a comparison between areas that were and were not used by the eremomelas, these data gave information on macro-habitat choice by the eremomela within the forest.

2.2.3.3 Plot-based vegetation sampling

Plot-based vegetation sampling was carried out in the eremomela-present and eremomela-absent habitats. In each of the vegetation transects described above, the first and the last trees encountered were used as plot centres. In the few situations where the resulting plots were overlapping, the tree closest to the centre of the transect was used as the centre of a plot. The objective of carrying out this sampling was to obtain data important for providing information about the specific structure of the forest. By providing a comparison between the eremomela-location sites (as described in section 2.2.3.1 above) and the eremomela-present habitats, these data gave information on micro-habitat choice by the eremomela. And by comparing the eremomela-present with the eremomela-absent habitats, these data gave information on macro-habitat choice for additional vegetation variables not included in the transect-based sampling.

Data were collected based on the James and Shugart (1970) 0.04 ha tree-centred plots (Figure 2), showing the four quarters used in estimation of index of tree dispersion. This is indicated by the perpendicular lines. The dotted lines indicate the ‘transects’ (2 m wide) along which percentage canopy cover and density within each plot were estimated. All plots were tree-centred i.e. identical with the plots used for habitat survey at the eremomela-location sites.

Within each plot, the following vegetation parameters were recorded:-

(i) The number of trees in three diameter at breast height (DBH) categories: class A, 10-35 cm, class B, 36-60 cm and class C, >60 cm.

(ii) Canopy height (CH): the minimum and the maximum branch heights were taken, and the average canopy height calculated.

(iii) Index of Tree Dispersion (ITD): obtained from a point-centred- quarter technique. Each plot was divided into four quarters. In each quarter, the distance to the nearest tree of Dbh >10 cm and the Dbh of that tree was measured.

(iv) Canopy cover (CC): estimated as the percentage above the observer by sighting through a tube of diameter 4.5 cm with cross hairs at one end. Within each plot, two transects running perpendicularly to one another were established. A total of 20 (10 each transect) readings were taken, scored 1 or 0 depending on the presence or absence respectively of green vegetation at the intersection points of the cross hairs. Canopy cover was calculated as no. of hits/20 X 100

(v) Tree Density (TD): estimated using the same lines as in CC measurements. While walking along these transects and at two metre width, all the trees of dbh >10 cm encountered were counted.

(vi) The number of trees in three tree height (TH) categories; class S, <10 metres; class P, 11-20 m and class T, >20 m. A Suunto Clinometer was used.

To examine habitat choice at the tree-species level, data were collected on the seven main tree species utilized by the eremomela. Their numbers and heights were recorded from these plots (i.e. from eremomela-location sites, eremomela-present and absent plots). Their heights were then categorised into the three height categories as described above.

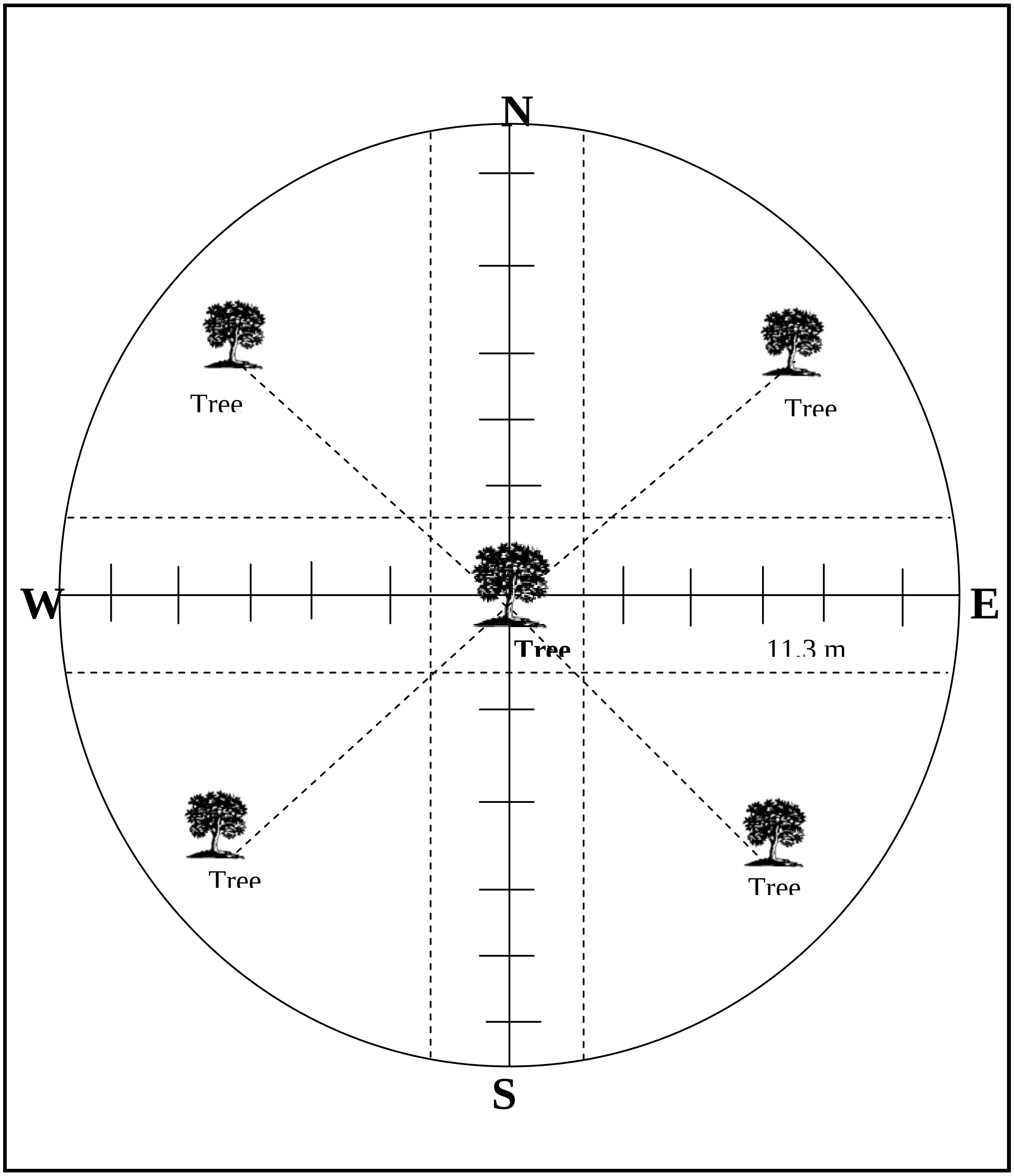


Figure 2: Layout of the 0.04 ha circular plots (r = 11.3 m) used in the measurement of vegetation parameters. (*Adopted from James and Shugart 1970*)

2.3 DATA ANALYSIS

Data were entered, organized and managed using the EXCEL spreadsheet for Window's 95.

Data from distance sampling (perpendicular distances, y_i and eremomela group sizes, s_i) was analyzed using program DISTANCE version 2.2 (Lake *et al*, 1993). These distance data were fitted into five models (or estimators). The model which fitted the data best was selected by the program using the Akaike Information Criterion (AIC) and the chi-square goodness of fit statistics. The AIC provides a quantitative method for model selection whether or not models are hierarchical (Akaike 1973). AIC treats model selection within an optimization rather than a hypothesis-testing framework and the best model is the one with the minimum AIC. The selected model(s) was/were subsequently used in the estimations of density of groups, the density of the eremomelas in each study block and overall estimates of these two parameters. The selected model(s) also computed the detection probabilities, the encounter rates, the average group sizes and the expected group sizes of the eremomelas in each block of the forest.

Detection probability is the probability of detecting or locating a group of eremomelas present at a given distance off the transect line. This distance is called the Effective Strip Width (EWS). The ESW is the half-width of the strip extending either side of the transect line such that as many eremomela groups are detected outside the strip as remain undetected within it. Encounter rate is given by as n/L, where n is the number of observed eremomela groups and L is the total length of transects in a block. The mean group size is the true mean of the size of Ns eremomela groups while the expected group size (E(s)) is the expected size of all eremomela groups whether detected or not (i.e assumed independent of y_i).

An analysis of data where the group size is independent of the detection distance may be complicated by the difficulties in obtaining an unbiased estimate of E(s). Hence, to obtain an unbiased estimate of E(s) to be used in computing density, the expected group size was estimated based on regression of log(s(i)) on g(x(i)) where (s(i)) is the group size of the i-th observation and x(i) is the perpendicular distance to i-observation . A one-sided t-test of mean group sizes against expected group sizes was performed because size-bias typically increases the observed mean group size at large detection distances.

Vegetation parameters measured in the vegetation transects and plots were compared using Student's paired t-test statistics. These comparisons are between: - i) the eremomela-location sites and the eremomela-present plots, ii) the eremomela-present and absent plots and iii) the eremomela-present and absent vegetation transects. In each case, mean differences were calculated within each survey transect and vegetation parameters were subjected to t-test analysis at block level and for the blocks combined. Paired t-tests were carried out using ANALYSIS package in EXCEL'97 for windows.

Habitat selectivity index (E_i) (Jenkins 1994) was calculated for each of the seven main tree species utilized by the eremomela in the forest so as to determine tree species preference in the Turner's Eremomela. This was done by comparing the observed usage and the expected usage of each tree species. The following equation was used to obtain the E_i values for each tree species:

Selectivity index $(E_i) = (p_i-q_i)/(p_i+q_i-2p_iq_i)$

$p_i=N_i/N_t$ $q_i=A_i/A_t$

N_i= Number of trees of each species in which the eremomelas were sighted

N_t= Total number of all trees in which the eremomelas were sighted

A_i= Number of species i in whole block/forest

A_t= Total number of all trees in whole block/forest

E_i values can range from +1 (entirely preferred) to –1 (entirely avoided).

Between blocks analysis of variance (ANOVA) of the number of eremomela counted, eremomela group sizes, vegetation parameters and abundance of the seven main tree species utilized by the eremomela was carried out. The transects passing through the heavily degraded parts of the forest (particularly in blocks M and H) registered low eremomela sightings. The causes of disturbances were mainly the recent and ongoing logging (e.g Plates 2 and 3), construction of an electricity power line among others.

To determine whether or not disturbance has resulted in alteration of the forest structure hence the low eremomela sightings in these areas, first I compared the means of the vegetation parameters measured from the randomly sampled plots from the survey transects passing through the less disturbed areas with the ones sampled from the disturbed areas using Anova tests. Then, I compared the means of parameters measured from the less disturbed areas only taking blocks as a factor using Anova (i.e excluding in the analysis data from the plots sampled from the survey transects passing through the disturbed areas). A similar procedure was used but instead of vegetation parameters, I used the abundance of the seven tree species utilized by the eremomela. I also carried out comparison tests between the survey transects passing through the disturbed and the less disturbed areas in the number of eremomela sightings. Finally, I compared the survey transects passing through less disturbed areas and only in the eremomela sightings.

Further analysis using Tukey’s (1953) pairwise comparison tests were carried out to determine where block means were different in cases where anova values were significant. Correlation analysis was carried out on the vegetation parameters measured and correlation matrices were generated to determine the degree of interrelation. The Anova and Correlation statistics were carried out using Program MINITAB (1991), Release 8.2 for IBM.

Normal and logistic regression models were used to select the best habitat predictors of the eremomela’s presence and density in the forest respectively. I used a stepwise backward procedure in the statistical program GLIM version. 3.77 (NAG, 1986) to select the final models containing only significant parameters.

CHAPTER THREE

3.0 RESULTS

3.1 STATUS

3.1.1 Population and distribution of *E. turneri* in S. Nandi Forest

More sightings of eremomela groups were registered in the low than the medium and high altitude blocks. There were 73 (42.0%) eremomela groups sighted in block L (low altitude), 51 (29.3%) in block M and 50 (28.7%) in block H, giving a total of 174 groups from the five rounds of counts (Appendix I).

On these 174 sightings, a total of 746 eremomelas were counted, c 150 per round of counts. Total numbers per block were: - Block L, 308 (41.3%), block M, 224 (30.0%) and block H, 214 (28. %). The eremomelas were recorded only in even numbered groups (of two, four, six and eight birds), with groups of four representing 55.2% of all the sightings, followed by groups of six (25.3%), two (16.7%) and eight (2.9%) (Appendix I). However, the probability of encountering the eremomelas by chance in even numbered groups was small (probability = 4.18^{-53}). Figure 3 gives the average number of sightings in each group size category per block and in the overall forest. There were no significant differences in observed and expected eremomela sightings in these group sizes in each block (chi-square = 0.16, df = 4). Though the mean number of sightings in groups of four birds was consistently high among the blocks and in the whole forest, there were no significant differences in the means of eremomela sightings in each group size category between the three blocks (Table 2).

Analysis of variance results indicated that there were no significant differences between the transects in the number of eremomelas counted (ANOVA: F = 0.86, df 17,156, $p \leq 0.05$) (Appendix III). There were no significant differences between blocks in the overall block means of the eremomela group sizes sighted and also in the means of the total numbers of eremomelas counted per block from the five rounds of counts. However, the blocks significantly differed in the number of eremomela groups sighted (Table 1). Table 1 indicate that there were more eremomela groups sighted in block L than in either block M or block H.

Table 1: Comparisons of means (± stdev) of the number of *E. turneri* groups sighted, mean group size and total birds sighted per block (n= 3 blocks) between the blocks. Means with the same letter are not significantly different (Tukey's test)

	Block L	Block M	Block H	F-value
	mean ± stdev	mean ± stdev	mean ± stdev	
No. eremomela groups sighted	12.2 ± 1.33 **a**	8.5 ± 2.7 **b**	8.3 ± 3.62 **b**	3.8*
Mean group size	4.2 ± 0.17 **a**	4.4 ± 0.62 **a**	4.3 ± 0.60 **a**	0.2
Total birds sighted per block	51.3 ± 5.32 **a**	37.3 ± 12.37 **a**	35.7 ± 15.72 **a**	3.1

*- Significant at $P \leq 0.05$ ($F_{2,5\ crit}$= 3.7, Tukey's test, $q_{15,3} = 3.7$)

Table 2: Between blocks comparisons of means (+ stdev) of the number of *E. turneri* sightings in each group size category from the five rounds of counts

	Group size categories			
	group size of 2	group size of 4	group size of 6	group size of 8
F-value	0.8	2.0	3.1	2.1
	mean ± stdev	mean ± stdev	mean ± stdev	mean ± stdev
Block L	2.0 ± 0.63	6.8 ± 1.60	3.3 ± 0.82	0.0 ± 0.00
Block M	1.3 ± 0.82	4.7 ± 2.73	2.0 ± 1.41	0.5 ± 0.55
Block H	1.5 ± 1.22	4.5 ± 2.23	2.0 ± 0.89	0.3 ± 0.52

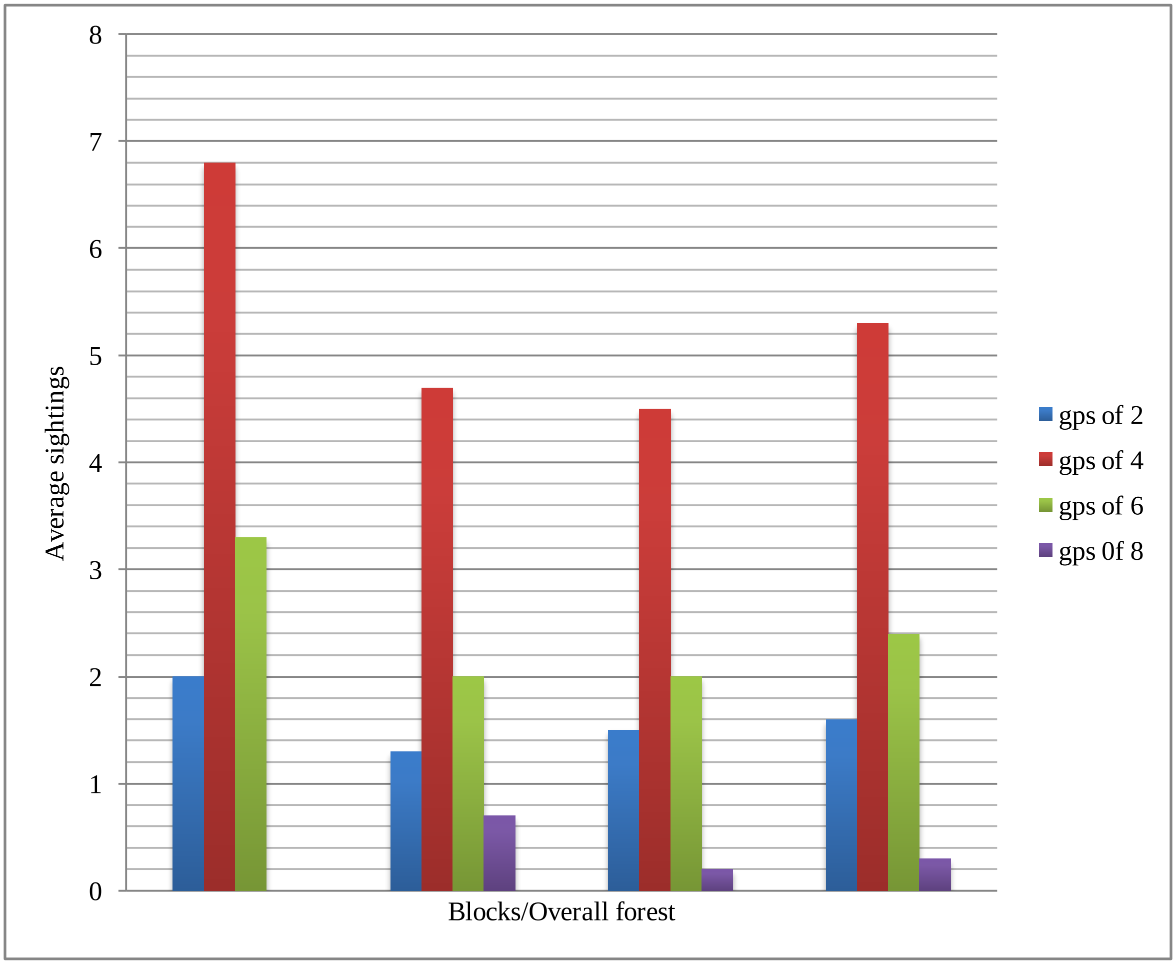


Figure 3: A graphical representation of *E. turneri* group sizes in S. Nandi forest, showing the average number of sightings in each group size per block/overall forest

There were significant differences in between transects passing through the less disturbed and disturbed areas in the means of eremomela groups sightings (12.0 ± 1.05 and 6.8 ± 2.25 respectively, ANOVA: F = 43.1, df 1, 16, $p \leq 0.05$). But there was no significant difference between block L, M and H (12.2 ± 1.33, 11.5 ± 0.71 and 12.0 ± 0.00, respectively) in the means of eremomela group sightings considering the less disturbed transects only for comparisons (ANOVA: F = 0.25 df, 2,7, $p \leq 0.05$).

Anova results indicated that the plots sampled from the survey transects passing through the disturbed areas were significantly different from those sampled from the less disturbed areas in the means of eight vegetation parameters (Table 3). The differences in means of maximum canopy height, number of trees with height >20 m, average canopy height and the number of trees with height of 11-20 m were highly significant (ANOVA: F= 25.8, 23.8, 19.3 and 17.2 respectively, df 1, 16, $p \leq 0.005$) (Table 3). Anova results indicated that the three blocks were significantly different in the means of three parameters measured from the plots sampled from survey transects passing through the less disturbed areas only (Table 4). The results of the Tukey's test indicated that block L was significantly different (though the differences were small in magnitude) from blocks M and H in the means of two parameters only, maximum canopy and percentage canopy cover (Anova: F= 6.9 and 6.0 respectively, df 2,7, $p \leq 0.05$) (Table 4). The means of both parameters were higher in block L.

There were significant differences in the mean abundance of two of the seven tree species utilized by the eremomela, *Croton megalocarpus* and *Celtis africana* for a comparison between plots sampled from the less disturbed habitats and disturbed habitats (Anova: F= 27.1 and 5.1 respectively, df 1,16, $p<0.05$) (Table 5). Table 5 indicate that there were more *C. megalocarpus* and less *C. africana* in the less disturbed areas.

The three blocks were significantly different in the mean abundance of *C. africana* and *Neoboutonio macrocaly* counted from the plots passing through the less disturbed habitats only (Anova: F= 5.8 and 4.3 respectively, df 1, 16, $p\leq 0.05$). Tukey's test (Table 6) indicated that the mean abundance of *C. africana* was higher in block M than in block H

Table 3**:** Comparison between less disturbed and disturbed habitats in the means (± stdev) of vegetation parameters

	Less disturbed areas	Disturbed areas	F-value
	n= transects	n= transects	
Parameters	mean ± stdev	mean ± stdev	
No. trees with dbh of 10-35 cm	8.7 ± 1.06	8.9 ± 1.44	0.1
No. trees with dbh of 36-60 cm	2.2 ± 0.49	1.6 ± 0.32	9.3*
No. trees with dbh of >60 cm	1.0 ± 0.24	0.6 ± 0.18	15.5*
Min. canopy height (m)	6.0 ± 0.38	5.8 ± 0.20	1.8
Max. canopy height (m)	18.0 ± 0.19	14.9 ± 0.93	25.8*
Aveg. Canopy height (m)	10.8 ± 0.91	9.3 ± 0.56	19.3*
Index of tree disp.(dist) (m)	5.3 ± 0.24	5.5 ± 0.42	1.0
Index of tree disp.(dbh) (m)	27.3 ± 1.53	25.7 ± 1.78	4.2
Canopy cover (%)	47.9 ± 3.84	40.7 ± 4.43	13.6*
Tree density (ha^{-1})	6.1 ± 0.55	5.7 ± 0.24	4.1
No. trees with height of <10 m	6.3 ± 1.64	7.9 ± 1.30	5.0
No. trees with height of 11-20 m	5.5 ± 1.48	3.1± 0.70	17.2*
No. trees with height of >20 m	0.5 ± 0.19	0.1 ± 0.09	23.8*

*Significant at $p \leq 0.05$ ($F_{1, 16crit}$= 4.5

Table 4: Between blocks comparison of means (+ stdev of vegetation parameters, considering the plots sampled from less disturbed areas only. Means with the letter are not significantly different (Tukey's test).

	Block L	Block M	Block H	F-value
Parameters	mean ± stdev	mean ± stdev	mean ± stdev	
No. trees with dbh of 10-35 cm	8.5 ± 1.20 **a**	8.9 ± 1.51**a**	9.1 ± 0.19 **a**	0.2
No. trees with dbh of 36-60 cm	2.4 ± 0.46 **a**	1.7 ± 0.14 **a**	1.9 ± 0.04 **a**	3.3
No. trees with dbh of >60 cm	1.1 ± 0.22 **a**	0.9 ± 0.06 **a**	0.7 ± 0.01 **a**	3.9
Min. canopy height (m)	6.1 ± 0.42 **a**	6.0 ± 0.25 **a**	5.7 ± 0.41 **a**	0.7
Max. canopy height (m)	18.8 ± 1.13 **a**	17.6 ± 0.56 **b**	15.9 ± 0.32 **b**	6.9*
Aveg. Canopy height (m)	11.3 ± 0.86 **a**	10.3 ± 0.17 **a**	9.9 ± 0.07 **a**	3.6
Index of tree disp.(dist) (m)	5.4 ± 0.28 **a**	5.3 ± 0.17 **a**	5.2 ± 0.09 **a**	0.7
Index of tree disp.(dbh) (m)	27.8 ± 1.50 **a**	27.6 ± 1.78 **a**	25.8 ± 0.95 **a**	1.4
Canopy cover (%)	49.7 ± 2.62 **a**	48.2 ± 2.96 **b**	42.2 ± 2.38 **b**	6.0*
Tree density (ha^{-1})	6.2 ± 0.68 **a**	6.0 ± 0.13 **a**	5.8 ± 0.41 **a**	0.3
No. trees with height of <10 m	5.6 ± 1.83 **a**	7.0 ± 0.58 **a**	7.5 ± 0.81 **a**	1.3
No. trees with height of 11-20 m	6.4 ± 1.17 **a**	4.4 ± 0.88 **a**	3.9 ± 0.39 **a**	5.5*
No. trees with height of >20 m	0.6 ± 0.18 **a**	0.3 ± 0.12 **a**	0.3 ± 0.05 **a**	2.8

*Significant at $p \leq 0.05$ ($F_{2,\,7crit}$= 4.7, Tukey's test, $q_{7,\,3cri}$=4.2)

Table 5: Comparison between less disturbed and disturbed habitats in the mean abundance (± stdev trees) of the seven tree species utilized by *E. turneri*

	Less disturbed areas	Disturbed areas	F-value
Tree species	mean ± stdev	mean ± stdev	
Croton megalocarpus	0.4 ± 0.95	0.1 ± 0.07	27.1*
Macaranga kilimandscharica	1.1 ± 0.95	1.4 ± 0.86	0.7
Celtis africana	0.2 ± 0.56	0.4 ± 0.23	5.1*
Prunus africana	0.1 ± 0.04	0.2 ± 0.17	2.7
Croton macrostachyus	0.1 ± 0.11	0.3 ± 0.28	2.2
Neoboutonioa macrocalyx	0.4 ± 0.47	0.7 ± 0.77	1.5
Albizia gummifera	0.2 ± 0.18	0.2 ± 0.22	0.0

*Significant at $p \leq 0.05$ ($F_{1,16crit} = 4.5$)

Table 6: Between blocks comparisons of mean abundance (± stdev) of trees of the seven species, considering the plots sampled from the less disturbed areas only. Means with the same letter are not significantly different (Tukey's test)

	Block L	Block M	Block H	F-value
Tree species	mean ± stdev	mean ± stdev	mean ± stdev	
Croton megalocarpus	0.5 ± 0.17 **a**	0.33 ± 0.11 **a**	0.3 ± 0.03 **a**	1.5
Macaranga kilimandscharica	0.6 ± 0.16 **a**	1.2 ± 0.42 **a**	2.2 ± 1.58 **a**	2.8
Celtis africana	0.1 ± 0.10 **a**	0.4 ± 0.1 **b**	0.01 ± 0.06 **a**	5.8*
Prunus africana	0.05 ± 0.03 **a**	0,1 ± 0.06 **a**	0.1 ± 0.04 **a**	2.5
Croton macrostachyus	0.1 ± 0.14 **a**	0.1 ± 0.44 **a**	0.1 ± 0.06 **a**	0.0
Neoboutonioa macrocalyx	0.2 ± 0.17 **a**	0.2 ± 0.13 **a**	1.1 ± 0.86 **a**	4.3*
Albizia gummifera	0.2 ± 0.02 **a**	0.1 ± 0.00 **a**	0.2 ± 0.23 **a**	0.7

*Significant at $p \leq 0.05$ ($F_{2,\&crit}$= 4.7, Tukey's test, $q_{7,3cri}$=4.2)

3.1.2 Estimates of eremomela density, density of groups, encounter rates and detection probability

3.1.2.1 Model section

To select the best model for estimation of eremomela density, distance data (perpendicular distances, y_i and group size, s_i) were fitted into five models namely:- 1) Half-normal + cosine, 2) Half-normal + polynomial, 3) Uniform + cosine, 4) Uniform + polynomial and 5) Hazard rate + cosine. The first term in each model is called a key while the second one is called an adjustment term.

Distance data were stratified according to the blocks and transect lines and entered into Program DISTANCE. The Akaike Information Criterion (AIC) was computed for each model and the model with the minimum AIC was selected. The AIC selected the Uniform + cosine as the best model for the distance data in blocks L and M. Half-normal +cosine was selected for the data in block H. The chi-square probability (chi-sq. p) test for model fit for selected models suggested that the models fitted the respective data adequately (Table 7). As a rule, if chi-sq. p is $\geq$0.5 the fit is adequate.

The selected models were used in the estimation of eremomela density, density of groups, the encounter rates, detection probabilities, mean and expected group sizes.

Table 7: Model selection statistics using AIC and chi-square goodness of fit for eremomela density estimation in S. Nandi forest

Block	Model selected	AIC	chi-sq. p
Block L	Uniform + cosine	600.7	0.98
Block M	Uniform + cosine	407.0	0.51
Block H	Half-normal + cosine	416.4	0.69

AIC- Akaike Information Criterion

3.1.2.2 Estimates of mean and expected group sizes of *E. turneri*

There was very little difference in the eremomela mean group sizes in the three blocks (Table 8). Though slightly lower, the expected group sizes are close to the mean group sizes, and not significantly different, indicating that detectability of the birds did not increase markedly with group size. The expected eremomela group sizes in each block as well as the regression statistics are given in Table 8.

Table 8: Estimates of eremomela mean and expected group sizes in each block in S. Nandi forest computed by the selected models

Block	Parameter	Estimate	se	%CV	Df	95%CI
Block L	Mean group size	4.2	0.15	3.65	72	3.9 4.5
	Expected group size	4.1	0.08	4.33	71	3.7 4.4
Regression:- Slope= -0.19 ± 0.16, intercept = 1.52 ± 0.12, t = -1.20 ($p \leq 0.05$, df = 71)						
Block M	Mean group size	4.4	0.22	4.9	50	4.0 4.9
	Expected group size	4.1	0.23	5.6	49	3.7 4.6
Regression:- Slope= -0.29 ± 0.21, intercept = 1.63 ± 0.16, t = -1.20 ($p \leq 0.05$, df = 49)						
Block H	Mean group size	4.3	0.21	5.0	49	3.9 4.7
	Expected group size	3.8	0.22	5.7	48	3.7 4.6
Regression:- Slope= -0.31 ± 0.19, intercept = 1.58 ± 0.12, t = -1.20 ($p \leq 0.05$, df = 48)						

3.1.2.3 Estimates of density and groups of *E. turneri*

The estimated eremomela densities of groups are given in Table 9. The density of eremomelas and density of groups in block L were higher than in block H which in turn were higher than in block M. The overall density in the forest was estimated to be 1.06 eremomelas ha^{-1} and 0.27groups ha^{-1}.

Thus, on extrapolation, the population of Turner's Eremomela in S. Nandi forest was estimated to be 13,900 individuals (in the range of 11,400 to 17,000 individuals at 95% confidence intervals), taking only the 13,200 ha of the closed canopy forest. Similarly, the number of eremomela groups in the forest was estimated to be 3,600 (in the range of 2,900 to 4,200 groups at 95% confidence intervals).

3.1.2.4 Detection probabilities and encounter rates of *E. turneri*

The probability of detecting a group of eremomelas was different for each block. Block L had the highest detection probability while block H had the lowest value (Table 10). The selected model(s) computed Effective Strip Width (ESW) for each block and the results are given in Table 10. The ESW was higher in block L and lower in block H.

The encounter rates also varied with blocks. Block L had a higher encounter rate while blocks M and H had the same value (Table 10).

Table 9: Estimates of density and density of groups of *E. turneri* in South Nandi forest

Block	Density (ha^{-1})	Estimate	% CV	95% CI
Block L	Density of groups	0.30	8.5	0.25 0.36
	Density of eremomelas	1.21	9.5	1.00 1.47
Block M	Density of groups	0.24	14.1	0.17 0.33
	Density of eremomelas	0.97	15.2	0.69 1.37
Block H	Density of groups	0.26	24.5	0.16 0.43
	Density of eremomelas	0.99	25.1	0.59 1.67
Overall	Density of groups	0.27	9.6	0.22 0.32
	Density of eremomelas	1.06	9.8	0.87 1.29

Table 10: Detection probabilities and encounter rates of *E. turneri* in S. Nandi forest using the selected model(s) at the computed effective strip width (ESW)

Block	Parameter	Estimate	s.e	% CV	df	95% CI
Block L	Detection probability	0.58	0.04	7.2	72	0.50 0.67
	Encounter rate (groups $m^{-1}x10^{-1}$)	0.24	0.01	4.5	72	0.21 0.27
	Effective strip width	40.6	2.92	7.2	72	35.16 46.83
Block M	Detection probability	0.53	0.03	5.1	50	0.48 0.58
	Encounter rate (groups $m^{-1}x10^{-1}$)	0.17	0.02	5.1	50	0.12 0.24
	Effective strip width	35.9	1.82	5.1	50	32.41 39.74
Block H	Detection probability	0.44	0.07	16.9	49	0.31 0.61
	Encounter rate (groups $m^{-1}x10^{-1}$)	0.17	0.03	17.7	49	0.11 0.26
	Effective strip width	31.9	5.38	16.9	49	22.80 44.70

3.2 HABITAT CHOICE

Habitat choice was assessed at two levels, micro- and macro- habitat levels. The assessment of micro-habitat choice was done using the 0.04 ha circular plots sampled from the eremomela-location sites and eremomela-present habitats. The assessment of macro-habitat choice was done using the 0.04 ha plots and the 40 m vegetation transects randomly sampled from eremomela-present and eremomela-absent habitats.

3.2.1 Macro-habitat choice

Macro-habitat selection was assessed using the 40 m vegetation transects and the 0.04 ha plots (for additional parameters) randomly sampled from eremomela-present and eremomela-absent habitats. A total of 178 and 177 forty-metre vegetation transects from the eremomela-present and eremomela-absent habitats respectively were assessed. Seven parameters were measured in these transects.

The three blocks were significantly different in the means of two vegetation parameters, maximum canopy height and average canopy height from these randomly sampled vegetation transects. The means of both parameters were higher in block L than in block H. Tukey’s multiple comparison tests indicate that block L was significantly different from block H in the two parameters (Table 11).

The parameters measured from the randomly sampled vegetation transects were correlated to varying degrees. In the correlation matrix (Appendix V) all values of $r \geq 0.67$ are significant at $p \leq 0.05$ (as indicated in bold). Average canopy height was positively correlated with maximum canopy height while number of trees with height >20 m was positively correlated with maximum and average canopy height.

There was a significant difference in the means of maximum canopy height between eremomela-present and eremomla-absent vegetation transects (Table 12). Taking each block separately, there was a significant difference in the means of the same parameters for the comparison in block L (Table 13). In Block M none of the means of these parameters was significantly different (Table 14) while the mean of only one parameter was significantly different in block H (Table 15).

Table 11: Comparison of means (+ stdev) of vegetation parameters between the blocks from the randomly sampled transects. Means with the same letter are not significantly different (Tukey's test)

	Block L	Block M	Block H	F-value
Parameters	mean ± stdev	mean ± stdev	mean ± stdev	
No. trees encountered	6.0 ± 0.78 **a**	5.7 ± 0.45 **a**	5.0 ± 0.70 **a**	3.4
Min. canopy height (m)	6.5 ± 0.78 **a**	6.4 ± 0.34 **a**	6.2 ± 0.32 **a**	0.7
Max. canopy height (m)	15.3 ± 1.23 **a**	14.6 ± 1.40 **ab**	12.6 ± 1.95 **b**	4.6*
Aveg. canopy height (m)	10.4 ± 0.90 **a**	9.5 ± 0.44 **ab**	9.0 ± 0.85 **b**	5.5*
No. trees with height <10 m	3.3 ± 1.07 **a**	3.8 ± 0.43 **a**	4.0 ± 0.66 **a**	1.2
No. trees with height 11-20 m	2.6 ± 0.34 **a**	1.8 ± 0.56 **a**	2.4 ± 2.80 **a**	0.4
No. trees with height >20 m	0.2 ± 0.11 **a**	0.1 ± 0.09 **a**	0.1 ± 0.08 **a**	2.9

*Significant at $p \leq 0.05$ ($F_{2, 15crit}$=3.7, Tukey's test, $q_{15, 3cri}$=3.7)

Table 12: A comparison between transect means of the eremomela-present and eremomela-absent transects using paired student t-test (n= 18 transects, df= 17)

	Ere-present transects	Ere-absent transects	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees encountered	5.7 ± 0.87	5.5 ±1.03	0.9
Min. canopy height (m)	6.3 ± 0.57	6.5 ± 0.80	-1.3
Max. canopy height (m)	14.3 ± 2.05	13.6 ± 1.76	2.8*
Aveg. canopy height (m)	9.8 ± 1.00	9.5 ± 1.02	1.6
No. trees with height <10 m	3.7 ± 0.73	3.7 ± 1.06	0.2
No. trees with height 11-20 m	1.9 ± 0.83	1.8 ± 0.97	0.2
No. trees with height >20 m	0.2 ± 0.15	0.1 ± 0.09	1.8

*Significant at $p \leq 0.05$ ($t_{5crit}=2.1$); ere= eremomela

Table 13: A comparison between transect means of the eremomela-present and eremomela-absent transects in Block L using paired student t-test (n= 6 transects, df= 5)

	Ere-present transects	Ere-absent transects	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees encountered	6.4 ± 0.68	5.6 ± 1.30	1.5
Min. canopy height (m)	5.6 ± 0.72	6.6 ± 1.32	-0.1
Max. canopy height (m)	16.0 ± 1.43	14.6 ± 1.03	4.0*
Aveg. canopy height (m)	10.8 ± 0.81	10.2 ± 1.15	1.9
No. trees with height <10 m	3.4 ± 1.02	3.1 ± 1.45	0.7
No. trees with height 11-20 m	2.8 ± 0.42	2.4 ± 0.99	1.2
No. trees with height >20 m	0.3 ± 0.21	0.1 ± 0.09	1.4

*Significant at $p \leq 0.05$ ($t_{5crit}=2.1$); ere= eremomela

Table 14: A comparison between transect means of the eremomela-present and eremomela-absent transects in Block M using Paired student t-test (n= 6 transects, df= 5)

	Ere-present transects	Ere-absent transects	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees encountered	5.8 ± 0.38	5.5 ± 0.75	1.1
Min. canopy height (m)	6.2 ± 0.50	6.5 ± 0.46	-1.1
Max. canopy height (m)	14.2 ± 1.24	13.8 ± 1.83	0.7
Aveg. canopy height (m)	9.6 ± 0.47	9.5 ± 0.73	0.4
No. trees with height <10 m	3.8 ± 0..50	3.8 ± 0.82	0.1
No. trees with height 11-20 m	1.9 ± 0.44	0.1 ± 0.13	1.1
No. trees with height >20 m	0.1 ± 0.07	0.1 ± 0.13	0.8

*Significant at $p \leq 0.05$ ($t_{5crit}=2.1$); ere= eremomela

Table 15: A comparison between transect means of the eremomela-present and eremomela-absent transects in Block H using paired student t-test (n= 6 transects, df= 5)

	Ere-present transects	Ere-absent transects	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees encountered	4.8 ± 0.63	5.2 ± 1.11	-1.2
Min. canopy height (m)	6.0 ± 0.34	6.3 ± 0.41	-2.4*
Max. canopy height (m)	12.7 ± 2.10	12.4 ± 1.82	1.1
Aveg. canopy height (m)	9.0 ± 0.77	9.0 ± 0.92	0.1
No. trees with height <10 m	3.9 ± 0.62	4.1 ± 0.71	-1.0
No. trees with height 11-20 m	1.0 ± 0.33	1.5 ± 1.1.02	-1.4
No. trees with height >20 m	0.1 ± 0.09	0.1 ± 0.06	1.0

*Significant at $p \leq 0.05$ (t_{crit}=2.1); ere= eremomela

Circular plots (0.04 ha) were used in the measurement of additional parameters predicted to influence habitat choice at this level (macro). A total of 338 and 334 plots from the eremomela-present and eremomela-absent habitats respectively were assessed. Thirteen parameters were measured.

Analysis of variance results indicated that the three blocks were significantly different in the means of nine parameters from the randomly sampled plots. The number of trees with height of 11-20 m, maximum and average canopy height and the number of trees with height >20 m were the most significant (ANOVA: $F= 20.3, 17.8, 17.8, 13.4$ respectively, df 2,15 $p< 0.05$) (Table 16). The means of these parameters were higher in block L than in blocks M and H.

A further analysis using Tukey's multiple comparison indicated that block L was significantly different from both blocks M and H in six parameters and significantly different from block H in three parameters. Blocks M and H were not significantly different from each other in any of the parameters (Table 16).

The parameters measured from the randomly sampled plots were correlated to varying degrees. In the correlation matrix (Appendix IV) all values of $r \geq 0.67$ are significant at $p \leq 0.05$ (as indicated in bold). Number of trees with dbh of 36-60 cm was strongly and positively correlated with average canopy height and number of trees with height 11-20 m but negatively correlated to the number of trees <10 m in height. Maximum canopy height was strongly and positively correlated with average canopy height, maximum canopy height, number of trees 11-20 m in height and number of trees >20 m in height. Average canopy height was strongly and positively correlated with number of trees 11-20 m in height. The rest of the correlations of parameters are given in Appendix IV.

There were significant differences in the means of five parameters between eremomela-present plots and eremomela-absent plots (Table 17). For a similar comparison, but taking the blocks independently, means of five parameters were significantly different in block L (Table 18), four in block M (Table 19) and none in block H (Table 20). In the two blocks (L and M) there were consistent differences in three parameters; percentage canopy cover, maximum canopy height and average canopy height. The means of all these parameters were higher in block L than in block M and H and also higher in eremomela-present than in eremomela-absent habitats (plots).

Table 16: A comparison of means (+ stdev) of vegetation parameters between the blocks from all the randomly sampled plots. Means with letter (Tukey's test)

	Block L	Block M	Block H	F-value
Parameters	mean ± stdev	mean ± stdev	mean ± stdev	
No. trees with dbh of 10-35 cm	8.5 ± 1.20 **a**	8.5 ± 1.40 **a**	9.4 ± 0.96 **a**	1.1
No. trees with dbh of 36-60 cm	2.4 ± 0.46 **a**	1.8 ± 0.14 **b**	1.5 ± 0.34 **b**	11.7*
No. trees with dbh of >60 cm	1.1 ± 0.22 **a**	0.7 ± 0.19 **b**	0.6 ± 0.17 **b**	10.7*
Min. canopy height (m)	6.1 ± 0.42 **a**	5.9 ± 0.21 **a**	5.7 ± 0.23 **a**	2.1
Max. canopy height (m)	18.8 ± 1.13 **a**	16.2 ± 1.22 **b**	14.9 ± 1.15 **b**	17.8*
Aveg. Canopy height (m)	11.3 ± 0.86 **a**	9.8 ± 0.40 **b**	9.8 ± 0.48 **b**	17.8*
Index of tree disp.(dist) (m)	5.4 ± 0.86 **a**	5.4 ± 0.39 **a**	5.4 0.38 **a**	0.0
Index of tree disp.(dbh) (m)	27.8 ± 1.50 **a**	27 ± 0.21 **ab**	25.0 ± 1.04 **b**	5.7*
Canopy cover (%)	49.7 ± 2.62 **a**	44.6 ± 3.21 **b**	39.8 ± 0.24 **b**	10.6*
Tree density (ha^{-1})	6.2 ±0.68**a**	5.8 ± 0.31 **a**	5.7 ± 0.31 **a**	2.1
No. trees with height of <10 m	5.6 ± 1.83 **a**	7.0 ± 0.86 **ab**	8.2 ± 1.11 **b**	5.9*
No. trees with height of 11-20 m	6.4 ± 1.17 **a**	3.8 ± 0.74 **b**	3.1 ± 0.79 **b**	20.8*
No. trees with height of >20 m	0.6 ± 0.18 **a**	0.8 ± 0.15 **b**	0.2 ± 0.11 **b**	13.4*

*Significant at $p < 0.05$ ($F_{2,\ 15\ crit}$= Tukey's test, $q_{15,\ 5crit}$= 3.7)

Table 17: A comparison between transect means of the eremomela-present and eremomela-absent plots using paired student t-test (n= 18, df= 17)

	Eremomela-present plots	Eremomela-absent plots	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees with dbh of 10-35 cm	8.9 ± 1.16	8.6 ± 1.55	1.0
No. trees with dbh of 36-60 cm	2.0 ± 0.53	1.9 ± 0.53	1.2
No. trees with dbh of >60 cm	0.9 ± 0.36	0.7 ± 0.28	3.2*
Min. canopy height (m)	5.9 ± 0.33	6.0 ± 0.43	-1.4
Max. canopy height (m)	17.4 ± 2.44	15.8 ± 1.62	5.4*
Aveg. Canopy height (m)	10.4 ± 1.22	10.0 ± 0.93	3.3*
Index of tree disp.(dist) (m)	5.4 ± 0.45	5.4 ± 0.39	0.5
Index of tree disp.(dbh) (m)	26.5 ± 2.69	26.8 ± 2.30	-0.4
Canopy cover (%)	46.1 ± 6.18	43.1 ± 5.30	3.8*
Tree density (ha^{-1})	5.9 ± 0,66	5.8 ± 0.54	1.1
No. trees with height of <10 m	6.9 ± 1.79	7.0 ± 1.79	-0.2
No. trees with height of 11-20 m	4.6 ± 1.75	4.3 ± 1.68	1.9
No. trees with height of >20 m	0.4 ± 0.37	0.2 ± 0.14	3.2*

*Significant at $p \leq 0.05$, (t_{crit}= 2.1)

Table 18: A comparison between transect means of the eremomela-present and eremomela-absent plots in block L using paired student t-test (n= 6, df= 5)

	Eremomela-present plots	Eremomela-absent plots	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees with dbh of 10-35 cm	8.7 ± 1.01	8.2 ± 1.62	1.2
No. trees with dbh of 36-60 cm	2.4 ± 0.51	2.4 ± 0.47	0.3
No. trees with dbh of >60 cm	1.3 ± 0.30	0.9 ± 0.26	2.8*
Min. canopy height (m)	6.0 ± 0.39	6.1 ± 0.67	-0.4
Max. canopy height (m)	20.1 ± 1.22	17.4 ± 1.36	5.6*
Aveg. Canopy height (m)	11.7 ± 1.02	11.0 ± 0.86	3,1*
Index of tree disp.(dist) (m)	5.6 ± 0.35	5.3 ± 0.33	1.6
Index of tree disp.(dbh) (m)	28.8 ± 2.88	26.9 ± 2.03	1.3
Canopy cover (%)	51.5 ± 3.06	47.7 ± 2.96	3.4*
Tree density (ha^{-1})	6.4 ± 0.66	6.0 ± 0.78	1.8
No. trees with height of <10 m	5.4 ± 1.85	5.7 ± 2.04	-0.9
No. trees with height of 11-20 m	6.7 ± 0.78	6.0 ± 1.48	1.9
No. trees with height of >20 m	0.8 ± 0.39	0.3 ± 0.13	3.2*

*Significant at $p \leq 0.05$, (t_{crit}= 2.6)

Table 19: A comparison between transect means of the eremomela-present and eremomela-absent plots in block M using paired student t-test (n= 6, df= 5)

	Eremomela-present plots	Eremomela-absent plots	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees with dbh of 10-35 cm	8.6 ± 01.39	8.3 ±1.53	0.9
No. trees with dbh of 36-60 cm	1.8 ± 0.23	17 ± 0.20	0.4
No. trees with dbh of >60 cm	0.8 ±0.19	0.60 ± 0.25	2.0
Min. canopy height (m)	5.9 ± 0.24	6.0 ± 0.27	-1.1
Max. canopy height (m)	16.8 ± 1.32	15.4 ± 0.98	4.6*
Aveg. Canopy height (m)	10.0 ± 0.41	9.7 ± 0.44	3.1*
Index of tree disp.(dist) (m)	5.3 ± 0.41	5.5 ±0.57	-0.8
Index of tree disp.(dbh) (m)	25.8 ± 1.66	28.2 ± 2.34	-2.9*
Canopy cover (%)	46.9 ± 2.25	42.1 ± 4.45	3.6*
Tree density (ha^{-1})	6.0 ±0.57	5.6 ± 0.22	1.4
No. trees with height of <10 m	6.9 ± 0.84	7.0 ± 1.15	-0.3
No. trees with height of 11-20 m	4.0± 0.58	3.6 ±0.95	1.5
No. trees with height of >20 m	0.3 ±0.19	0.1 ± 0.15	2.0

*Significant at $p \leq 0.05$, (t_{crit}= 2.6)

Table 20**:** A comparison between transect means of the eremomela-present and eremomela-absent plots in block H using paired student t-test (n= 6, df= 5)

	Eremomela-present plots	Eremomela-absent plots	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees with dbh of 10-35 cm	9.4 ± 1.06	9.4 ± 1.51	0.1
No. trees with dbh of 36-60 cm	1.6 ± 0.43	1.4 ± 0.29	1.3
No. trees with dbh of >60 cm	0.6 ± 0.22	0.5 ± 0.20	0.7
Min. canopy height (m)	5.7 ± 0.27	5.8 ± 0.24	-1.5
Max. canopy height (m)	15.2 ± 1.43	14.5 ± 0.98	1.9
Aveg. Canopy height (m)	9.4 ± 0.54	9.3 ± 0.43	0.1
Index of tree disp.(dist) (m)	5.5 ± 0.59	5.3 ± 0.26	0.6
Index of tree disp.(dbh) (m)	24.9 ± 1.81	25.4 ± 1.88	-0.4
Canopy cover (%)	39.9 ± 5.76	39.3 ± 4.80	0.5
Tree density (ha^{-1})	5.7 ± 0.67	5.7 ± 0.47	-0.2
No. trees with height of <10 m	8.4 ± 1.18	8.1 ± 1.44	0.4
No. trees with height of 11-20 m	3.1 ± 0.85	3.1 ± 0.83	-0.2
No. trees with height of >20 m	0.2 ± 0.14	0.1 ± 0.07	1.1

*Significant at p≤ 0.05, (t_{crit}= 2.6)

3.2.2 Micro-habitat choice

Micro-habitat selection was assessed using the 0.04 ha circular plots from eremomela-location sites versus those sampled from eremomela-present areas, which gave background habitat values for comparison. A total of 174 and 338 plots respectively were assessed for the thirteen parameters predicted to influence eremomelas' habitat choice.

There were significant differences between the means of all but one of all the means of the thirteen vegetation parameters for comparison between the eremomela-location plots and eremomela-present plots (Table 21). Percentage canopy cover and maximum canopy height returned the highest t-values. The means of both parameters were higher in block L than in block M and H.

The same comparisons were carried out taking each block independently. Means of three of these vegetation parameters were significantly different in block L (Table 22), seven in block M (Table 23) and nine in block H (Table 24). Among the blocks, there were consistent differences in the means of only two parameters, maximum canopy height and percentage canopy cover. There were similar trends as in overall forest in that the means of the two parameters were higher in block L than in the other two blocks. There were no significant differences between blocks in the means of all parameters in the eremomela-location plots (Table 25).

The results of Tables 11-25 are summarized in Table 26 below. The factors important in influencing macro-habitat choice (d vs e and f vs g) and those influencing micro-habitat choice (h vs f) in *E. turneri* are given. The factors positively (+) and negatively (-) influencing habitat choice in the bird at each level are indicated. The factors responsible for the differences between the blocks considering the randomly sampled vegetation transects and plots (i and j) respectively) are also given. The Tukey's multiple comparison test results are also presented here showing between which blocks the differences occur in the means of parameters that were significantly different. The results indicate that percentage canopy cover, maximum and average canopy height were consistently important in determining habitat choice at both levels (micro and macro). The three blocks were not significantly different in any of the parameters measured from the eremomela-location plots (h). However, block L was significantly different from blocks M and H in most of the parameters measured from the randomly sampled plots (j)

Table 21**:** A comparison between transect means of the eremomela-location and eremomela-present plots using paired student t-test (n= 18, df= 17)

	Eremomela-location plots	Eremomela-present plots	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees with dbh of 10-35 cm	10.4 ± 2.14	8.9 ± 1.16	3.7*
No. trees with dbh of 36-60 cm	2.9 ± 0.72	2.0 ± 0.53	5.5*
No. trees with dbh of >60 cm	1.1 ± 0.72	0.9 ± 0.36	2.4*
Min. canopy height (m)	6.5 ± 1.28	5.9 ± 0.33	2.3*
Max. canopy height (m)	20.9 ± 1.83	17.4 ± 2.44	8.0*
Aveg. Canopy height (m)	12.0 ± 0.88	10.4 ± 1.22	6.9*
Index of tree disp.(dist) (m)	5.0 ± 0.52	5.4 ± 0.45	-3.4*
Index of tree disp.(dbh) (m)	25.0 ± 3.17	26.5 ± 2.69	-1.6
Canopy cover (%)	59.4 ± 3.49	46.1 ± 6.18	8.7*
Tree density (ha^{-1})	7.3 ± 0.72	5.9 ± 0.66	7.2*
No. trees with height of <10 m	5.4 ± 1.14	6,9 ± 1.79	-3.9*
No. trees with height of 11-20 m	6.6 ± 1.44	4.6 ± 1.75	4.4*
No. trees with height of >20 m	0.7 ± 0.28	0.4 ± 0.37	4.1*

*Significant at $p \leq 0.05$, (t_{crit}= 2.1)

Table 22: A comparison between transect means of the eremomela-location and eremomela-present plots in block L using paired student t-test (n= 6, df= 5)

	Eremomela-location plots	Eremomela-present plots	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees with dbh of 10-35 cm	10.3 ±2.01	8.7 ± 1.01	2.1
No. trees with dbh of 36-60 cm	3.2 ± 0.66	2.4 ± 0.51	3.1*
No. trees with dbh of >60 cm	1.3 ± 0.25	1.3 ± 0.30	0.1
Min. canopy height (m)	6.4 ± 0.46	6.0 ± 0.39	2.1
Max. canopy height (m)	22.0 ± 0.65	20.1 ± 1.22	3.9*
Aveg. Canopy height (m)	12.6 ± 0.77	11.7 ± 1.02	2.0
Index of tree disp.(dist) (m)	5.1 ± 0.67	5.6 ± 0.35	-1.9
Index of tree disp.(dbh) (m)	26.2 ± 3.68	28.8 ± 2.88	-1.2
Canopy cover (%)	59.7 ± 1.71	51.5 ± 3.06	7.7*
Tree density (ha^{-1})	7.2 ± 0.88	6.4 ± 0.66	2.2
No. trees with height of <10 m	5.0 ± 1.15	5.4 ± 1.85	-0.7
No. trees with height of 11-20 m	7.1 ± 1.44	6.7 ± 0.78	0.9
No. trees with height of >20 m	0.9 ± 0.77	0.8 ±0.39	0.8

*Significant at $p \leq 0.05$, (t_{crit}= 2.6)

Table 23: A comparison between transect means of the eremomela-location and eremomela-present plots in block M using paired student t-test (n= 6, df= 5)

	Eremomela-location plots	Eremomela-present plots	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees with dbh of 10-35 cm	9.5 ± 2.67	8.6 ± 1.39	1.4
No. trees with dbh of 36-60 cm	2.6 ± 0.93	1.8 ± 0.23	2.1
No. trees with dbh of >60 cm	1.2 ± 0.42	0.8 ± 0.19	2.0
Min. canopy height (m)	6.2 ± 0.48	5.9 ± 0.24	1.8
Max. canopy height (m)	20.8 ± 1.13	16.8 ± 1.32	6.8*
Aveg. Canopy height (m)	11.9 ± 0.65	10.0 ± 0.41	8.3*
Index of tree disp.(dist) (m)	5.0 ± 0.41	5.3 ± 0.41	-1.3
Index of tree disp.(dbh) (m)	24.7 ± 3.38	25.8 ± 1.66	-1.0
Canopy cover (%)	58.9 ± 4.84	46.9 ± 2.25	9.4*
Tree density (ha^{-1})	7.0 ± 0.56	7.0 ± 0.57	9.6*
No. trees with height of <10 m	5.4 ± 0.77	6.9 ± 0.84	-3.9*
No. trees with height of 11-20 m	6.1 ± 1.19	4.0 ± 0.58	4.5*
No. trees with height of >20 m	0.6 ± 0.23	0.3 ± 0.19	3.2*

*Significant at $p \leq 0.05$, (t_{crit}= 2.6)

Table 24: A comparison between transect means of the eremomela-location and eremomela-present plots in block H using paired student t-test (n= 6, df= 5)

	Eremomela-location plots	Eremomela-present plots	
Parameters	mean ± stdev	mean ± stdev	T-stat
No. trees with dbh of 10-35 cm	11.5 ± 1.40	9.4 ± 0.19	2.8*
No. trees with dbh of 36-60 cm	2.9 ± 0.363	1.6 ± 0.43	5.2*
No. trees with dbh of >60 cm	0.9 ± 0.36	0.6 ± 0.22	2.0
Min. canopy height (m)	7.0 ± 2.17	5.7 ± 0.27	1.6
Max. canopy height (m)	19.9 ± 2.63	15.2 ± 1.43	6.2*
Aveg. Canopy height (m)	11.5 ± 0.89	9.4 ± 0.54	5.6*
Index of tree disp.(dist) (m)	4.9 ± 0.52	5.5 ± 0.59	-2.5
Index of tree disp.(dbh) (m)	24.3 ± 2.62	24.9 ± 1.81	-0.5
Canopy cover (%)	59.7 ±3.80	39.9 ± 5.76	7.3*
Tree density (ha^{-1})	7.6 ± 0.69	5.7 ± 0.67	9.3*
No. trees with height of <10 m	5.9 ± 1.49	8.4 ± 1.18	-3.2*
No. trees with height of 11-20 m	6.6 ± 1.70	3.1 ± 0.85	4.1*
No. trees with height of >20 m	0.7 ± 0.36	0.2 ± 0.14	5.0*

*Significant at $p \leq 0.05$, ($t_{crit} = 2.6$)

Table 25: Between blocks comparison of means (± stdev) of vegetation parameters in the eremomela-location plots

	Block L	Block M	Block H	T-value
Parameters	mean ± stdev	mean ± stdev	mean ± stdev	
No. trees with dbh of 10-35 cm	10.3 ± 2.01	9.4 ± 2.67	11.5 ± 1.39	1.4
No. trees with dbh of 36-60 cm	3.2 ± 0.67	2.6 ± 0.93	2.9 ± 0.47	1.1
No. trees with dbh of >60 cm	1.3 ± 0.24	1.2 ± 0.42	0.9 ± 0.35	2.0
Min. canopy height (m)	6.4 ± 0.46	6.3 ± 0.51	7.0 ± 2.16	0.6
Max. canopy height (m)	22.0 ± 0.67	20.8 ± 1.13	19.0 ± 2.63	2.4
Aveg. Canopy height (m)	12.6 ± 0.77	11.9 ± 0.66	11.5 ± 0.89	1.4
Index of tree disp.(dist) (m)	5.1 ± 0.67	4.9 ± 0.40	4.7 ± 0.21	1.1
Index of tree disp.(dbh) (m)	26.1 ± 3.69	24.7 ± 3.40	24.3 ± 2.61	0.5
Canopy cover (%)	59.7 ± 1.70	58.9 ± 4.82	59.7 ± 3.79	0.1
Tree density (ha^{-1})	7.2 ± 0.88	7.0 ± 0.56	7.6 ± 0.69	0.8
No. trees with height of <10 m	5.0 ± 1.04	5.4 ± 0.75	5.9 ± 1.49	1.0
No. trees with height of 11-20 m	7.1 ± 1.45	6.1 ± 1.17	7.0 ± 2.05	0.7
No. trees with height of >20 m	0.9 ± 0.16	0.6 ± 0.23	0.7 ± 0.36	2.2

Table 26: Summary of results (student paired t-tests and Anova tests) as contained in Tables 11- 25

	Student paired t-test												Anova tests											
Parameters	**d** vs **e** (macro)				**f** vs **g** (macro)				**h** vs **f** (micro)				**I**				**J**				**h**			
	O	L	M	H	O	L	M	H	O	L	M	H	F	L	M	H	F	L	M	H	F	L	M	H
No. trees with dbh 10-35 cm					ns	ns	ns	ns	+	ns	ns	+					ns	a	a	a	ns	a	a	a
No. trees with dbh 36-60 cm					ns	ns	ns	ns	+	+	ns	+					*	**a**	b	b	ns	a	a	a
No. trees with dbh > 6o cm					+	+	ns	ns	+	ns	ns	ns					*	**a**	b	b	ns	a	a	a
Min. canopy height (m)	ns	ns	ns	-	ns	ns	ns	ns	+	ns	ns	ns	ns	a	a	a	ns	a	a	a	ns	a	a	a
Max. canopy height (m)	+	+	ns	ns	+	+	+	ns	+	+	+	+	*	a	ab	b	*	a	b	b	ns	a	a	a
Aveg. canopy height (m)	ns	ns	ns	ns	+	=	+	ns	+	ns	+	+	*	a	ab	b	*	a	b	b	ns	a	a	a
Index of tree disp. (dist) (m)					ns	ns	ns	ns	-	ns	ns	ns					ns	a	a	a	ns	a	a	a
Index of tree disp. (dbh) (m)					ns	ns	ns	ns	ns	ns	ns	ns					*	a	ab	b	ns	a	a	a
Canopy Cover (%)					+	+	+	ns	+	+	+	+					*	a	b	b	ns	a	a	a
Tree density (ha^{-1})					ns	ns	ns	ns	+	ns	+	+					ns	a	a	a	ns	a	a	a
No. trees with height of <10 m	ns	ns	ns	ns	ns	ns	ns	ns	-	ns	-	-	ns	a	a	a	*	a	ab	b	ns	a	a	a
No. trees with height of 11-20 m	ns	ns	ns	ns	ns	ns	ns	ns	+	ns	+	+	ns	a	a	a	*	a	b	b	ns	a	a	a
No. trees with height of >20 m	ns	ns	ns	ns	+	+	ns	ns	+	ns	+	+	ns	a	a	a	*	a	b	b	ns	a	a	a
No. trees encountered	ns	ns	ns	ns																	ns	a	a	a

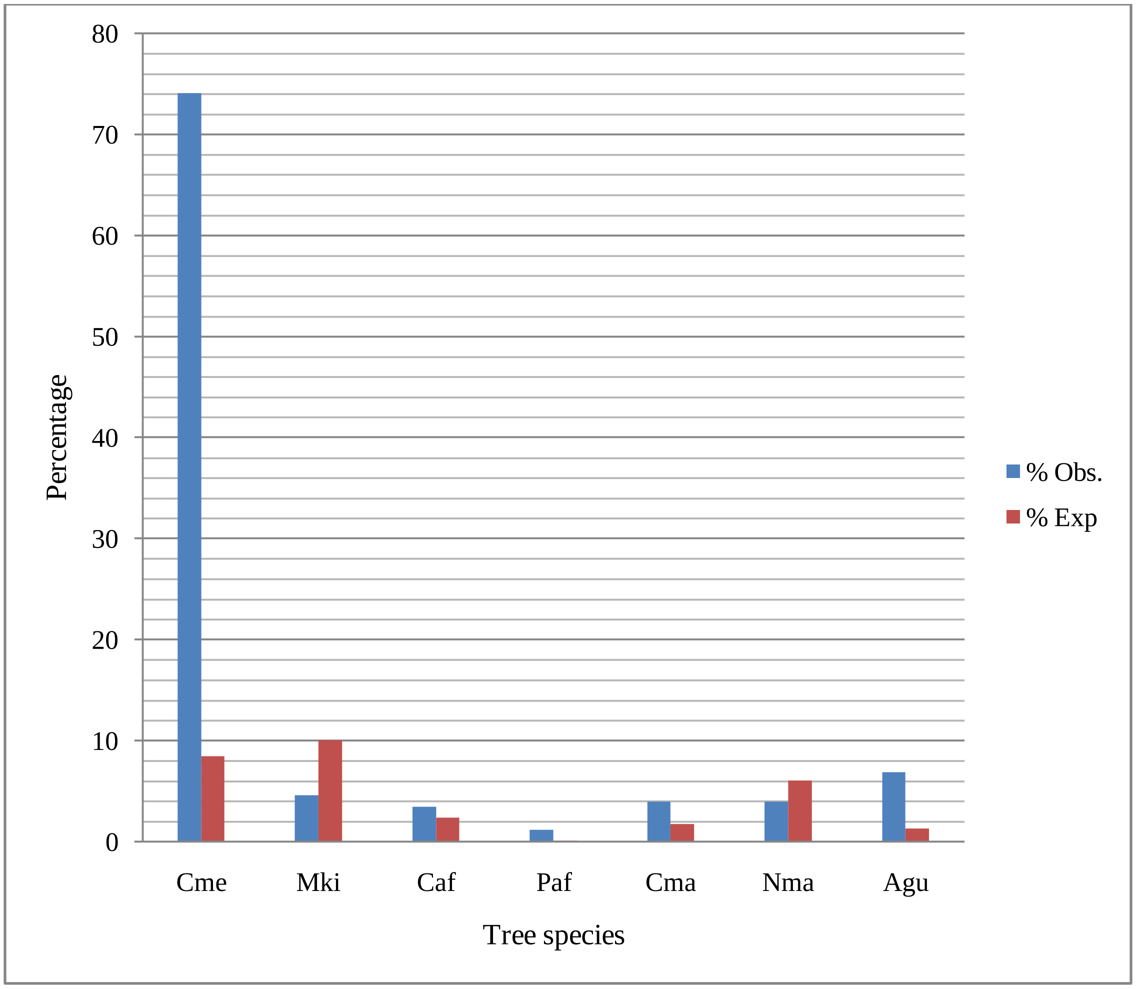
Key:- **b**= eremomela-present vegetation transects, **e**= eremomela-absent transects, **f**= eremomela-present-plots, **g**= eremomela-absent plots, **h**= eremomela-location plots, **i**= all sampled vegetation transects, **j**= all randomly sampled plots, **O**= Overall, **L**= block L, **M**= block M, **H**= block H, *****= significant, **ns**= not significant, **+**= positive predictor, -= negative predictor, Anova tests:-**F**= F-value, the same letters (**a**,**b**,**c**) indicate that the means are not significantly different, letters in bold indicate that the mean is higher in that block than in the other blocks (Tukey's test)

3.2.3. Tree species utilization and preference in *E. turneri*

The results of the preliminary survey indicated that *E. turneri* predominantly utilize only seven of the more than sixty tree species occurring in South Nandi forest. These species were identified as:-. *Croton megalocarpus*, *Macaranga kilimandscharica*, *Celtis africana*, *Prunus africana*, *Croton macrostachyus*, *Neaboutonia macrocalyx* and *Albizia gummifera*. Other species occasionally used by the eremomela (whether identified or not) were recorded as *others*.

Overall, nearly three-quarters of the eremomela sightings (74.1%) were in *Croton megalocarpus.* Blockwise, 78.1% of the birds sighted in block L were in this species, 72.6% in block M and 70.0% in block H. 71.3% of all the sightings in this species were in the tall trees that were >20 m in height.

The second tree species after *C. megalocarpus* in terms of eremomela sightings in them was *A. gummifera* (representing 6.9% of all the sightings). There were only two (1.2%) sightings in *P. africana*. This species has been almost logged out of the forest and is now very rare. Eremomelas were occasionally sighted in *N. macrocalyx* (4.0%) mainly in block H. 85.7% of all the sightings in this species were from block H. This was also the block that registered the highest number of this tree species. The results of the observed tree species usage are presented in Figure 4 (see also Appendix II).

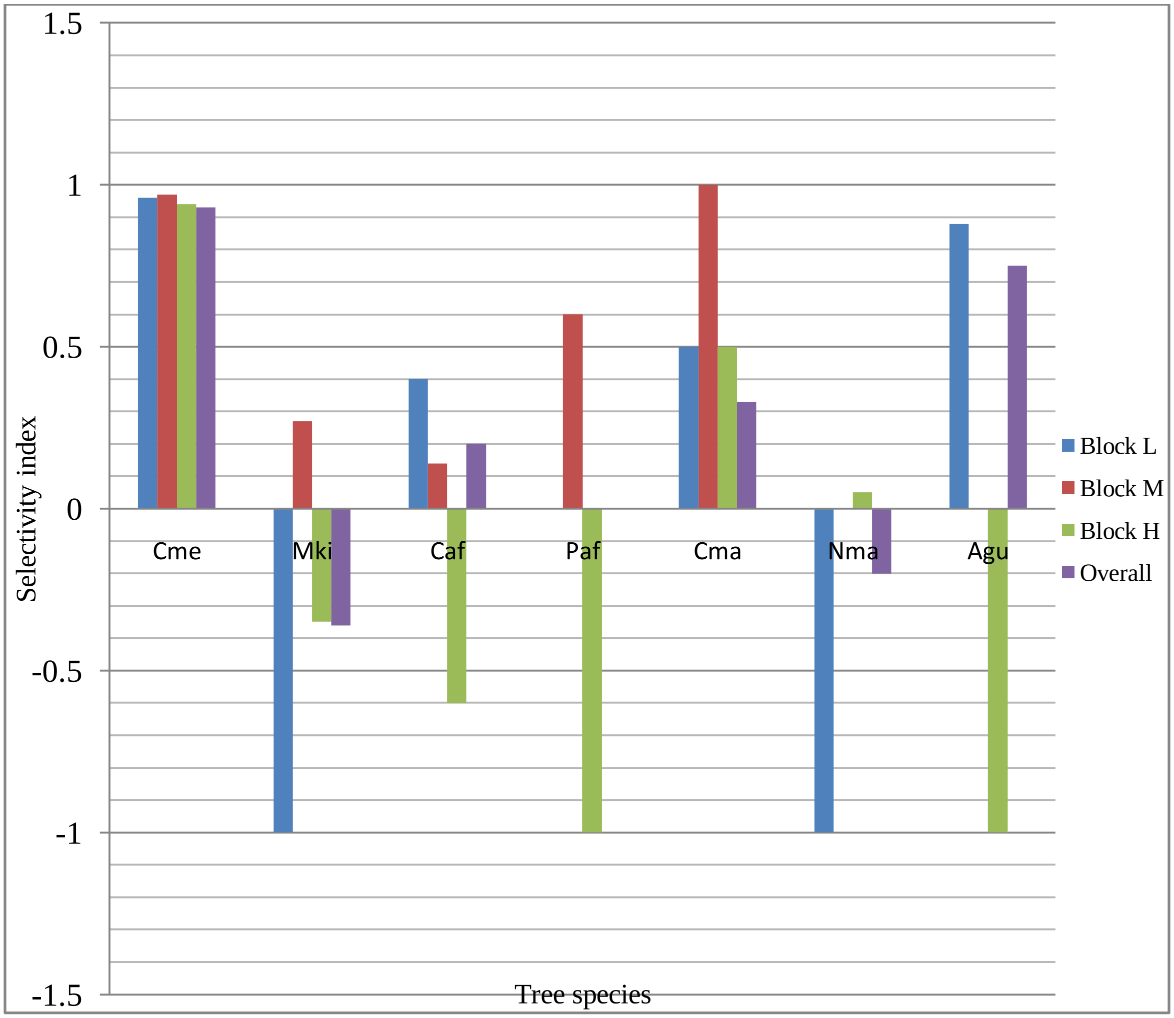


Key: Cme, *C. megalocarpus*, Mki, *M. kilimandscharica*, Caf, *C. africana*, Paf, *P. africana*, Cma, *C. macrostachyus*, Nma, *N. macrocalyx* and Agu, *A. gummifera*

Figure 4: Tree species utilized by *E. turneri*, showing percentage sightings in (Obs. Use) and percentage abundance of (Exp. use) each tree species

The selectivity indices (Figure 5) indicated that the bird's preference for each of the seven tree species varied with blocks. *Croton megalocarpus* and *Croton macrostachyus* were consistently preferred across all the blocks. Overall, *Croton megalocarpus* and *Albizia gummifera* were the most preferred tree species (E_i = 0.93 and 0.75 respectively) (Table 27). The expected usage were very high as compared to observed usage in these two tree species (Chi-square = 963.9 and 43.6 respectively, df = 1, $p \leq 0.05\%$) (Table 27). This indicated that there was true preference by the eremomela for these species rather than a chance phenomenon. Within blocks, the eremomela were not sighted in some of these seven tree species during counts. Their selectivity indices were negative (Figure 5) indicating that they were entirely avoided.

There were significant differences between blocks in the mean of abundance of five of the tree species counted from the randomly sampled plots (Table 28). There were also significant differences between the blocks in the means of abundance of tree species counted from the randomly sampled transects (Table 29). The results of Tukey's tests for these comparisons are given in Table 28 and 29 respectively.



Key: Cme, *C. megalocarpus*, Mki, *M. kilimandscharica*, Caf, *C. africana*, Paf, *P. africana*, Cma, *C. macrostachyus*, Nma, *N. macrocalyx* and Agu, *A. gummifera*

Figure 5: Habitat selectivity indices of *E. turneri* in terms of tree species preference

Table 27**:** Habitat selectivity indices of *E. turneri* in terms of tree species preference in S. Nandi forest

	Selectivity index tests					Chi-square tests		
Tree species	N_i	N_t	A_i	A_t	E_i	Obs.	Exp.	Chi-sq
C. megalocarpus	129	174	667	7847	0.93	129	14.8	963.9*
M. kilimamadscharica	8	174	792	7847	-0.36	8	17.6	5.8*
C. africana	6	174	183	7847	0.20	6	4.1	1.0
P. africana	2	174	71	7847	0.00	2	1.6	0.1
C. macrostachyus	7	174	139	7847	0.33	7	3.1	5.1*
N. macrocalyx	7	174	477	7847	-0.20	7	10.6	1.3
A. gummifera	12	174	100	7847	0.75	12	2.2	43.6*

Key:- $\mathbf{N_i}$= Number of trees of each species i in which the eremomelas were sighted, $\mathbf{N_t}$= Total number of all trees in which the eremomelas were sighted, $\mathbf{A_i}$= Number of trees of species i in whole block/forest, $\mathbf{A_t}$= Total number of trees in whole block/forest

Table 28**:** Between blocks comparison of mean abundance (+ stdev) of trees of the seven species utilized by *E. turneri* counted from the randomly sampled plots. Means with same letter are not significantly different (Tukey's test).

	Block L	Block M	Block H	F-value
Tree species	mean ± stdev	mean ± stdev	mean ± stdev	
Croton megalocarpus	0.5 ± 0.17 **a**	0.2 ± 0.14 **b**	0.2 ± 0.11 **b**	8.8*
Macaranga kilimandscharica	0.6 ± 0.61 **a**	1.0 ± 0.40 **a**	2.1 ± 0.93 **b**	7.4*
Celtis africana	0.1 ± 0.10 **a**	0.5 ± 0.18 **b**	0.2 ± 0.15 **b**	10.7*
Prunus africana	0.1 ± 0.03 **a**	0.2 ± 0.19 **a**	0.1 ± 0.17 **a**	1.0
Croton macrostachyus	0.1 ± 0.14 **ab**	0.1 ± 0.06 **a**	0.4 ± 0.27 **a**	4.2*
Neoboutonioa macrocalyx	0.2 ± 0.17 **a**	0.2 ± 0.17 **a**	1.2 ± 0.67 **b**	12.3*
Albizia gummifera	0.2 ± 0.20 **a**	0.1 ± 0.04 **a**	0.3 ± 0.23 **a**	2.3

*Significant at $p \leq 0.05$ ($F_{2,15}$= 3.7, Tukeys' test, $q_{15,3\ crit}$=3.7)

Table 29: Between blocks comparison of mean abundance (+ stdev) of trees of the seven species utilized by *E. turneri* counted from the randomly sample transects. Means with the same letter are not significantly different (Tukey's test)

	Block L	Block M	Block H	F-value
Tree species	mean ± stdev	mean ± stdev	mean ± stdev	
Croton megalocarpus	0.4 ± 0.17 **a**	0.4 ± 0.24 **a**	0.5 ± 0.31 **b**	0.6
Macaranga kilimandscharica	0.2 ± 0.22 **a**	0.5 ± 0.230 **ab**	0.9 ± 0.42 **b**	6.0*
Celtis africana	0.1 ± 0.08 **a**	0.2 ± 0.12 **a**	0.1 ± 0.09 **ab**	4.4*
Prunus africana	0.0 ± 0.00 **a**	0.1 ± 0.10 **a**	0.0 ± 0.06 **a**	0.8
Croton macrostachyus	0.1 ± 0.09 **a**	0.1 ± 0.11 **a**	0.2 ± 0.19 **a**	1.4
Neoboutonioa macrocalyx	0.1 ± 0.09 **a**	0.1 ± 0.18 **a**	0.7 ± 0.24 **b**	20.5*
Albizia gummifera	0.1 ± 0.41 **a**	0.0 ± 0.03 **a**	0.0 ± 0.03 **a**	3.3

*Significant at $p \leq 0.05$ ($F_{2,15}$= 3.7, Tukeys' test, $q_{15,3\ \mathrm{crit}}$=3.7)

3.3.4 Proximate factors influencing the presence and density of *E. turneri* in the forest

A stepwise backward procedure in the Statistical program GLIM was used to select the final minimum adequate model containing only significant parameters best predicting the presence of the eremomela in the forest. For a comparison of means of vegetation parameters between the eremomela-present and absent transects the logistic regression model selected average canopy height as the factor positively influencing the presence of the eremomela in the forest at macro-habitat level. Minimum canopy height was selected as the factor negatively influencing the presence of the bird at this level (Table 30).

For the same level (macro) but comparing means of vegetation parameters between eremomela-present and absent plots, the logistic regression model selected maximum canopy height, index of tree dispersion (distance of the nearest trees in each quarter from plot centre) and percentage canopy cover as the factors positively influencing the presence of eremomela in the forest at macro-habitat level while index of tree dispersion (dbh, i.e. dbh of trees nearest plot centre in each quarter) was selected as the negative predictor. Maximum canopy height was the strongest positive predictor (Table 31).

Percentage canopy cover, the number of trees with dbh 10-35 cm and maximum canopy height were selected by the logistic regression model as positive predictors of the presence of Turner’s Eremomela in S. Nandi forest at micro-habitat level. Percentage canopy cover was the strongest predictor. Index of tree dispersion (dbh), and number of trees with height <10 m were selected as the negative predictors (Table 32).

Table 30**:** Logistic regression model selecting habitat parameters which best predict the presence of *E. turneri* in S. Nandi forest at macro-habitat level. Parameters from eremomela- present and absent vegetation transects tested with stepwise backward procedure

Parameters	chi-sq	change in df	P ≤
Full model	3.5	5	0.05
Aveg. Canopy height	5.8	1	0.05
Min. canopy height	6.2	1	0.05

Model selected: $G(x_i)$ = -0.82 (+ 0.591)- 0.21 (+ 0.08) min. canopy height + 0.22 (+ 0.07) aveg. canopy height

Key: $G(x_i)$- Probability of presence of *E. turneri*

Table 31: Logistic regression model selecting habitat parameters which best predict the presence of *E. turneri* in S. Nandi forest at macro-habitat level. Parameters from eremomela- present and absent plots tested with stepwise backward procedure

Parameters	chi-sq	change in df	P ≤
Full model	5.2	8	0.05
Max. canopy height (m)	11.8	1	0.05
Index of tree disp. (dist) (m)	6.2	1	0.05
Index of tree disp. (dbh) (m)	4.3	1	0.05
Canopy cover (%)	4.2	1	0.05

Model selected: $G(x_i) = -2.58$ (± 0.51) + 0.12 (± 0.02) max. canopy height + 0.15 (± 0.06) index of tree disp. (dist) – 0.03 (± 0.01) index of tree disp. (dbh) + 0.01 (±0.01) % canopy cover

Key: $G(x_i)$- Probability of presence of *E. turneri*

Table 32: Logistic regression model selecting habitat parameters which best predict the presence of *E. turneri* in S. Nandi forest at micro-habitat level. Parameters from eremomela- location and present plots tested with stepwise backward procedure

Parameters	chi-sq	change in df	$P \leq$
Full model	8.3	7	0.05
Canopy cover (%)	32.5	1	0.05
Index of tree disp. (dbh) (m)	19.9	1	0.05
No. trees with height of < 10 m	12.2	1	0.05
No. trees with dbh of 10-35 cm	7.3	1	0.05
Max. canopy height (m)	5.1	1	0.05

Model selected: $G(x_i) = 5.9\ (\pm\ 0.99) + 0.13\ (\pm\ 0.04)$ no. trees with dbh of 10-35 cm + 0.12 (± 0.03) max. canopy height – 0.07 (± 0.06) index of tree disp. (dbh) + 0.10 (±0.01) % canopy cover -0.27 (± 0.06) no. trees with height < 10 m

Key: $G(x_i)$- Probability of presence of *E. turneri*

Stepwise backward and forward procedures were carried out using GLIM to select vegetation parameters and tree species best explaining the observed eremomela densities in S. Nandi forest.

Normal multiple regression model selected *Croton megalocarpus* and *Celtis africana* as the tree species important in determining the density of the eremomela in the forest (Table 33). On the other hand, the number of trees encountered (dbh > 10 cm) within the 40 m vegetation transects and number of trees with height 10-20 m significantly affected the density of the birds (Table 34)

Table 33: Normal multiple regression model selecting the tree species best explaining the observed eremomela densities per transect in S. Nandi forest. All the tree species are tested using stepwise forward and backward procedure

Parameter	t-value	change in df	$P \leq$
Full model	5.58	2	0.05
Celtis africana	3.61	1	0.05
Croton megalocarpus	2.41	1	0.05

Model selected: $Y(x_i) = 3.55\ (\pm\ 0.37) + 0.29\ (\pm\ 0.19)$ *C. megalocarpus* + $0.59\ (\pm 0.36)$ *C. africana*

Key:- $Y(x_i)$- Density (individuals ha^{-1}) of *E. turneri*

Table 34: Normal multiple regression model selecting the habitat parameters best explaining the observed eremomela densities in S. Nandi forest. All parameters are tested using stepwise forward and backward procedure

Parameter	t-value	change in df	$P \leq$
Full model	5.15	2	0.05
No. trees with height of 11-20 m	2.57	1	0.05
No. trees encountered	2.00	1	0.05

Model selected: $Y(x_i) = 4.12\ (\pm\ 0.80) + 0.18\ (\pm\ 0.17)$ No. trees encountered $-\ 0.38\ (\pm 0.17)$ No. trees with height of 11-20 m

Key:- $Y(x_i)$- Density (individuals ha^{-1}) of *E. turneri*

Plate 1: Photograph of S. Nandi Forest showing the eremomela-suitable habitats, a closed canopy forest dominated by *Croton megalocarpus*. Foreground are the Nyayo Tea Zones

Plate 2: Photograph of S. Nandi Forest showing felled *P. africana* and *C. megalocarpus*; two of the tree species utilized by the eremomela in the forest

Plate 3: Photograph of S. Nandi Forest showing logging. This is the main cause of the immense forest disturbance in the forest interior

Plate 4: Photograph of S. Nandi Forest showing excision of the forest for "ill-defined" development projects resulting in the ever-reducing forest size

CHAPTER FOUR

4.0 DISCUSSION

The study aimed at assessing the status of Turner's Eremomela in South Nandi Forest Reserve through population counts and determination of its densities. To understand habitat choice in the bird, I selected and measured habitat features (vegetation parameters) that I had predicted to be important in influencing the bird's habitat requirements. The results of the study allowed me to make predictions of the species' responses to habitat changes and to anticipate possible detrimental effects to its survival from forest-use practices. The study's findings are herein discussed.

4.1 Population size, density and distribution

The overall population of Turner's Eremomela in S. Nandi forest was estimated at 13,900 individuals with a density of 1.06 eremomlas ha-1 and 0.27 groups ha-1 (Table 9). The three blocks significantly differed in the number of eremomela groups sighted (Table 1) with more sightings in block L (42.0%) than in block M and H (29.3% and 28.7%) respectively (Appendix I).

These trends suggest that block L appears to have been a more suitable or high-quality habitat for the bird where survival and reproductive success are expected to be high (Gaston, 1978b). Pullium *et al*. (1992) suggested that such high-quality habitats could be proximally related to the species' survivorship and reproductive success hence influencing abundance and distribution of *E. turneri*. O'Connor and Fuller (1986) observed that the suitability of a particular habitat affects the breeding performance and population dynamics of each species as well as the dispersion of individuals within a species range.

The disparity in eremomela sightings between the three blocks may be attributed to difference in habitat quality. The study showed that canopy cover, canopy height and tree height as well as the abundance of *C. megalocarpus* were higher in block L than in the other blocks. Given that the eremomela is a top canopy species and having a very strong preference for *C. megalocarpus*, this combination makes block L to be a high-quality habitat in terms of foraging opportunities. These forging opportunities may have been fewer in block M and H which in view of the bird's requirements are low-quality habitats. According to Newton (1979), food and nesting sites may have been the two primary resources limiting bird's population in low-quality habitats.

Fitness in birds has been linked with variation in food abundance (Jones and Ward, 1979). High-quality areas (such as block L) are expected to offer both food and nesting opportunities and thus as Brown (1969) suggested, attracted higher numbers of the eremomelas than in the low-quality areas namely blocks M and H.

The study further revealed that block L was less disturbed than blocks M and H and disturbance was shown to have affected the number of eremomela sightings (less in disturbed areas). Therefore, as a result of disturbance, blocks M and H may be regarded as generally low-quality areas having mosaics of high-quality habitats. Greenwood

(1992) observed that this phenomenon affects the distribution of birds and may have been the case with the eremomela in S. Nandi forest.

Forest disturbance has negatively affected habitat quality through loss and fragmentation such that high-quality habitats may now be getting saturated with the eremomelas. Consequently, this could result in intraspecific competition where the outcompeted individuals may have been forced to move, adapt and occupy the low-quality habitats. Such habitats offer less resources therefore reducing their reproductive and survival success and increasing predation vulnerability hence low population as observed in blocks M and H. The eremomela's choice for *C. megalocarpus* conforms to those of Fretwell and Lucas (1969) who elegantly documented that habitats which are intrinsically less suitable in terms of food resources are tolerable if population densities there are lower than in the prime habitats.

Other key resources have been identified to influence the distribution of other threatened bird species. Njoroge (1994) observed that the distribution of *Lantana camara* was important in the distribution of Hindes Babbler, *Turdoides hindie*. The distribution of tussocks in Kinngop Plateau affected the distribution and densities of Sharpe's Longclaw, *Macronyx sharpie* (Muchai, 1998). In S. Nandi forest, the tall *C. megalocarpus* were more abundant in block L than in the other two blocks. The study showed that the bird has a very strong preference for this trees species. In this regard, the distribution of *E. turneri* seemed to follow the distribution of this tree species suggesting that the distribution of *C. megalocarpus* played a considerable role in the distribution of *E. turneri*.

4.2 Group sizes

The selective factors promoting group living and group size have been widely debated (Wittenberger and Hunt, 1985) and they include effects of habitat heterogeneity in which sites differ in the number of individuals that can be supported by the spatial and temporal availability of local resources (Fretwell and Lucas, 1970). Others include territory (Skutch, 1961, Muchai, 1998), predation (MacGowan and Woolfenden, 1989) and territorial defence and co-operative breeding (Njoroge, 1994).

Group living and group sizes in *E. turneri* could be as a result of one or more of these factors. The eremomelas were recorded in only even numbered groups (two, four, six and eight birds) suggesting that these groups were most probably foraging groups in which the monogamous pairs teaming up together for purposes of optimal foraging and vigilance against predation. However, the low probability of encountering these even numbered eremomela groups by chance suggests that there may be other factors influencing group living in Turner's Eremomela, hence there is need to carry out elaborate studies on Eremomela group dynamics over a longer period of time.

Although there were no significant differences between blocks in the means of eremomela sightings in the four group size categories, the bird was observed to forage in larger groups (six and eight) in blocks M and H. In block L the bird foraged predominantly in groups of four (Figure 3). The study showed that there were no significant differences in the observed and expected eremomela sightings in each block in the four group size categories. This implies that the eremomelas foraged in these groups in each block as observed (Appendix I). It is my impression that habitat quality in terms of spatial and temporal availability of local resources (Fretwell and Lucas, 1970) may have influenced group size in *E. turneri*.

Njoroge (1994) argued that where there are extensive high-quality habitats in terms of food resources, most birds live in larger groups because extensive suitable habitats offsets the benefits of group living and helping behaviour. This is because in high-quality areas the fitness of breeders increase by allowing the non-breeders to remain within the territory irrespective of whether they assist in reproduction (Gaston, 1978b).

As a result of forest disturbance, the eremomela-suitable habitats in S. Nandi have been made less extensive and the available high-quality habitats may actually be getting saturated. Consequently, the eremomelas may have to forage in a group size that strikes the balance between reducing intraspecific competition and that of keeping vigil for predators. If this is the case, then group size of four birds may be advantageous.

On the other hand, the adverse conditions in the low-quality habitats such as open canopies and scattered resource trees resulting from forest use may have compelled the bird to forage in bigger group sizes. Foraging in bigger group sizes may enhance vigilance therefore reducing predation in such habitats (where predation is likely to be high) as well as enhancing searching for the scattered resource trees within their foraging range.

This suggestion conforms with the argument by Njoroge (1994) that the ultimate result of continued loss of habitat is the increase in group size regardless of the disadvantages of enlarged groups. In my study the eventual effect of habitat changes brought by forest use is continued loss of eremomela-suitable habitats which coupled with greater natal philopatry will lead to large eremomela group sizes and lower per capita reproductive rate (Skutch, 1961).

Aspects of eremomela group size composition, behaviour of group unit, and group social structure and behaviour were beyond the scope of the present study. I strongly recommend a study on these aspects as it will allow us to fully understand group living in Turner’s Eremomela.

4.3 Habitat choice and tree species preference

4.3.1 Habitat choice

A comparison of the measured habitat features (parameters) in the eremomela-occupied areas with those in the unoccupied areas revealed that the two areas differed significantly (Table 26) indicating that the bird is non-randomly distributed with respect to habitat features.

The study showed that habitat features in the eremomela-location sites differed significantly with the background features in eremomela-present areas which in turn were significantly different from those in the eremomela-absent areas within blocks and in the overall forest. The study further revealed that block L was consistently different from blocks M and H in the means of vegetation parameters and abundance of some of the tree species utilized by the bird. Block M and H were not significantly different. Further, there were no significant differences between blocks in the means of any of the parameters measured from eremomela-location sites. These results are summarized in Table 26. It is evident that the important factors that *E. turneri* uses to distinguish between the suitable and unsuitable areas were mostly percentage canopy cover, canopy height and tree height. All these parameters are higher in the eremomela-occupied areas than in the eremomela-unoccupied areas and also in block L than in blocks M and H.
These results imply that within each block, there appeared to be eremomela-suitable and unsuitable habitats which were distinctively different in terms of vegetation structure and composition of the seven tree species utilized by the bird, Further, in the largely suitable habitats (namely the eremomela-present areas, e.g Plate 1), there existed specific micro-habitats or high-quality habitats which the bird chose specially for its foraging activities. This is the reason why the eremomela-location plots significantly differed with the eremomela-present pots in the means of vegetation parameters (Table 21).

These findings therefore advance my supposition that the bird exhibited a high degree of micro-habitat choice. Therefore, the habitat features crucial for the survival of the eremomela operate at micro-habitat scale. These micro-habitats seemed to be defined by a tree species (and mostly *C. megalocarpus*) which the bird selects to center its foraging activities.

These micro-habitats appear to occur in South Nandi forest as fragmented patches or mosaics having similar features regardless of altitudinal gradient. The three blocks differed in vegetation structure, overall and in areas frequented by the eremomela but were not significantly different in the means of any of the vegetation parameters measured in the eremomela-location plots (Table 25). It is perhaps the patchiness (due to disturbance) of these micro-habitats that best explains the current disparity in the spatial distribution of the bird among the three blocks.

Rostald (1991) argued that because of their mobility and large home ranges, birds usually perceive fragmented forests in a fine-grained manner and bird species select different parts of the vegetation or as Hilden (1965) observed, different structural niches in which to center their activities. The eremomela's response to habitat variability in choosing a suitable habitat concurs with these observations. Fanshawe (1995) documented that as a result of removal of particular tree species, selectively logged forests present a mosaic of degraded areas. It is my impression therefore that *E. turneri* were selecting patches within the overall mosaic and this justifies the term micro-habitat choice.

4.3.2 Tree species preference

Of the tree species initially recorded to be utilized by Turner's Eremomela, the bird exhibited a very strong preference for *Croton megalocarpus* within and among the three blocks (Table 27, Figure 4). The abundance of *C. megalocarpus* accounted for 8.5% of all the trees counted from the randomly sampled plots yet its observed use by the bird was 74.1% giving an overall selectivity index of 0.93 (Table 27). The eremomela can therefore be said to be specialized in the use of this tree species.

The bird may be preferring this tree species for a number of reasons. According to optimal foraging theory (Stephens and Krebs, 1986), one of the strategies to reduce competition for food while exploiting resources and maximizing energy returns/rewards is to be a specialized feeder. With respect to this argument, *E. turneri* perhaps could be a specialized and selective feeder probably exploiting some arthropod species exclusively supported by *C. megalocarpus*. Another equally possible explanation is that leaf configuration and foliage density of *C. megalocarpus* may be conducive for the bird's search-and-probe tactics used in exploiting food items among the foliage. Holmes (1981) advanced this argument that for forest birds the opportunities and obstacles to foraging provided by different foliage configuration are most influential. It can be argued that the tall *Croton* trees coupled with their broad canopies increase the area for optimal foraging as well as offering good vantage position for the bird hence enhancing keeping vigil against any unsuspecting predators. The foliage density of *C. megalocarpus* may have also been conducive in easing the bird's movements among the foliage in search of food items.

In similar researches (e.g Holmes and Robinson, 1981, Robinson and Holmes, 1984), it has been found that many bird species preferentially select certain tree species for foraging. Robinson and Holmes (1982) argued that tree species choice is influenced by the unique morphological and behavioural traits of individual bird species that allows them to differentially exploit arthropods among various foliage structures exhibited by various forest trees. Seeking cover by the prey in reducing predation vulnerability has been well documented in previous researches (e.g Ekman, 1986, Muchai, 1998) and therefore my suggestion seem to conform with these observations.

From a conservation view, this strong preference of *C. megalocarpus* by Turner's Eremomela is a matter of great concern. This is an issue to worry about since the present logging is concentrating on *C. megalocarpus* (KIFCON, 1993). Complete removal of this tree species (especially the taller trees) from the forest will mean a sudden crash in the population of the eremomela or even worse, an imminent local extinction of the bird in South Nandi forest.

There is therefore need to carry out a definitive study on the relationship between Turner's Eremomela and *Croton megalocarpus* with a view to formulating pragmatic measures to actively conserve this tree species among others in the forest.

In the study it appeared that the eremomela's use of the other tree species was out of convenience rather than necessity. The eremomelas seemed to have used these other tree species while on ‘transit’ from one *C. megalocarpus* to another rather than using them for active foraging. The birds were recorded in these other tree species mainly in the disturbed areas where the canopy was not continuous and characterized by large open caps.

4.4 Threats facing *E. turneri*

It is perceivable that disturbance of S. Nandi forest particularly due to logging (e.g Plate 2 and 3) has resulted in immense habitat degradation and this could have led to loss and fragmentation of eremomela-suitable habitats. Habitat loss in terms of vegetation and tree species utilized by Turner’s Eremomela (especially *C. megalocarpus*) are the serious threats facing the bird. The habitat features that were shown by the study to be strong positive predictors of the eremomela’s presence and density have been and continue to be altered by forest use, and especially logging.

This observation conforms with findings of various researches on the effects of changing forest structure on forest birds (e.g Järvinen and Väisänen, 1978, Kilgore, 1971, Bibby, 1978). Newmark (1991) observed that although there are few data available for Africa on the effects of disturbance and fragmentation on forest birds, it is the forest specialist species that suffer.

Plumtre and Mutungire (1996) observed that forest disturbance led to a drastic decrease in the number of insectivorous birds in Ituri forest, Zaire. In his study, Fanshawe (1995) documented that the loss of foliage density and height led to dramatic decline in canopy birds like the Amani Sunbird, *Anthreptes pallidigaster,* in the secondary forest in Arabuko-Sokoke forest. Forest loss and degradation are the factors which most commonly account for threats to Red Data Book (RDB) species in Africa (Stuart, 1985, Collar and Stuart, 1988). These two factors have also been cited by Coulson and Crockford (1995) as the major causes of avian species decline. In S. Nandi forest this phenomenon of species decline as a result of forest disturbance seem to be already underway as it was observed that the eremomela sightings were lower in disturbed areas than in less disturbed areas.

This observation is not unexpected and as Bennun and Waiyaki (1992a) suggested, the effect of disturbance and fragmentation may show up first as a reduction in the densities rather than the complete disappearance of a species. According to Brooks and Balmford (1996), populations of many organisms may appear to survive despite large-scale habitat destruction. However, their risk of extinction is often greatly increased through the effects of demographic and environmental stochasticity and the reduction of the remaining habitat patches (Caughley, 1994). In my study, it is predictable that *E. turneri* may not actually survive large-scale habitat destruction especially if logging of the preferred tree species continues.

Collar *et al*. (1994) argued that the commonest way in which bird species have been judged to be at risk is by their possessing a declining population numbering less than 10,000 mature individuals. They also observed that the number of mature individuals is regarded as a better guide to the conservation status of a species than is a simple total of all individuals.

The population of Turner’s Eremomela in south Nandi forest was estimated at 13,900 individuals. The study showed that the numbers of the bird were low in the disturbed areas of the forest. This suggests that as a result of the current activities taking place in the forest (especially logging and forest clearance), the overall population of the bird may actually be declining though lack of past records on the population of the bird precludes firm conclusions. It can also be argued that not all of the 13,900 eremomelas were mature individuals. This implies that the actual number of mature eremomelas in the forest could be less than 10,000 hence the bird qualifies to be classified under the IUCN’S C Criterion i.e < 10,000 mature individuals and declining (Collar *et al*. 1994). Thus as previously listed, the study has confirmed that Turner’s Eremomela is globally Vulnerable species, with a 10% chance of extinction in 100 years (Collar *et al*. 1994). But if forest destruction does not cease in the near future, *E. turneri* may soon be moving to worse threat categories.

The possible consequences on Turner’s Eremomela of removing *C. megalocarpus* from the forest have been highlighted in section 4.3.2 above. The effects of logging out the tree species utilized by some bird species have been documented. Bawa and Handley (1990) observed that logging changes the environmental regime and spacing of conspecific trees. The distribution of trees become patchy following intensive logging and this may affect the ranging and foraging behavior among animals. Those species that cannot readily adapt will be put in a competitive disadvantage (Johns, 1986b).

These observations further supports my argument that removal of *C. megalocarpus* as it is now taking place in S. Nandi forest may not augur well for the survival of the eremomela. Further, my concern concurs with those of Freed *et al*. (1988) who observed that avian extinction patterns shown by those which became extinct and those which survived indicate an unusual sensitivity to loses of plant species.

Lack of past records of the ecology of turner's Eremomela in South Nandi forest preclude firm conclusions. However, this study has laid foundation(s) of some aspects of the ecology of this species in South Nandi Forest Reserve. Some firm conclusions can be drawn from the study from which a few recommendations have been put forward and particularly those, which will go along way to reversing the present trend of events in South Nandi forest (see Chapter Five).

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

i) The three blocks were not only different in altitude but in vegetation structure. Block L was significantly different from blocks M and H and mainly in canopy cover, canopy height and tree height. These three parameters were shown to be important factors influencing habitat choice and presence of the bird in the forest.

ii) Blocks M and H were more disturbed than block L. Logging was the main cause of disturbance.

iii) Logging has negatively altered the factors important as positive predictors of Turner's Eremomela's presence and density in the forest. These are tree height, canopy height, canopy cover and inter-distance of conspecific trees used by the bird for foraging, especially the taller *C. megalocarpus,*

iv) Logging has led to loss and fragmentation of the eremomela's suitable habitats. These fragmented habitats presently occur as 'pockets' or 'islands' in the bird's foraging ranges containing tall *C. megalocarpus*. These micro-habitats offer optimal foraging opportunities for the eremomela, hence the term micro-habitat selection.

v) The less disturbed block L appeared to contain most of these optimal foraging micro-habitats hence the higher eremomela sightings and density in this block.

vi) The way the *E. turneri* responds to habitat change makes it an excellent bio-indicator/bio-monitor. This can be further explored in the management/conservation options for South Nandi Forest Reserve.

vii) The forest is predicted to continue reducing in size due to mismanagement practices especially the ’shamba’ system and excisions (Plate 4). Logging is also predicted to continue causing immense disturbance to the forest resulting in habitat loss and fragmentation. The practices pose the worst threat to the continued survival of Turner’s Eremomela in the forest.

In spite of these sickening revelations, S. Nandi forest appears to be the world's stronghold of Turner's Eremomela's eastern nominate race *turneri*.

5.2 Recommendations

An alternative course of action is urgently needed as a top priority in the management and conservation of South Nandi Forest Reserve, without which Turner’s Eremomela will soon be moving to worse threat categories or even become locally extinct. I suggest and strongly recommended the following measures:

a) The Government through the Ministry of Natural Resources and Wildlife must implement the recommendations suggested by KIFCON as contained in the *Forest*

Inventory Report No.11; for S. Nandi and Ururu Forests. In view of the results of the present study, I wish to place emphasis on one of the recommendations, that the discontinuation of logging be enforced and to allow a substantial period for growth and recovery before logging could recommence.

b) Presently there is need for a research to be carried out to ascertain the extent and result of past logging including monitoring of regeneration and growth and testing of silvicultural interventions which may accelerate recovery and modify the composition of the growing stock, especially *C. megalocarpus.*

c) A thorough survey should be carried out to establish and mapped out all the undisturbed pockets in the forest and designate them as ‘ecological zones’ where human activity will be restricted to only that of conservation and maintenance of biological diversity. The eremomela stands out to be the main beneficiary.

d) If logging must continue because of political and economic reasons, then it must be carefully planned and executed with involvement of experts. Great emphasis must be on sustainable harvesting i.e harvesting the forest in such a way that it provides a regular yield of forest produce without destroying or radically altering the composition and structure of the forest as a whole.

e) The local community should be involved in the management and conservation of the forest e.g in the restocking of the badly degraded parts of the forest. This can be achieved by giving them incentives e.g allowing controlled bee-keeping in the forest and by radically changing the present ‘ill-defined’ *shamba* system to a more sustainable one.

f) A comparative study should be carried on the Kakamega forest population of Turner’s Eremomela so as to create a database for the race *turneri* in Kenya. Thereafter, a long-term study for purposes of long-term monitoring should follow. These studies should include breeding, population dynamics, genetic diversity etc.

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APPENDICES

Appendix I: The number of eremomela sightings in S. Nandi forest showing the number of birds in each transect and in the various group size categories

	sightings	No. birds	No. of sightings in:			
Transect	(n =)	(n =)	groups of 2	groups of 4	groups of 6	groups of 8
1LA	12	52	1	8	3	0
2LA	10	42	2	5	3	0
3LA	12	50	2	7	3	0
4LB	12	54	2	5	5	0
5LB	13	52	3	7	3	0
6LB	14	58	2	9	3	0
1MA	8	40	0	5	2	1
2MA	9	36	2	6	0	1
3MA	6	22	2	3	1	0
4MB	11	44	2	7	2	0
5MB	5	26	1	0	4	0
6MB	12	56	1	7	3	1
1HA	12	56	1	7	3	1
2HA	9	44	1	4	3	1
3HA	9	32	3	5	1	0
4HB	4	20	0	2	2	0
5HB	12	46	3	7	2	0
6HB	4	16	1	2	1	0
G.TOTAL	**174**	**746**	**29**	**96**	**44**	**5**
%			**16.67**	**55.17**	**25.29**	**2.87**

KEY: G.TOTAL, Grand total

Appendix II: Data of the number of trees of each species in which the Eremomela were sighted during the counts

	Tree species							
Transect	Cme	Mki	Caf	Paf	Cma	Nma	Agu	Oth
1LA	9	0	2	0	1	0	0	0
2LA	9	0	0	0	0	0	0	1
3LA	12	0	0	0	0	0	0	0
4LB	9	0	0	0	0	0	2	1
5LB	10	0	0	0	0	0	7	0
6LB	8	0	0	0	2	0	3	1
B.TOTAL	**57**	**0**	**2**	**0**	**3**	**0**	**12**	**3**
1MA	6	1	1	0	0	0	0	0
2MA	4	2	1	0	0	0	0	2
3MA	4	1	0	1	1	0	0	0
4MB	7	0	0	1	0	1	0	1
5MB	4	1	0	0	0	0	0	0
6MB	12	0	0	0	0	0	0	0
B.TOTAL	**37**	**5**	**2**	**2**	**1**	**1**	**0**	**3**
1HA	10	1	0	0	0	1	0	0
2HA	4	0	1	0	2	2	0	0
3HA	6	0	1	0	0	2	0	0
4HB	2	1	0	0	0	1	0	0
5HB	10	1	0	0	1	0	0	0
6HB	3	0	0	0	0	0	0	1
B.TOTAL	**35**	**3**	**2**	**0**	**3**	**6**	**0**	**1**
G.TOTAL	**129**	**8**	**6**	**2**	**7**	**7**	**12**	**7**
%	**74.1**	**4.6**	**3.5**	**1.2**	**4.0**	**4.0**	**6.9**	**4.0**

KEY: B.TOTAL, Block total; G.TOTAL, Grand total; Cme, *Croton megalocarpus*; Mki, *Macaranga kilimandischarica*; Caf, *Celtis africana*; Paf, *Prunus africana*; Cma, *Croton macrotychus*; Nme, *Neoboutunia macrocalyx*; Agu *Albizia gummifera* and Oth, Others

Appendix III: Between transects comparison of the means (± stdev) of the number of *E. turneri* in S. Nandi forest

Transect	Mean ± stdev
1LA	4.3 ± 1.56
2LA	4.2 ± 1.48
3LA	4.2 ± 1.34
4LB	4.5 ± 1.51
5LB	4.0 ± 1.41
6LB	4.1 ± 1.23
1MA	5.0 ± .1.51
2MA	4.0 ± 1.73
3MA	3.7 ± 1.51
4MB	4.0 ± 1.27
5MB	5.2 ± 1.79
6MB	4.7 ± 1.56
1HA	4.7 ± 1.56
2HA	4.9 ± 1.76
3HA	3.6 ± 1.33
4HB	5.0 ± 1.15
5HB	3.8 ± 1.34
6HB	4.0 ± 1.63

Appendix IV: Simple correlation analysis for the vegetation parameters measured from the randomly sampled plots. Values in bold are significant at p≤ 0.05

P1= No. trees with dbh of 10-35 cm	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
P2= No. trees with dbh 36-60 cm	-2.292											
P3= No. trees with dbh >60 cm	0.234	**0.711**										
P4= Min. canopy height (m)	-0.466	0.529	0.148									
P5= Max. canopy height (m)	-0.165	**0.869**	**0.868**	0.425								
P6= Aveg. canopy height (m)	-0.326	**0.932**	**0.735**	0.626	**0.920**							
P7= Index of tree disp.(dist) (m)	-0.257	0.029	-0.075	0.054	-0.019	-0.035						
P8= Index of tree disp.(dbh) (m)	-0.506	**0.767**	0.469	0.511	**0.695**	**0.728**	0.236					
P9= Canopy cover (%)	-0.050	**0.824**	**0.817**	0.562	**0.885**	**0.853**	0.030	0.656				
P10= Tree density (ha-1)	0.342	0.497	**0.693**	-0.053	**0.567**	0.444	-0.437	0.287	0.533			
P11= No. trees with height < 10 m	**0.750**	**-0.761**	-0.316	-0.599	**-0.677**	**-0.830**	-0.081	**-0.718**	-0.534	-0.092		
P12= No. trees with height 11-20 m	-0.084	**0.908**	**0.839**	0.435	**0.922**	**0.944**	-0.097	0.646	**0.848**	0.558	**-0.691**	
P13= No. trees with height of > 20 m	-0.120	**0.853**	**0.867**	0.340	**0.913**	**0.891**	-0.121	0.633	**0.751**	0.639	**-0.626**	**0.881**

Appendix V: Simple Correlation analysis for the vegetation parameters measured from the randomly sampled transects. Values in bold are significant at $p \leq 0.05$

P1= No. trees encountered	P1	P2	P3	P4	P5	P6
P2= Min. canopy height (m)	-0.026					
P3= Max. canopy height (m)	0.444	0.403				
P4= Aveg. canopy height (m)	0.327	0.626	**0.895**			
P5= No. trees with height of < 10 m	0.380	0.534	-0.377	-0.632		
P6= No. trees with height of 11-20 m	0.122	0.080	-0.044	0.021	-0.052	
P7= No. trees with height of > 20 m	0.290	0.487	**0.826**	0.739	0.281	-0.067