# Population dynamics and habitat use by murid rodents in maize cropping systems in Rongai Division, Nakuru District, Kenya

A thesis submitted in partial fulfilment of the requirements for the award of the Degree of Master of Science (Vertebrate Pest Studies) of Kenyatta University

by

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# Declaration

I hereby declare that this thesis is my original work except where specifically acknowledged and that it has not been presented to any University or Institution for the award of any degree.

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# Dedication

*For my dear parents, Dad Philip and Mum Mary whom I owe so much for their inspiration, encouragement and commitment to my education*

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# Abstract

Murid rodents are an important pest group in eastern African agriculture by causing crop depredation, and as reservoirs for epizoonotic infections. On a global scale, they also pose some of the most complex management problems leading to huge capital expenditures towards their control. Gaps in our knowledge of how to plan for effective control need ecological theory and field data to provide vital ingredients in the design of sustainable management strategies. Efforts to obtain such information have gathered momentum especially in southeast Asia and Tanzania. Relatively less work has been done in Kenya and information lacking includes long-term ecological studies of pest species in cropping systems. This study, therefore, aimed at providing information towards bridging this gap.

In order to achieve the above-mentioned goal, I set to investigate the demographic patterns and habitat use by murid rodents in maize cropping systems between May 2000 and December 2001. Capture Mark Recapture (CMR) technique was used on four permanent one-ha square grids established along an altitudinal gradient. Rodents were captured using Sherman's live traps placed at 10m spacing between trapping stations. Traps were baited with fried coconut cubes mixed with peanut butter and Elianto cooking oil.

A total of 1240 captures including recaptures of 837 individuals were made of rodents and shrews in 20,100 trap nights. Fifty-three animals were found dead in the traps during handling. The rodents included six murid rat species (*Aethomys* cf. *kaiseri* Noack 1887, *Arvicanthis* cf. *neumanni* 1822, *Lemniscomys striatus* Linnaeus 1758, *Mastomys* cf. *erythroleucus* Smith 1834, *Rattus rattus* and *Mus minutoides* Smith 1834)

and a cricetid (*Tatera* cf. *robusta* Cretzschmar 1830*)* while the shrews were all soricids (*Crocidura* species).

*Mastomys* was the dominant species within and across grids, accounting for 71.0 % of all captures. Other common rodents were *Arvicanthis* (14.1 %) and *Mus* (8.0 %). The other species represented less than five percent of captures, with *Aethomys* being represented by three individuals and *Rattus* by one. *Aethomys* and *Rattus* were captured only at the Mugo grid located at highest altitude (1922m ASL) while *Tatera* was restricted to lowest altitude (1712m) at the Moto grid. Small mammal species diversity was highest at Mugo's (D=2.411 and H'=1.639) and least at Kurt's (D=1.333 and H'=0.829). Rodent species equitability was highest at Moto grid (E I/D = 0.586) and least at Beth's (E I/D = 0.266). Beth was closer to Kurt in terms of species assemblages, while Mugo and Moto grids were least similar. Rodent population densities showed similar dynamics, with most captures being made towards the end of the cropping season. Density fluctuations were low but influenced by the distribution of annual rainfall.

*Mastomys* cf. *erythroleucus* population structure changed over time. Age distribution was influenced by the amount of precipitation. Sex ratio was of the expected 1:1 ratio with exception of a few months. The overall body mass dynamics showed no sexual dimorphism between males and females. Seasonal variations had strong effect on body mass dynamics (F = 14.268, P = 0.0004, *n* = 48), and field growth rates (F = 8.791, P = 0.005, *n* = 58). Larger individuals and higher growth rates were recorded during the wetter seasons. Population density did not have any significant effect on body mass dynamics or field growth rates.

Breeding in *Mastomys* was depressed by drought but when there was adequate distribution of rainfall throughout the year, reproductively active individuals were encountered in all the months. The first breeding commenced following 100mm of rainfall between May and June 2000. The second followed 332mm of rainfall in November 2000 and January 2001, leading changes in population structure and subsequent increase in population densities. Heterogeneity in recruitment and survival occurring between sexes and age classes across grids were perhaps influenced by rainfall distribution. Maturation rates were low (mean ± SEM: 0.113 ± 0.029 males and 0.156 ± 0.035 females), respectively. Rodents exhibited very low population persistence with individuals staying in an area for an average of 37 ± 1.635 days.

Male and female *Mastomys* cf. *erythroleucus* showed similar range lengths. However, between any given trapping period, males exhibited wider range distances than females. There was significant seasonality in range lengths with animals covering longer distances during wet than dry conditions. Distribution of rodents was aggregated at the edge of the farms. Ground cover had stronger influence than habitat structure on capture frequency of rodents.

This study has documented the presence of seven rodent species with potential pest statuses in maize cropping systems of Rongai Division, Kenya. *Mastomys,* a multimammate rat, was the most important species due to numerical dominance in all the maize crop fields. Multimammate rats are recognised across Africa as important pests of crops and as disease reserviors. The prolonged drought occurring in two consecutive years prior to the commencement of the study led to low rodent numbers in the area. Population recovery was noted towards the end of the first cropping season. This

suggests higher growth rates may occur during unusually higher rainfall leading to population outbreaks.

The strong association between rodent captures and patches of dense weed cover reiterate the importance of cover removal as a strategy in ecologically based rodent pest management. Rodents were also captured largely along farm edges, and crops at these points are likely to get damaged. Field edges may therefore be important target areas during chemical control operations. This study has contributed vital though not exhaustive information on rodent population ecology in maize crop fields, which is important in designing ecologically based rodent pest management for Kenya.

# Chapter 1

## Introduction and literature review

### 1.1 Introduction

Rats and mice (Family Muridae, Gray 1821) are an important group of vertebrate pest all over the world (Fiedler 1994, Buckle and Smith 1994, Doonan and Slade 1995, Brown *et al.* 1999, Tristiani *et al.* 1998). A variety of crops and other house hold goods are susceptible to rodent damages both in fields and stores (Fiedler 1994). Rodents damage about 33m tons of agricultural products every year in the world, enough to feed 133 million persons (WHO 1996). The global population is projected at 8.5 billion people by the year 2025. The greatest growth is due to take place in developing countries with an expected 1.2 billion people living in sub-Saharan Africa (FAO 1995). This will necessitate increased food production to carter for the accelerated population growth.

Despite harvest prospects in East Africa, food supply difficulties persist with about 18 million people still depending on emergency food and other humanitarian assistance (FAO 2001). In many parts of the regions' 'cereal baskets', crop depredations by rodent pests appear among the top five constraints in agricultural production (Myllamaki 1979). Rats and mice are also hosts to a broad spectrum of parasites for instance the flea, *Xenopsylla cheopis* (Gratz 1988, 1997), vector to the plague bacteria *Yersinia pestis*. Since they live in close association with human settlements epidemiological risks to zoonotic infections is increasingly high. Control of rodents is, therefore, necessary in mitigating crop losses and for public health concern.

Rodents have received relatively little attention as vertebrate pest in Kenya (Nicholas Oguge Pers. Comm.). However, their capacity for crop depredation and transmission of diseases introduces an applied aspect of rodent ecology. Where rodent outbreaks have been reported, control measures have favoured application of toxic chemicals often at a time too late to be effective (Sullivan 1987). The contemporary approach to rodent problems is that of ecologically based management. This has received fewer considerations due to insufficient basic field and experimental data in support of their efficacy (Makundi *et al.* 1999). Thus strategies in management of rodents both in the field and stores are poorly developed.

One of the fundamental goals in ecology is to understand the distribution and abundance of organisms and to use this knowledge for the management of populations in a variety of natural and managed ecosystems (Gutierrez 1994). Ecologically based management has re-emerged as a sustainable approach to rodent problems in Africa and elsewhere (Singleton *et al.* 1999). Current researches for alternative management strategies are based on population dynamics, reproductive biology, diets and behavioural ecology of the rodent pest. These may allow development of long-term control measures, and overcome the limitations of conventional techniques that are mortality based.

Gaps in our knowledge of how to plan for effective control need information on accurate pest identity, ecological theory and field data to provide vital ingredients in the design of sustainable management strategies (Singleton *et al.*, 1999). Efforts to obtain such base line information have gathered momentum especially in South-East Asia and Tanzania. Our knowledge of rodent pests in Kenya is inadequate while issues on pest problems are anecdotal. The ultimate goal of this study was, therefore, designed to provide information towards breaching this gap.

## 1.2 Literature review

### 1.2.1 Murid rodents

#### 1.2.1.1 Taxonomy and geographical distribution

The Family Muridae is the most abundant both in numbers of extant species and in absolute numbers within order Rodentia (Rosevear 1969, Delany and Happold 1979). Phylogenetically, this Family is considered a recent group having evolved in the late Miocene. Murids are unknown in the African Miocene but had already differentiated in the Pleistocene suggesting that they probably entered the continent in Pliocene (Roberts 1977). Their greatest diversity is in the tropical regions of South East Asia where they are believed to have originated (Kingdon 1974). Their natural ranges occur in Africa, Europe, Asia (except in extreme north), the Malayan region, Australia, Tasmania, and Micronesia (Walker 1975).

Rats and mice form a diverse group numbering over 100 genera. The sequence of classification herein largely follows that of Walker (1975), who recognised six subfamilies. The largest and most diversified of which is the Murinae that contains 70 existing genera and hundred of species. They are not indigenous to America though certain species - *Rattus norvegicus* (Fischer), *Rattus rattus* (Barkenhouse) and *Mus musculus* (Linnaeus) - introduced by humans have a nearly world wide distribution (Walker 1975, Kingdon 1997). The Dendromurinae (the African tree mice) has six genera, with more than 50 listed species found in Africa south of Sahara. The Otomyinae (grooved tooth rats) has one genus with eleven species and are found in Africa south of Sahara. The Phloeomyinae (the giant Philippine rats) occur in the Oriental-Australian area, from Assam, Burma, and Yunnan to Java, Borneo, Celebes, and associated small islands. There are six exant genera and more than 20 species, and one fossil genus on Timor (Pleistocene). The Rhynchomyinae (the shrew rats) is known only from Mt. Data, northern Luzon, and Philippine Islands where one species is so far recorded. The Hydromyinae (the Australian water rats) has 13 species grouped in nine genera recorded in Australia, Tasmania, New Guinea, New Britain and associated islands and northern Luzon in the Philippines.

#### 1.2.1.2 Characteristics of murid rodents

Murids have many forms that are divergent from the basic 'rat or mouse-like' form though superficially similar (Rosevear 1969). Like other true rodents, rats and mice exhibit the following general characteristics as described by Roberts (1977) and illustrated in Figures 1a and b:

- the presence of a diastema due to absence of canines and a reduction in number of premolars
- one upper and one lower pair of continuously growing chisel-like incisors or gnawing teeth (prominently curved front teeth)
- cheek teeth with large grinding surfaces composed primarily of cement and dentine, patterned with loops or folds of enamel (particularly herbivorous species)
- unguiculgrade, four fingered (the fifth being completely vestigial) and five toed plantigrades with hind-limbs rarely lengthened, and
- an *os* penis or *os* clitoris usually present

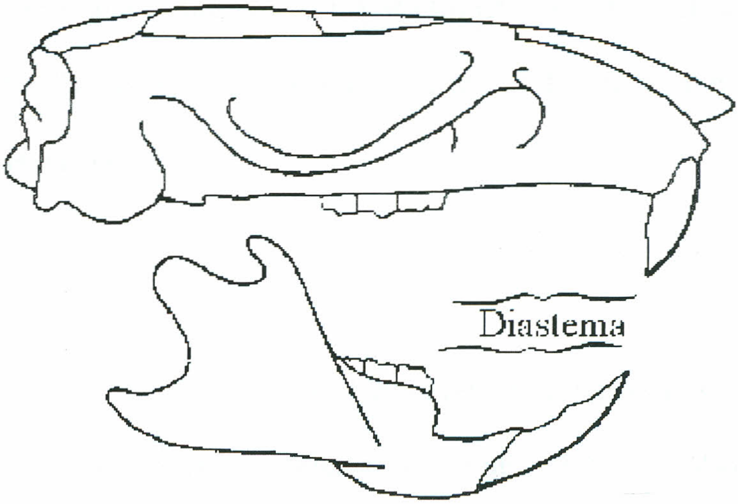


Fig. 1a. The skull of *Rattus norvegicus* showing dental characteristics

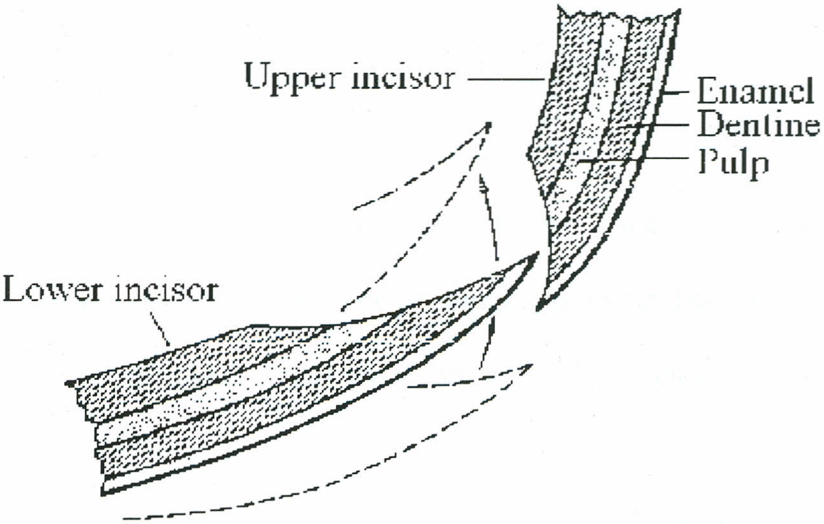


Fig. 1b. Self-sharpening action of rodent incisors

adapted from WHO/VBC/79.726, page 97

Distinctively, murids have relatively blunt and rounded heads with no peculiarity in ears. Their tails are typically naked and scaly, the scales closely intricate forming very sharply defined rings. Sexual dimorphism especially in body mass (e.g. *Praomys taitae* Heller may be present (Nicholas Oguge Pers. Comm.). Their mammae are considerable in number and disposition, a major character to differentiate genera. They are situated pectorally and inguinally (chest and groin) and in pairs on each body side (Rosevear 1969, Happold 1987).

**Colour**

Majority of murids show a wide range of dull grey or brown shades with light or dark banding of hair. Few species have brilliant colouring. Murid rats also show a wide range of pelage: short glossy lying close to body; long and upstanding; harsh or soft. A few species have silver-grey or yellowish-sandy coat (Rosevear 1969, Kingdon 1997).

### 1.2.1.3 Habitat and dietary habits

Murid rodents present the most extensive adaptive radiation, which allows colonisation of major habitat types. They are ubiquitous in distribution and most are terrestrial. Some species such as *R. rattus* are commensal living in close association to human habitation.

Many murid groups are opportunistic feeders. Gnawing which sets rodents apart from other mammals has undoubtedly been an important factor in their widespread destruction of crops and other household goods. Dense population of adults usually form important vertebrate pests in the East African agro-ecosystems (Fiedler 1994). Many are herbivores, feeding on grasses (graminivorous), roots, seeds (granivorous) or fruits (frugivorous). Some are omnivorous or capable of consuming a variety of foods including animal material while some species feed on insects (Yahner 1986, Adler 1994, Oguge 1995).

#### 1.2.1.4 Activity patterns and social behaviour

Most rodent species are nocturnal, while some species are diurnal or crepuscular (Kingdon 1997). *Mastomys natalensis* (Smith 1834) is nocturnal but may be seen foraging during the day in situations of high population densities (Oguge 1996). *Lemniscomy striatus* (Linneaus 1758) is diurnal with two activity peaks during the day, but activity end only after dusk (Hoffmann and Klingel 2001). Several species construct burrows leaving behind distinguishable runways.

Many murid rodents, especially lactating females, communicate using ultra sounds to locate their young ones (Kingdon 1974). Some make ultra-sonic signals while mating, fighting, threatening or in sub-mission (Sewell 1967). Many have poor eyesight but rely heavily on their acute sense of smell especially in locating food and in regulation of social behaviour (Kingdon 1974).

#### 1.2.1.5 Reproductive biology

Some murids are prolific breeders and can breed continuously in the presence of a permanent source of food and vegetation cover (Duplentier and Rakotondravony 1999). Few murids have a productive life of more than 18 months (Kingdon 1974). Under laboratory conditions female *M. natalensis* can conceive at the age of 96 days (Leirs 1992). Although litter sizes of 11-13 are common in this species, females can potentially produce up to 24 young per litter under good environmental conditions (Fiedler 1994). Such a high biotic potential and turn over rates are responsible for compensatory reproduction and resiliency of rodent population in controlled areas making them become difficult pests to manage (Sullivan 1987).

### 1.2.2 Pest

The term pest is often based on value judgement and therefore can be extremely subjective depending on aesthetic, biological and political factors (Jones and Jones 1974, Oguge 1991). Several definitions of the terminology exist in literature, many of which emphasises economic significance. In this thesis, I adapt the operational definition of a pest as being any organism which causes harm or damage to human crops, animals or possessions, or even annoyance to economically significant levels (Oguge 1991, Putman 1992, Leirs 1992). Agricultural pests cause losses in yields or quality of crops resulting in loss of profit by the farmer. In smallholding farming systems common in developing countries, it is accepted that economic pest status is reached when there is a 5 to 10% loss in yield on a particular crop (Hill and Waller 1982, Fiedler 1994).

Pest species cause significant economic losses at certain densities. The lowest pest population densities that will cause economic damage vary in relation to the crop, area and season (Oguge 1996). Control measures should, therefore, prevent an increasing pest population from reaching high densities rather than offering curative solutions as exhibited in increased mortality by poisoning (Hill and Waller 1982).

### 1.2.3 Rodent pest species in East Africa

The correct identification of implicated pest species is an important base line information in ecologically based rodent management. There are controversies regarding the taxonomy of murid rodents, and sometimes control of field rats is handicapped by misidentification of the target species. About 25 species of rodents have been recorded as important pests in East African agriculture, out of which 10 species are found in Kenya (Fiedler 1994, Oguge 1996, unpublished report). An early report (Taylor 1968), had listed eight species of rodents causing damage and losses to cereal crops in the Kenyan Rift Valley Province. Murid rats were implicated in most of the serious rodent problems.

Some of the pests are found in certain geographical conditions, while others are widely distributed. For example brown rat, *R. norvegicus* is found in the Coastal seaports and inland port cities of East Africa (Mwanjabe 1987, Fiedler 1994). The house mouse, *M. musculus* is found mostly in urban areas and in some village dwellings (Delany 1975, Fiedler 1994) while the four-striped grass mouse *Rabdomys pumilio* (Sparman) is commonly found in grasslands lying at high elevations (Hubbard 1972). However, the roof rat, *R. rattus*, the multimammate rat, *M. natalensis* and the nile rat, *Arvicanthis niloticus* (Desmarest), are found in many parts of East Africa (Kingdon 1974). Others included in the list are the giant rat, *Cricetomys gambianus* (Waterhouse) and the crested porcupine, *Hystryx cristata* (Thomas).

### 1.2.4 Rodent borne diseases

Besides causing crop damages, rodents are reservoir hosts of myriad zoonotic infections, which in some areas have claimed many lives (Cox 1979, Fiedler 1994, Gratz 1997). Outbreaks of disease epidemics in endemic areas of East Africa are often associated with high densities of rodent numbers, influenced by profound ecological disturbances (Robert 1935).

There are a number of ways in which these infections have been noted to reach humans. Vectors, for example fleas or mites transmit diseases such as plague, murine typhus, lassa fever, leishmania or rickettsial pox. Ixodid ticks, parasites of vertebrate hosts, are the main vectors of lyme disease affecting the American and European continents (reviewed in Ostfeld and Keesing 1999, 2000). For plague which is the most fatal, the chain of transmission begins from the susceptible reservoir hosts in the wild, *Tatera* spp., to peri-domestic species, *M. natalensis*, to pure commensal species, *R. rattus* and finally to *Homo sapiens* L. (Heisch *et al.* 1953). Direct bites may transmit diseases such as leptospirosis, lymphocytic choriomenengitis, and rabies or rat bite fever. Contamination of foodstuffs with salmonella from faeces, urine or nasal secretions is responsible for food poisoning, or may spread intestinal parasites such as tapeworms and round worms. Mechanical transmissions may also occur when infected rodents move materials from one place to another (Greaves 1982).

With all rodent-borne diseases, the biodiversity and ecological interactions of local species of vectors and their hosts often influence the local epidemiology of the diseases (Ostfeld and Keesing 2000). Successful control of rats must, therefore, include control of disease vectors. Understanding rodent ecology and their zoonotic dynamics remains a keystone in the fight against these diseases.

### 1.2.5 An overview of crop depredation by murid rodents

Although the fauna of tropical Africa is rich in endemic murid rodents, deleterious outbreaks appear to be a recent phenomenon, or at least poorly documented in the older literature (Myllymaki 1979, also reviewed in Oguge 1996). Damage to crops is probably far more wide spread than has been recorded in literature (Myllymaki 1979), occurring at all the stages of crop growth (Taylor 1962, 1968, Myllymaki 1987, Key 1990a). Rodents are wasteful feeders and therefore, through contamination (via urine, droppings and hairs) of grains in the stores, they spoil more food than they consume (Hall 1970).

Massive rodent damages to cereal crops occur irregularly in the Kenyan Rift Valley (Delany and Happold 1979) resulting into losses of high magnitude to food and cash crops. Earlier reports have indicated 20% loss of maize, 34-100% loss of wheat and barley during the 1951 and 1962 rodent outbreaks in western Kenya, the latter extending from northern Tanzania to Gezira in Sudan (Taylor 1962, 1968). In southern Kenya damage by the striped ground squirrel (*Xerus erythropus*) to planted maize seeds and seedlings is estimated at an average of 9.7% while those of maize cobs is 5.4% (Key 1990a,b). Crop damages of 40-80% have been reported from Morogoro and Chunya Districts in Tanzania (Mwanjabe 1990, Mwanjabe and Leirs 1997).

### 1.2.6 Agricultural systems and land management practises

Under the natural conditions of the African grassland and intact forest ecosystems rodent populations remain at relatively low densities.. Agro-ecosystems provide unstable habitats for rodents (Taylor and Green 1976), thus serious rodent infestations are the consequence of the changes in land use practices. A common and important ecological feature of large-scale farms is cultivated areas of extensive land coverage by a continuous single crop. In East Africa a vast area of arable land is characterised by small-farms of 0.5-2 hectares and a mosaic of fallow patches. Where rainfall is well distributed over the year, these patches form 'refugias' from which rodents attack crops in the field (Makundi *et al.* 1999, Singleton *et al.* 1999). Agricultural crops have been selected for their nutritive value, and are typically large and succulent with especially large fruits or seeds. Thus, high yielding maize varieties are more nutritious than are wild grasses. During harvesting, farmers often leave cereal crops in the field to dry. This practise predisposes the crops to severe attack by rodents (Anna Mutinda, Pers. Comm.). In addition, mechanised crop harvesting may result in large quantities of food spillage available to rodents. Since natural enemies do not respond quickly enough to regulate the increases in rodent numbers pest status is attained (Van Gulck *et al.* 1998).

### 1.2.7 Demographic patterns in small rodents

Within the tropics small rodent populations' manifest fluctuating dynamics capable of rapid expansion under optimal conditions (Happold and Happold 1986; Sirrlero-Zubiri *et al.* 1995, Talamoni and Dias 1999). But in the temperate regions, where there are distinct seasonal patterns, microtine rodents show regular multiannual oscillations (Lima *et al.* 1999, 2001, Merritt *et al.* 2001). It has been demonstrated that population regulation in African rodents is a result of the simultaneous action between the deterministic and stochastic factors (Leirs *et al.* 1997, Julliard *et al.* 1999). Both cause numerical fluctuations by influencing demographic processes such as survival, recruitment and emigration. The significance of these two factors on various small mammal studies conducted in the past is reviewed in subsequent sub section.

### 1.2.8. Factors influencing small rodent demography

#### 1.2.8.1 Effects of rainfall

Many studies have proposed rainfall to be the most important climatic factor on rodent population in East Africa (Taylor and Green 1976, Telford 1989, Leirs 1992, Leirs *et al.* 1996, 1997). Rainfall influences the availability of vegetation, which is the main source of food and shelter for rodents. In seasonal habitats, it is therefore, the most likely proximate factor in breeding (Neal 1984). Among murid rodents most of the breeding females and young are encountered when nutritious food is abundant following rainfall (Neal 1984, also reviewed in Delany and Happold 1979).

The 1962 rodent outbreak was linked with unusually heavy rainfall during the preceding rainy season (Taylor 1968). This led to retention of ripened crop and caused a luxuriant weed growth. Rodents showed a prolonged breeding season and high densities.

Some rodent species in semi arid regions have also been observed to show dramatic density fluctuations following unusually heavy rainfalls (Lima *et al.* 1999). The severe rodent plague experienced in Gezira, Sudan, in 1975-76 was linked to heavy rainfall following two successive years of extreme drought (Beshir *et al.* 1976).

In a dry sub-humid zone of Kenya, the populations of small mammals were found to be low in the late dry season, but increased in the wet season only to decline towards the end of the season (Martin and Dickinson 1986, Oguge 1995). Pregnant females of *M. natalensis* were caught throughout the year in Sierra Leone (Brambell and Davis 1941) and Transvaal (Coetzee 1965) though peak reproduction was realised towards the end of the wet season. In the Zamba plateau, Malawi, the trappable population of small mammals in the grassland increased almost two-folds during the wet season as a result of immigration and reproduction, and decreased in the dry season due to emigration and mortality (Happold and Happold 1986). Contrary to these findings, are the commensal rodents for example, *R. rattus* whose reproduction is not associated with season (Duplentier and Rakotondravony 1999).

### 1.2.8.2 Effects of food

Taylor and Green (1976), while studying the nile rat, *A. niloticus* in the Kenya Highlands found that increase in testes size and the incidences of pregnancy coincided with the occurrence of large quantities of cereals and other seeds in the diet. Fat was deposited towards the end of the rains, with these reserves becoming exhausted at the end of the dry and beginning of the wet season when leaves and stems formed the bulk of the diet.

Experimental results have shown that varying food conditions may influence rodent population densities. In the cotton rat (*Sigmodon hispidus*), supplemental foods have been shown to increase its population without dampening pronounced seasonal variations (Doonan and Slade 1995). Food-supplemented populations carried more juveniles and small adults than controls. Social behaviour may have limited increase in numbers of large adults in this study but did not alter their survival rates. Densities were shown to increase due to both reproduction and immigration (Doonan and Slade 1995) - possibly food being an attractant.

Similar studies on the rice field rat, *Rattus argentiventer*, in west Java showed that nutritional quality of rice was an important factor influencing the rate of rat population increase (Tristiani *et al.* 1998). It was further noted that seasonal changes in weight, sexual condition, and rat density fluctuated according to the stages of rice growth.

### 1.2.8.3 Effect of predation on rodents

Because of their primary abundance, rodents support the majority of carnivorous animals including raptors, serpents, felines, canines and even human beings (Kingdon 1974, Fiedler 1994)). The predator-prey interaction can have effects on prey species composition and demographic changes with time (Happold and Happold 1986). In a study in Malawi, *Otomys angoniensis* formed a high proportion in the grass owls' pellets, inferring evolution of a significant predator-prey relationship (Happold and Happold 1986).

In East Africa, the use of avian predators in biological control has been shown to be ineffective in control of farm rodents (Van Gulck *et al.* 1998). Although in this study the placement of perches increased the hunting activity of the black-shouldered kite, no significant reduction was realised in population size or survival of *M. natalensis*. This was due to the high reproductive potential and compensating dispersal effects of rodents. It was further noted that the highest predation intensity occurred when rodent densities were highest, but too late for regulation. New evidence has, however, emerged from south America, demonstrating that predation from barn and magellanic owls and climate act simultaneously in regulating rodent populations (Lima *et al.*, 2001).

### 1.2.9 Habitat use

Habitat of rodents is determined by many attributes such as the plant community; the distribution and spatial patterns of plant; the proportion of edible to inedible plant species; changes in phenology; biomass; ground cover and plant species composition (Zhong *et al.* 1999). Habitat heterogeneity across landscape creates patches (Stenseth and Lidicker 1992). Through dispersal, small mammals respond differently when connecting to these patches (Manson e*t al.* 1999). For example, in a study in the dry sub-humid grassland in Kenya, the abundance of different species of small mammals was correlated with different grass species and more captures were realised as grass cover increased (Oguge 1995). In the Kenyan Rift Valley, dispersal routes of *A. niloticus* seemed to occur along field edges and other areas of undisturbed cover rather than across the fields or more exposed areas (Delany and Monro 1985). Percent canopy cover and plant heights of patch corridors between interconnected habitats influences movements of the hispid cotton rat, *S. hispidus* (Bowne *et al.* 1999). It has been recognised that regular grazing, bush clearing, grass cutting and weeding reduces suitable habitat for rodents, thus markedly reducing their population densities (Taylor and Green 1976, DeGraaf 1981, Mwanjabe 1993).

Shelter and food are the main factors affecting reproduction and survival of young to reach the reproductive age (Taylor and Green 1976). However, habitat manipulation as a control strategy of rodents in East Africa has achieved limited success due to lack of extensive incorporation as a component of smallholder farming systems (Makundi *et al.* 1999). But where this has been practised as a management strategy, conclusions have largely been drawn from observations rather than quantification of habitat parameters.

### 1.2.10 Implications of rodent ecology on their management

The interaction of a pest and its environment is an intricate one. In many cases, a complex of vertebrate or invertebrate pests and diseases attack a particular crop. It is usually possible to single out one or two pest species in the complex as the most important, hence forming key pests. Control measures used against a pest species are designed usually only to lower the population below that density, hardly does it aim at complete eradication of the pest population. Therefore, ecologically based management offers a wide range of control methods for alternative considerations. To give the best chance for a successful control, it is generally agreed that understanding of the natural phenomenon and appreciation of the biology of pest species is prerequisite in making informed choices when dealing with rodent pest management. The basic aim of demographic study is to quantify the fundamental processes such as mortality, immigration and emigration responsible for numerical changes. From the studies of populations, it is suggested that the intrinsic rate of increase (r), tends to be higher when a population is below its carrying capacity (K), than when it is close to (K) (Begon and Mortimer 1981).

Manipulating environmental resources (i.e. removal of cover or food) reduces the carrying capacity of the environment. Poisoning the population temporarily reduces numbers, which rodents swiftly counteract by their increased reproduction or survival. Good knowledge of the factors causing these changes would enable rodent pest managers to incorporate ecological techniques that reduce population at the time of outbreaks and those that limit their growth rates during the non out-break periods.

## 1.3 Study rationale

Despite persistent control, rodents continue to present a major problem in agricultural production. During outbreaks, control measures lack co-ordination favouring *ad hoc* application of acute rodenticides by farmers. Such measures have proved to be short-termed with possibilities of pest resurgence, development of resistance, effects on non-target species and environmental pollution (Buckle 1999, Meehan 1984). Despite several studies on the ecology and biology of rodents in East Africa concentrating mainly in natural or semi-natural habitats, relatively little is known about their ecology and population dynamics in relation to the developmental stages of maize crop.

Different strategies for success in small mammal populations have implications for artificial control of pest species. An effective control can be achieved by designing the control program to target those demographic parameters most critical to the success of the population (French *et al.* 1975). Since populations are more vulnerable with alteration of their habitats than do a direct reduction of numbers (Caughley 1977), understanding feeding habits and movements of rodent pests would enable managers to know when and where to place baits in the crop fields. In addition, cultural methods of farm management systems that would help maintain low numbers of rodents can be incorporated to be part of integrated pest management (IPM) strategy.

## 1.4 Study hypotheses

In this study the following hypotheses were tested:

1). Rodents from Rongai division are the same population and would, therefore, show similar structural community compositions, demographic patterns, body mass dynamics and field growth rates.

2). Rodent population ecology show no seasonal variation in maize fields.

3). Maize crop fields have a homogenous habitat structure, therefore, rodents show similar patterns of distribution and dispersal across these habitats.

## 1.5 General objective

This study aimed at (1) determining murid rodents' species composition, (2) their distribution and densities, (3) their demographic patterns, and (4) habitat use in maize cropping systems under different climatic regimes in Rongai Division, in Nakuru District, Kenya.

# Chapter 2

## Study area and general methods

### 2.1 Study area

The study was carried out in Rongai Division, occupying an area of approximately 682 km$^2$. The Division lies in the western part of Nakuru District, Kenya at latitudes 35° 28′ - 35° 36′ E, longitudes 0° 13′ - 1° 10′ S, and altitudes of between 1520 and 2400 m ASL (Fig. 2). The major landforms in this area are hills with slopes of 35-60% on the western part gradually reducing to plains with slopes of 3-9% to the east dissected by streams (Fig. 3). The soils are developed from various rocks and recent volcanic ash admixtures. They are fertile and range from moderately to well drained, deep to very deep, dark red to brown-red, friable and smeary, firm clay-loam to silty-clay or clay, with humic top soils (Jaetzold and Schmidt, 1983).

The climate in this area falls between semi-arid (annual rainfall less than 760 mm) in the lower areas and dry sub-humid (annual rainfall of 1270mm) regions in the higher altitudes. Rainfall is bimodal with peak precipitations (70-80%) in March to May and late August to October, though great variations may occur from year to year (Fig. 4). The maximum temperature is about 30° C with December to March being hottest and July being coolest at an average of 23.9° C (Government of Kenya 1997).

Agro-ecologically, this Division falls within the high potential zones of the Lower Highlands (LH) and Upper Midland (UM) suitable for growing maize, wheat, barley, millet, sorghum, beans, coffee, tea and dairy industry (Jaetzold and Schmidt, 1983).

## 2.2 Maize cropping systems

Rongai Division is an important area for maize production, mainly for subsistence or local trading in seasons of bumper harvest. Smallholdings of 0.5 to 20 hectares under partial mechanisation are a prominent activity in this Division. In addition to low inputs and intensive labour, these units exhibit low productivity. Nevertheless, their contribution to the region's food security is crucial since they produce most of the maize, beans and potatoes (Government of Kenya, 1997). Subsequently, losses in production as a result of pest population, unreliable rainfall or plant diseases are critical especially to smallholdings. Large-scale farmers absorb such setbacks through crop insurance policies.

Land preparations are done by hired tractors. Maize is the first crop to be planted in mid February, followed by beans, cowpea, Irish potato, sweet potato, sorghum or finger millet respectively. Maize is harvested from November through December.

## 2.3 Study sites

Trapping was done on four permanent grids of one hectare sized plots coded (i) Mugo, (ii) Beth, (iii) Kurt, and (iv) Moto in maize crop fields (Fig. 4). The first three names were adapted after the owners of the farms and latter was derived from the name of locality. The grids were established in April 2000 along an altitudinal gradient from Mugo grid (1922m ASL) a sub-humid to Moto grid (1712m ASL) semi-arid condition, respectively (Fig. 3).

## 2.4 Vegetation

The original vegetation of moist forest has been replaced largely by a mosaic of cropped and fallow areas with exotic tree species: -*Grevillea robusta* and *Cyprus* spp.- on the high slopes. In Kandutura area where Mugo and Beth grids were located, the current vegetation has resulted from repeated burning, grazing or cultivation except along moist ravines (Hanrich, 1971). The most common ravine tree species were *Pordocapas lartifollius* (Thunb.) Mirb., *Syzygium guineense* (Willd.) DC., *Ficus stuhlmannii* Warb., *Albizia coriaria* Oliv. and *Acacia nilotica* (L.) Del. Kurt grid was in the intermediary vegetation dominated by species of *Acacia xanthophloea* (Benth.), *Acacia seyal* (Del.), *Acacia nubica* (Benth.), and *Acacia senegal* (L.) Willd. The common grasses are *Themeda triandra* (Forssk.), and *Themeda diplandra* (Anderss).

Moto grid was located on the driest part of the Division. The grid lied along River Rongai, where the riverine vegetation is dominated by shrubs of *Lantana camara* (L.). Other common species included scattered *Acacia* species, succulents such as *Euphorbia candelabrum* (Kotschy), *Euphorbia tirucalli* (L.), and *Aloe ballyi* (Reynolds). The dominant grasses in fallow areas around Moto grid were *Panicum maximum* (L.), *Cynodon dactylon* (L.) Pers., and *Themeda triandra* (Forssk.).

## 2.5 Material and general methods

### 2.5.1 Capture-Mark-Recapture (CMR) study

The Capture-Mark-Recapture (CMR) technique was used in sampling small mammal populations. This technique operates on the basic assumption that marking does not alter the behaviour or survival of the animal (Krebs 1989). The grids consisted of ten parallel lines and ten orthogonal rows, spaced at 10m between lines and rows, resulting in 100 trapping stations per grid. Each trapping station was identified by co-ordinates A to J and numbered 1 to 10 (Fig. 5). White painted bricks with labels were used for marking the trapping stations.

Rodents were live-trapped using Sherman's LFA traps measuring 23 x 8 x 9 cm (Sherman Traps Inc., Tallahassee, Florida, USA), between May 2000 and December 2001. Trapping in Mugo and Beth grids commenced in May 2000, at Moto grid in July 2000, and at Kurt grid in April 2001. The Kurt grid was a replacement grid following loss of one trapping area to livestock grazing. Traps were set late in the afternoon (between 1600-1800hrs) and inspected every morning (between 0700-1000hrs). One trap was placed at each station during trapping. Primary trapping was made every 28 days and secondary ones for three consecutive days and nights during each primary trapping. Traps were baited with a mixture of peanut butter, corn oil and fried coconut cubes. Densities, demography, movements, and habitat use were assessed from capture-mark-recapture data.

Rainfall data were obtained from weather stations at Gogar farm which was located at about 12 km from Mugo grid, 10 km from Beth grid, 4 km from Kurt grid and at Kampi ya Moto weather station about 3 km from Moto grid.

### 2.5.2 Processing of captured animals

The animals were processed in the field. Captured animals were identified to species level whenever possible and assessed for marks. New individuals were marked by toe clipping (DeBlase and Martin, 1981). A number was assigned to each toe- fore feet 1-8, hind feet 10-100- as in Figure 6. Toe clipping is widely used for marking small mammals in the field because of its efficacy and low cost (Murray and Fuller 1998). Several studies have revealed toe clipping to have no negative effects on rodents, though a few studies in the temperate region have detected some effects on their behaviours, movements and survival (*see* Murray and Fuller 1998).

The tip of a given toe was clipped and preserved in 25% DMSO (Dimethyl sulphoxide, SIGMA). For each of the captured rodent, the following information was recorded: the grid name and co-ordinates of the trapping stations; date of toe-clipping code; sex; recapture status; reproductive condition; and body weight. These were made in a standard recording sheets (Appendix 1) and later transferred into a spreadsheet software. Other observations recorded under remarks included animal condition. Animals found dead in traps or those that escaped unmarked during handling were recorded as not released. After recording all the necessary data, the animals were released at points of capture and traps re-baited.

### 2.5.3 Assessment of vegetation cover and habitat use

Vegetation sampling was done monthly in each study grid beginning from November 2000 to the end of the study. Systematic sampling design was used where 5 columns and 5 rows were randomly selected (Njue 2000). At each sampling point, vegetation was examined within a radius of 5m intervals. Information recorded included (i) the common weed species or any other crop apart from maize, and (ii) vegetation cover estimates.

Plant species were identified in the field whenever possible following Ivens (1967). Unknown plant samples were collected and identified at Kenyatta University Herbarium in the Department of Botany. Vegetation cover estimates were obtained visually as percentages of total area under cover. These were expressed in absolute numbers between 0 and 100, while the other variables were recorded as present or absent in standard recording sheets (Appendix 2).

## 2.6 Data analyses

Population densities were estimated from secondary captures using the program CAPTURE (Rexstad and Burnham 2002). The 3-day period between the captures is considered sufficiently short to assume negligible demographic processes. Demographic patterns were determined from the primary captures. The 4-week interval is considered sufficient to allow demographic processes. Survival ($\phi$) and recruitment ($1-\gamma$) were estimated following the methods of Lebreton *et al.* (1992) using the Program MARK (White and Burnham 1999). Akaike's criterion was used to select for the best model estimator. Persistence was determined from calendar of primary captures (Julliard *et al.* 1999). Reproductive rates (R) were estimated for both sexes for each month (Lima *et al.* 2001). Maturation was determined as the proportion of juveniles that showed first reproductive activity in the study grids.

Sex ratios were calculated for every grid in each month of the year and the differences were compared using Chi-square goodness-of-fit test (Zhar 1999). The number of reproductively active males and females were expressed as percentage proportions. An index of dispersion test was done to estimate distribution of rodents in each grid using the log-likelihood ratio of Poisson distribution with Williams' correction (Krebs 1989). A student *t*-test was used to assess mean capture frequencies of rodents and areas covered by vegetation to determine the relationship (Zhar 1999).

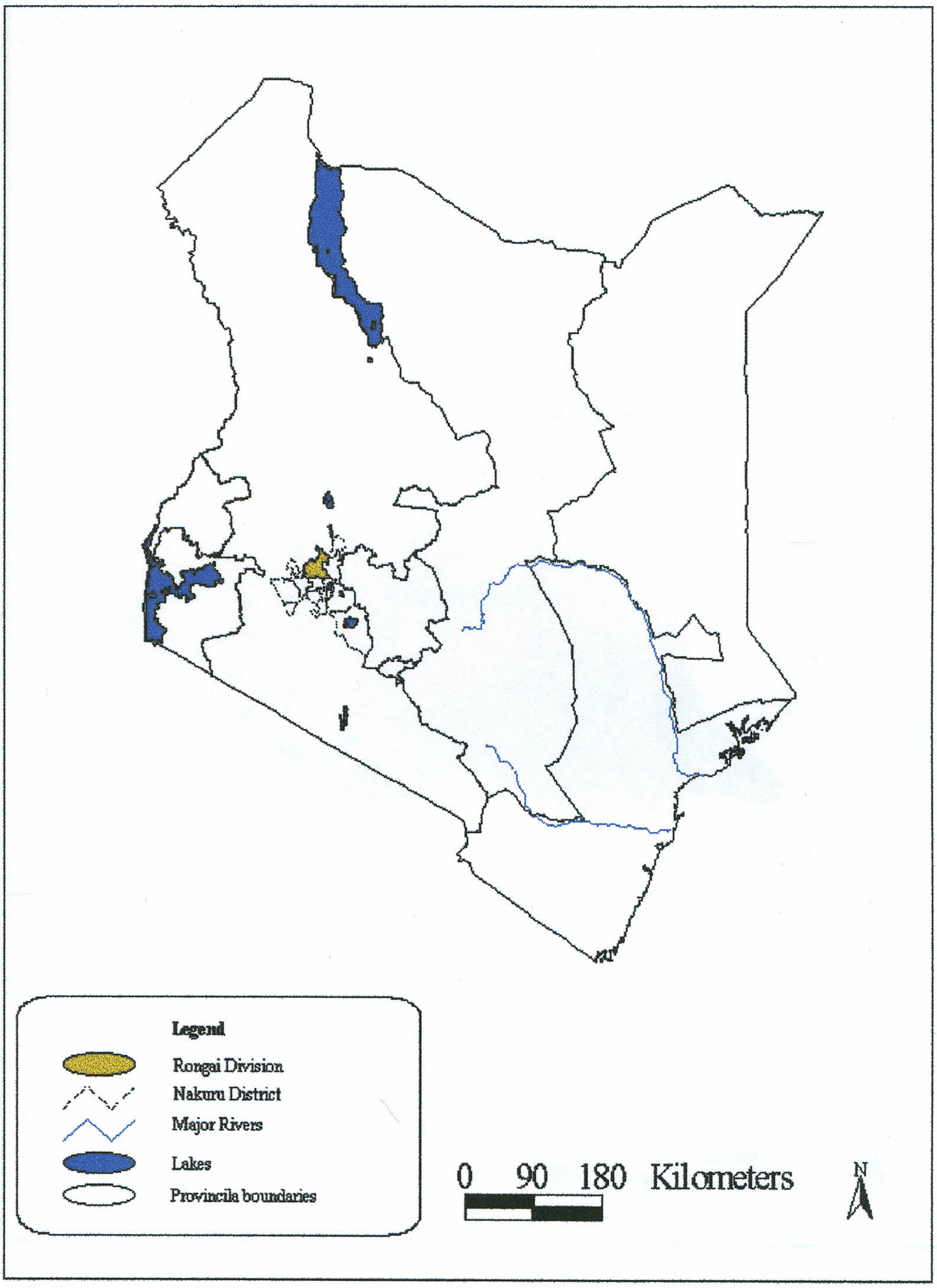


**Fig. 2.** A map showing the location of Nakuru District with its administrative boundaries.

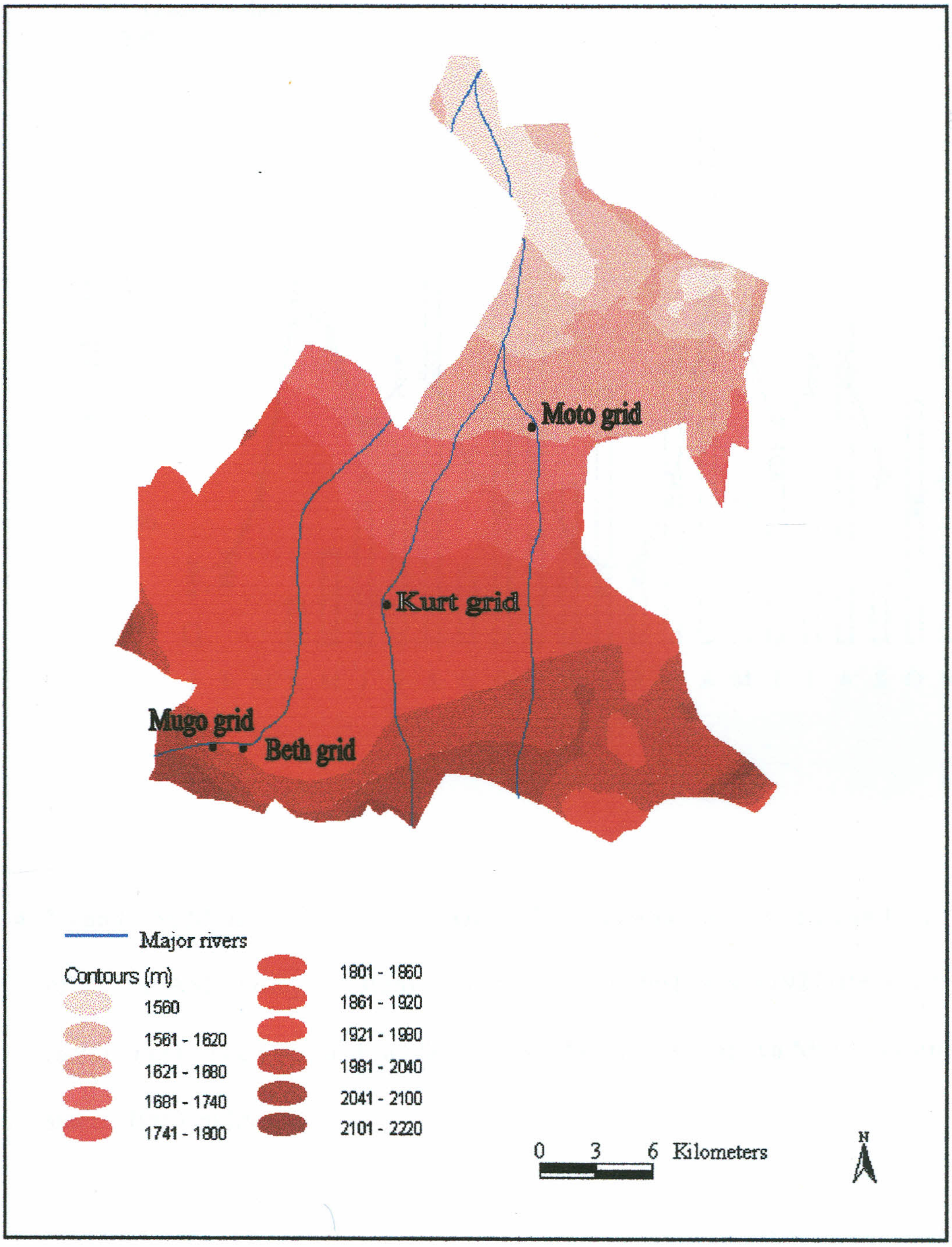


**Fig. 3.** A map showing the location of the study sites in relation to their altitudinal gradients.

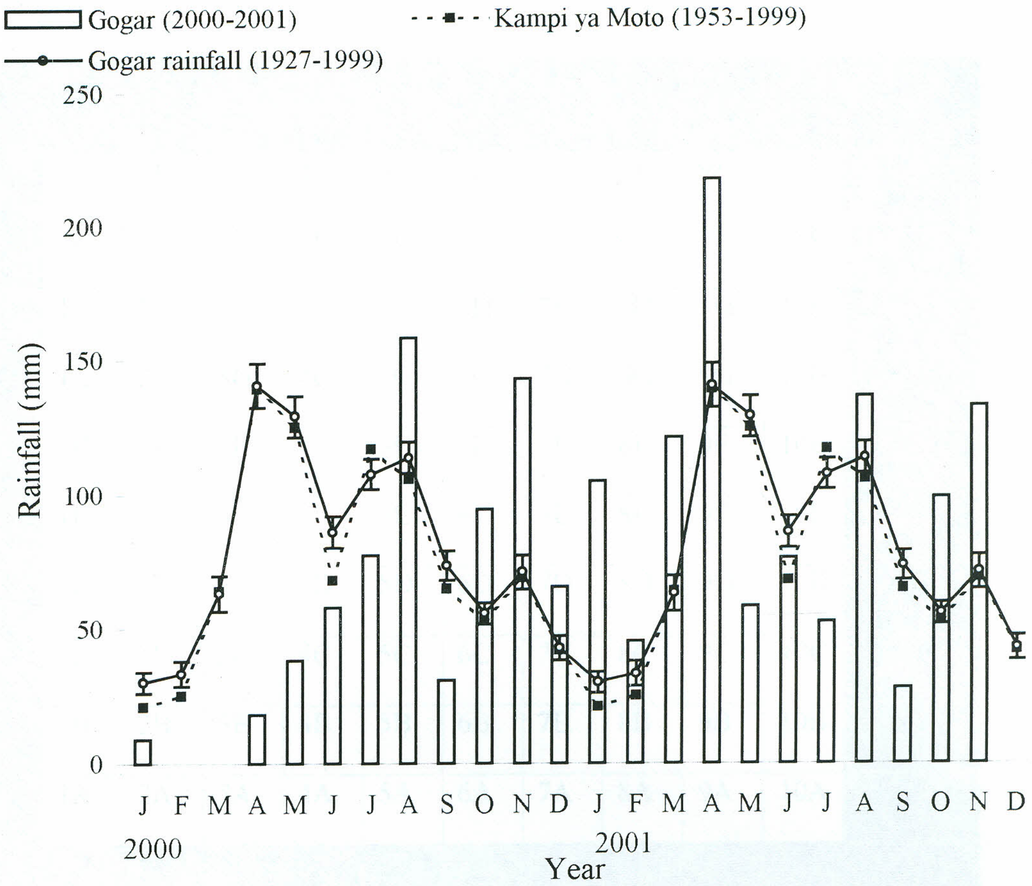
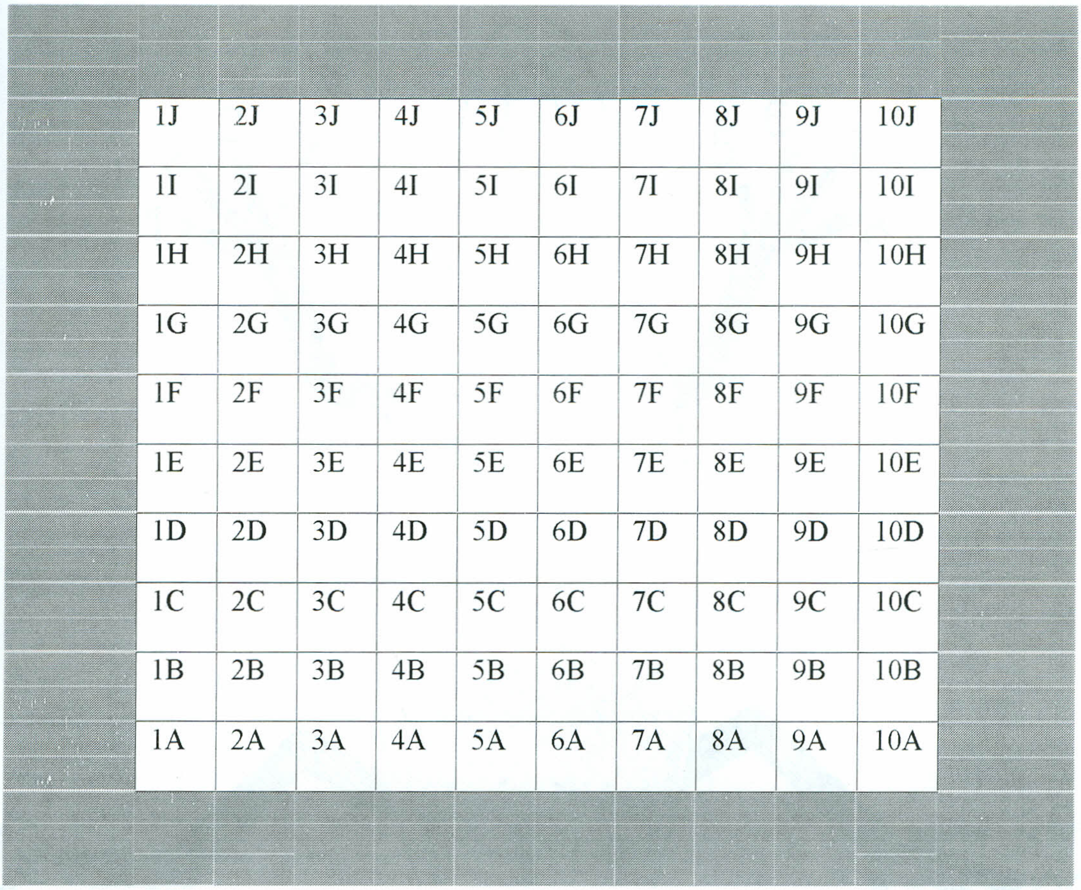


**Fig. 4.** Mean (± SEM) monthly rainfall at Gogar Farm weather station at an altitude of 1852m ASL during the study period (bars) and historical (1927-1999) ones (solid lines). The historical rainfall (1953-1999) for 'Kampi ya Moto' weather station (broken lines).



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1J | 2J | 3J | 4J | 5J | 6J | 7J | 8J | 9J | 10J |
| 1I | 2I | 3I | 4I | 5I | 6I | 7I | 8I | 9I | 10I |
| 1H | 2H | 3H | 4H | 5H | 6H | 7H | 8H | 9H | 10H |
| 1G | 2G | 3G | 4G | 5G | 6G | 7G | 8G | 9G | 10G |
| 1F | 2F | 3F | 4F | 5F | 6F | 7F | 8F | 9F | 10F |
| 1E | 2E | 3E | 4E | 5E | 6E | 7E | 8E | 9E | 10E |
| 1D | 2D | 3D | 4D | 5D | 6D | 7D | 8D | 9D | 10D |
| 1C | 2C | 3C | 4C | 5C | 6C | 7C | 8C | 9C | 10C |
| 1B | 2B | 3B | 4B | 5B | 6B | 7B | 8B | 9B | 10B |
| 1A | 2A | 3A | 4A | 5A | 6A | 7A | 8A | 9A | 10A |

| **Legend:** | Grid size | 100m x 100m (1ha.). |
|---|---|---|
| | Numbers | 1 – 10 Trapping Lines. |
| | Letters | A - J Trapping stations. |

**Fig. 5.** A schematic diagram of a typical trapping grid showing trapping stations.

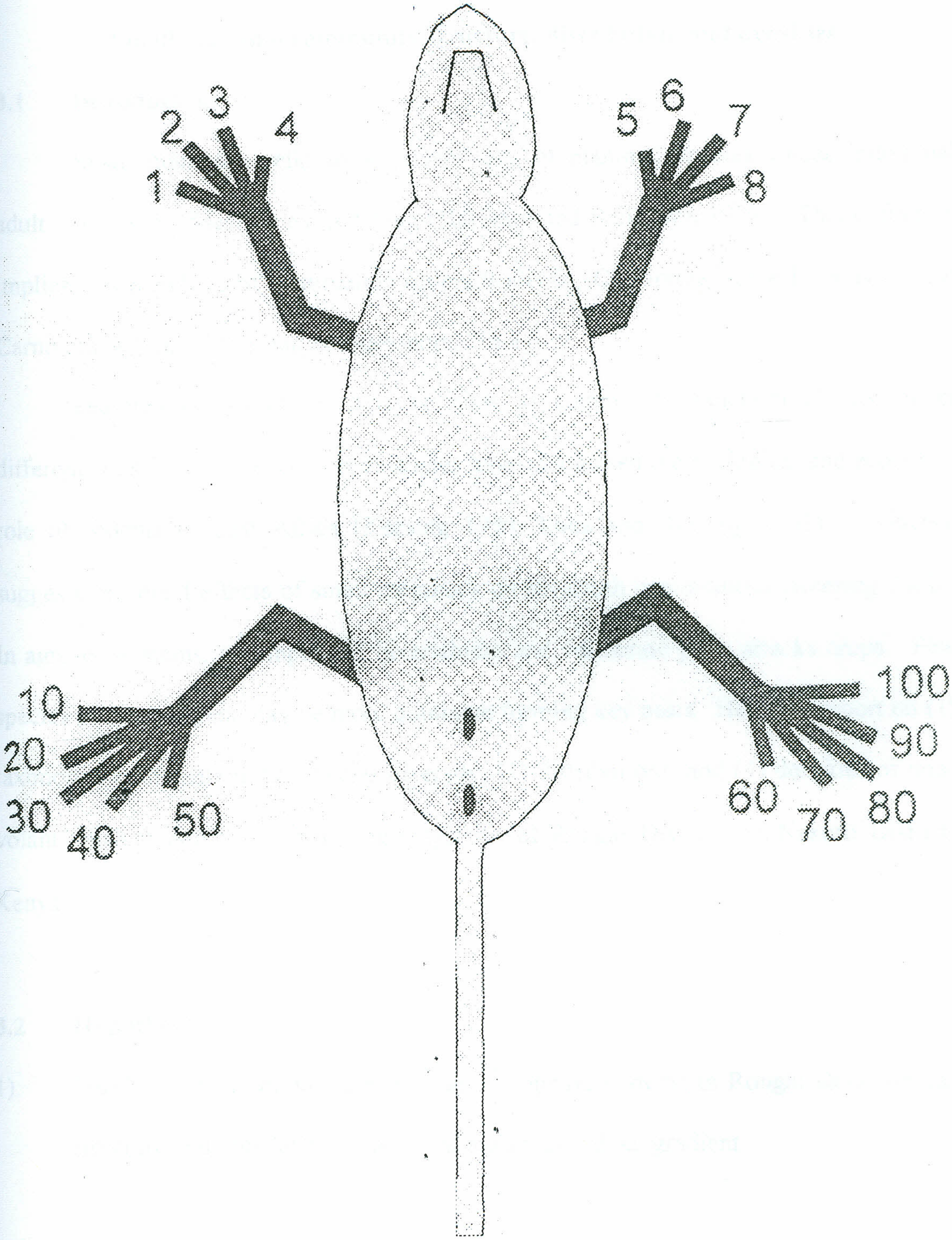


**Fig.6.** Body plan of rodents giving a presentation of the toe clipping codes.

# Chapter 3

## Small mammal community structure, distribution and densities

### 3.1 Introduction

Small mammals refer to an assemblage of mammal species whose individual adult live weight does not exceed 5 kg (Hayward and Phillipson 1979). This definition implies that members of mammalian orders Rodentia, Chiroptera, some Insectivora and Carnivora fall into this broad non-taxonomic category.

Features of faunal structure relevant to community functioning vary under different ecosystems. Hence, recent studies have recognised the ecological and economic role of rodents in East Africa (Keesing 1998, Metz and Keesing 2001). Evidence suggests profound effects of small mammals on savannah communities (Keesing 2000). In agro-ecosystems, a complex of invertebrate and vertebrate pests attacks crops. Few species in the complex may be more dominant forming key pests. Herein, I report on (1) taxonomic composition, (2) species diversity, (3) distributions, and (4) densities of non-volant small mammals in maize agro-systems of Rongai Division in Nakuru District, Kenya.

### 3.2 Hypothesis

1). Small mammal communities in maize cropping systems in Rongai show similar structure and population densities along an altitudinal gradient.

### 3.3 Objectives

1). To determine the taxonomic diversity and distribution of murid rodents and other small mammals in maize cropping systems in Rongai Division.

2). To assess for patterns in diversity and density between grids along an altitudinal gradient.

### 3.4 Methods

The Capture-Mark-Recapture (CMR) method used was as detailed in section 2.5.1 above.

**Data analyses**

Measures of species diversity were calculated using Simpson-Yule and Shannon-Weiner indices. The Simpson-Yule index is based on the assumption that diversity is inversely related to the probability that two individuals picked at random belong to the same species. Thus,

$$1\text{-}D = 1\text{-}\sum (Pi)^2$$

Where $1\text{-} D$ = Simpson's index of diversity

$Pi$ = Proportion of individuals of species $i$ in the community

The Shannon-Weiner index assumes that individuals are from random samples and are drawn from a large community in which all species are represented in the sample. Thus,

$$H' = -\sum (Pi)(lnPi)$$

Where H' = Index of species diversity

$Pi$ = Proportion of individuals belonging to $i$th species

Simpson-Yule diversity index tend to be biased towards rare species in number while Shannon-Weiner is biased towards dominant species (Krebs 1989). The two indices were thus computed to assess consistency in patterns in diversity among grids. Species evenness (or equitability) was calculated using Jacknife estimates for grids and Simpson's index methods in the program DIVERS Version 5.2. Similarity of rodent species among the grids was calculated by the Morrisita index using program SIMILAR Version 5.1 (Krebs 1989).

Densities for *Mastomys* were estimated using the program CAPTURE (Rexstad and Burnham 2002). The estimators used in this program assume the population is closed, meaning the number of individuals in the population remains constant for the duration of the study. Thus, history-of-captures were made from secondary captures. The XY reduced capture histories were used in the input file. This design involves provision of data on an individual only when captured and recording the exact position of capture. The output file thus provides densities, maximum distance travelled and aspects of habitat use. The program CAPTURE uses algorithms which test for the various possible sources of variations in the trapping data arising from (i) the null model of no time, behaviour or individual effects ($M_0$); (ii) effects of heterogeneity of individuals ($M_h$); (iii) effects of time ($M_t$); (iv) effects of behaviour of individual animals, e.g. trap shyness after initial capture ($M_b$); (v) effects of time and behaviour ($M_{tb}$); (vi) effects of heterogeneity and behaviour ($M_{hb}$); (vii) effects of time and heterogeneity ($M_{th}$); (viii) effects of combination of all these factors ($M_{htb}$) that may lead to biased estimates of densities. An important part of population estimation is selecting the appropriate model to perform estimation. Selection of the appropriate model is dependent upon testing the assumptions of the models. Although the program selects for the best model that accounts for this bias, I constrained the analysis to jackknife model ($M_h$) that fitted the data reasonably (>80%). The other model that fitted the data well was that of $M_o$ which, however, is not biologically feasible.

Due to low capture rates in other species, MNA technique (Krebs 1966) was used to estimate their relative abundances. This method is based on the assumption that the population at time *t*, includes those individuals not present but were previously encountered and captured again later. Wilcoxon matched-pairs sign-rank test was used to compare dry- and wet-season density estimates (Zhar 1999).

## 3.5 Results

### 3.5.1 Small mammal community structure

Between May 2000 and December, 2001, a total of 1240 captures of 837 individuals were made of seven rodent and shrew species in 20,100 trap nights. This gave a trap success of 6.2%. Fifty three animals were found dead in traps. Rodents captured included six murids (*Aethomys* cf. *kaiseri* (Noack 1887), *Arvicanthis* cf. *neumanni* (Matschie 1894), *Lemniscomys striatus* (Linnaeus 1758), *Mastomys* cf. *erythroleucus*, *Rattus rattus* and *Mus minutoides* Smith 1834) and a cricetid (*Tatera* cf. *robusta* Cretzschmar 1826) while the shrews were all soricids (*Crocidura* species). The species identifications herein are based on karyotypes and await confirmation.

The frequency distributions of various rodent species were heterogeneous in each grid (Mugo; $\chi^2$ =198.136, P<0.00001, *n* = 238, Beth; $\chi^2$ =144.8, P<0.00001, *n* = 160, Kurt; $\chi^2$ =211.764, P<0.00001, *n* = 202 and Moto; $\chi^2$ =150.549, P<0.00001, *n* = 213)

(Table 1). The most dominant species in all the trapping grids was *Ma.* cf. *erythroleucus* accounting for 71% of all captures (Plate 1), followed by *Ar.* cf. *neumanni* (14.1 %) and *Mu. minutoides* (8.0 %). The distribution of *Mastomys* was uniform ($\chi^2$ = 4.855, P=0.182, *n* = 594) in all the grids. However, the distribution of less common species (taxa for which absolute frequency were more than 5), varied significantly among the four grids: *Arvicanthis* ($\chi^2$ = 28.529, P = 0.000003, *n* = 119), *Mus* ($\chi^2$ = 64.632, P <0.00001, *n* = 67), *Lemniscomys* ($\chi^2$ = 20.538, P = 0.0001, *n* = 13), *Tatera* ($\chi^2$ = 81.000, P < 0.00001, *n* = 27) and *Crocidura* spp. ($\chi^2$ = 15.000, P=0.0001, *n* = 13) (Table 1). The other species represented less than 5 percent of the captures, with *Aethomys* being represented by only two individuals and *Rattus* by one (Table 1). *Aethomys* was captured in the more humid Mugo grid while *Tatera* was found only in the drier Moto grid. Mugo grid accounted for 30% of the total small mammal captures, Beth 21%, while Kurt and Moto accounted for 20% each. Overall trap success in each grid was 11.2% (Kurt), 6.0% (Mugo), 5.8% (Beth), and 5.1% (Moto), respectively (Table 1). Monthly trap success ranged from 0 to 30% as recorded in the Moto grid.

Small mammal species diversity was highest at Mugo (D = 2.411; H' = 1.639) and least in Kurt (D = 1.333; H' = 0.829) (Table 2). Moto grid was most equitable 0.586 and Beth grid was the least (0.266) equitable. All indices of species diversity - Simpson - Yule ($\chi^2$ = 0.505, P = 0.917, *n* = 4), Shannon – Wiener ($\chi^2$ = 0.439, P = 0.932, *n* = 4) and species evenness ($\chi^2$ = 0.149, P = 0.985, *n* = 4) did not differ significantly. Beth was closer to Kurt in species assemblages, while Kurt and Moto grids were least similar (Table 3).

### 3.5.2. Small mammal densities

The small mammal populations showed low densities in all grids with minor fluctuations (Figs. 7a-d and 8a-d). Densities increased from 0 animals to peaks of 72 animals per hectare in December 2001 (Mugo), 48 animals per hectare in November 2001 (Beth), 68 per hectare in November 2001 and 84 animals per hectare in December 2001 (Moto). Significant differences were noted in densities of *Mastomys* between the rainy and dry months in all grids (Mugo, T=10, P = 0.0004, *n*=20; Beth, T =5, P = 0.001, *n* = 20; Kurt, T = 6, P = 0.05, *n* = 9; and Moto, T = 11, P = 0.001, *n* = 18) (Figs. 7a-d). Rodent densities at the different study grids showed a similar pattern in rising from low (0 individuals/ha) to high (>50 individuals/ha) densities over the 21-month period. The other less common rodent densities were recorded at low levels throughout the study (Figs. 8a-d).

## 3.6 Discussion

I recorded eight species of small mammal in four grids in the maize cropping system of Rongai Division, Kenya (Table 1). These included six murids (*Aethomys kaiseri* Noack 1887, *Arvicanthis* cf. *nuemanni* Matschie 1894, *Lemniscomys striatus* Linnaeus 1758, *Mastomys* cf. *erythroleucus*, *Rattus rattus* Barkenhouse, and *Mus minutoides* Smith 1834) and a cricetid (*Tatera robusta* Cretzschmar 1836), and at least one species of soricid shrew (*Crocidura* spp). *Mastomys* cf. *erythroleucus* was the most common rodent (Mugo 61.6%; Beth 86.4%; Kurt 80.8% and Moto 59.6%) forming 71.0% of the total captures. The importance of this species in eastern Africa has only been documented in maize fields of Ethiopia. Although it was not reported in the early rodent outbreaks in Kenya (Taylor 1962, 1968, Taylor and Green 1972), this may have been due to misidentification. In literature the distribution of *Mastomys erythroleucus* has been documented in Southern Africa (Hubert *et al.* 1983), Senegal (Duplantier *et al.* 1990), Uganda, Sudan and Ivory Coast (Paulo Colangelo Pers. Comm.). In East Africa, *Mastomys natalensis* has been reported as the most important murid rodent pest in Tanzania (Fiedler 1988, Leirs *et al.* 1996, 1997) and in cereal fields of western Kenya (Martin *et al.* 1989). Other important rodents also recorded in this region include *Lemniscomys striatus* and *Rhabdomys pumilio* (Taylor 1962, 1968, Taylor and Green 1976). Although the first two species were captured in low numbers, *Rabdomys pumilio* was not recorded during the study. *Aethomys* was only captured in the more humid grid (Mugo) while *Tatera* was restricted to the drier part of the area of loose soil structure (the Moto grid).

The effects of habitat heterogeneity and its role in competitive interaction and abundance of small mammal community structures have been demonstrated in previous studies (Keesing 1998). The observed variations in distribution of *Arvicanthis* and *Lemniscomys* between grids could be explained by the edge effect arising from the fallow grass patches and pasturelands that occasionally bordered the study grids. Mugo grid had the highest number of species assemblage including two rare species (*Aethomys* and *Rattus*) not recorded from the other grids. These were also largely due to edge effect. The restriction of *Tatera* to Moto grid suggests the possibility of habitat preference. The similarities in the small mammal fauna (Table 2 and 3) may be due to equity in distribution of the common rodent taxa.

Monthly captures were very low during the first eleven months of trapping and in some instances no animals were captured (Figs. 7a-d and 8a-d). After recovery from low densities, *Mastomys* populations went through phases of sharp increases and declines. At the end of the study *Mastomys* population continued to increase at Mugo and Kurt grids, but declined at Beth and Kurt grids (Figs. 7a-d). The numbers of the other common small mammal species did not show marked fluctuations but notable changes were recorded during the dry season and higher densities during the wet season (Figs. 8a-c). *Arvicanthis* numbers were also noted to increase at the end of the study at Mugo and Moto grids, but all the other species numbers were on the decline phase.

Distribution of yearly rainfall has been shown to produce large fluctuations in numbers and occasional exterminations of populations (Lima *et al.* 2001). The prolonged drought persistent in the area prior to and at the beginning of this work (Figs. 7a-d and 8a-d) may have attributed to the low rodent numbers in the first year of the study. *Mastomys* and other rodent populations here recovered from near extinction to their peak densities over a period of 12 months. Peak densities were attained during the dry months that followed rainfall. Under experimental conditions, very low rodent densities have been shown to respond numerically to increased food availability (Doonan and Slade 1995, Yunger 2002). Thus population recovery and their subsequent density dynamics were influenced by rainfall as the proximate factor affecting the availability of food and other resources. Several investigators have also reported the effects of habitat seasonality on rodent abundance, reproductive activity and their recruitment from the African savannah (Taylor and Green 1976, French *et al.* 1975, Happold and Happold 1986, Martin and Dickinson 1986, Oguge 1995). Food and climate are the main environmental factors limiting small mammal populations (Taylor and Green 1976, also reviewed in Delany and Happold 1979). The results of this study concur with those of other related rodent species (Mwanjabe 1990, Leirs *et al.* 1996).

Low densities of 3-40 rodents per hectare have also been reported in the past in Nakuru (Delany and Robert 1978). Other studies elsewhere in Africa have demonstrated fluctuating figures in densities and total weights. Happold and Happold (1991) obtained densities ranging from 3-17 animals per hectare in woodland Savannah of Liwonde National Park, Malawi. Bekele (1996) recorded rodent densities of 12-36 hectare in the Menegesha state forest, Ethiopia.

In conclusion, small mammal community structure was similar in the number of species caught and their distributions. *Mastomys* was the dominant species within and across the entire grids. Other common rodents were *Arvicanthis, Mus* and *Lemniscomys. Aethomys* and *Rattus* were rare species captured only at Mugo grid, located at highest altitude, while *Tatera* was restricted to Moto grid, located on the lowest altitude. Density fluctuations were low but influenced by the distribution of the monthly and yearly rainfalls.

**Plate 1.** *Mastomys* cf. *erythroleucus*, the most numerically abundant rodent species captured in maize crop fields of Rongai Division, Nakuru District, Kenya.

**Table 1.** The community structure, number of individuals and proportional abundance (in parenthesis) of rodents and *Crocidura* captured in four trapping grids in maize fields of Nakuru District, Kenya between May 2000 and December 2001.

| | Study grids and trap nights | | | | |
|---|---|---|---|---|---|
| | Mugo | Beth | Kurt | Moto | Total |
| Species | 6000 | 6000 | 2700 | 5400 | 20100 |
| (a) Rodentia | | | | | |
| *Mastomys* cf *erythroleucus* | 151 (61.6%) | 152 (86.4%) | 164 (80.8%) | 127 (59.6%) | 594 (71.0%) |
| *Arvicanthis* cf. *neumanni* | 32 (13.1%) | 8 (4.5%) | 30 (14.8%) | 49 (23.0%) | 119 (14.1%) |
| *Mus minutoides* | 45 (18.4%) | 4 (2.3%) | 8 (3.9%) | 10 (4.7%) | 67 (8.0%) |
| *Lemniscomys striatus* | 10 (4.1%) | 3 (1.7%) | 0 (0.0%) | 0 (0.0%) | 13 (1.6%) |
| *Tatera* cf. *robusta* | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 27 (12.7%) | 27 (3.2%) |
| *Aethomys* cf. *kaiseri* | 3 (1.2%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 3 (0.4%) |
| *Rattus rattus* | 1 (0.4%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 1 (0.1%) |
| (b) Insectivora | | | | | |
| *Crocidura* spp. | 3 (1.2%) | 9 (5.1%) | 1 (0.5%) | 0 (0.0%) | 13 (1.6%) |
| Total | 245 (100%) | 176 (100%) | 203 (100%) | 213 (100%) | 837 (100%) |
| % Trap success | 6.0 | 5.8 | 11.2 | 5.1 | 6.2 |

**Table 2.** The species diversity and evenness of small mammal communities in the entire trapping grids of maize cropping systems in Rongai Division, Nakuru District, Kenya.

| | **Grid** | | | |
|---|---|---|---|---|
| **Index** | **Mugo** | **Beth** | **Kurt** | **Moto** |
| Shannon-Wieners' diversity index, H' | 1.639 | 0.878 | 0.829 | 1.517 |
| Simpson-Yule diversity index I/D | 2.411 | 1.479 | 1.333 | 2.344 |
| Simpson's evenness index E I/D | 0.330 | 0.266 | 0.370 | 0.586 |

**Table 3.** Similarity among trapping grids based on Morisita's similarity coefficient as estimated from program SIMILAR Version 5.1.

| | Mugo | Beth | Kurt | Moto |
|---|---|---|---|---|
| Mugo | 1.00 | | | |
| Beth | 0.92 | 1.00 | | |
| Kurt | 0.91 | 0.99 | 1.00 | |
| Moto | 0.95 | 0.94 | 0.90 | 1.00 |

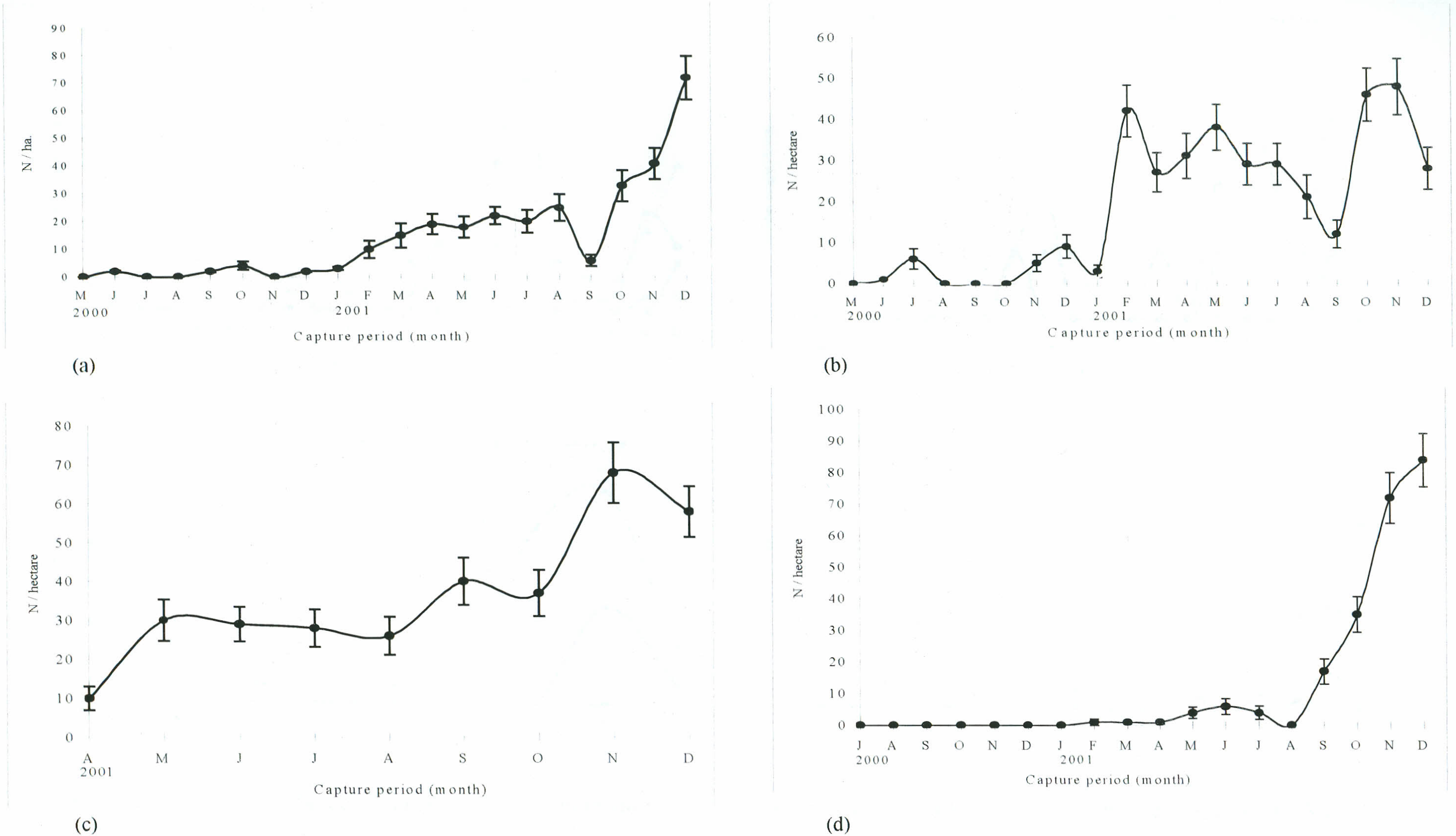


**Fig. 7.** Monthly densities (± SEM) of *Mastomys* cf. *erythroleucus* captured in (a) Mugo grid, (b) Beth grid, (c) Kurt grid and (d) Moto grid between May 2000 and December 2001 as estimated by the jackknife ($M_h$) model.

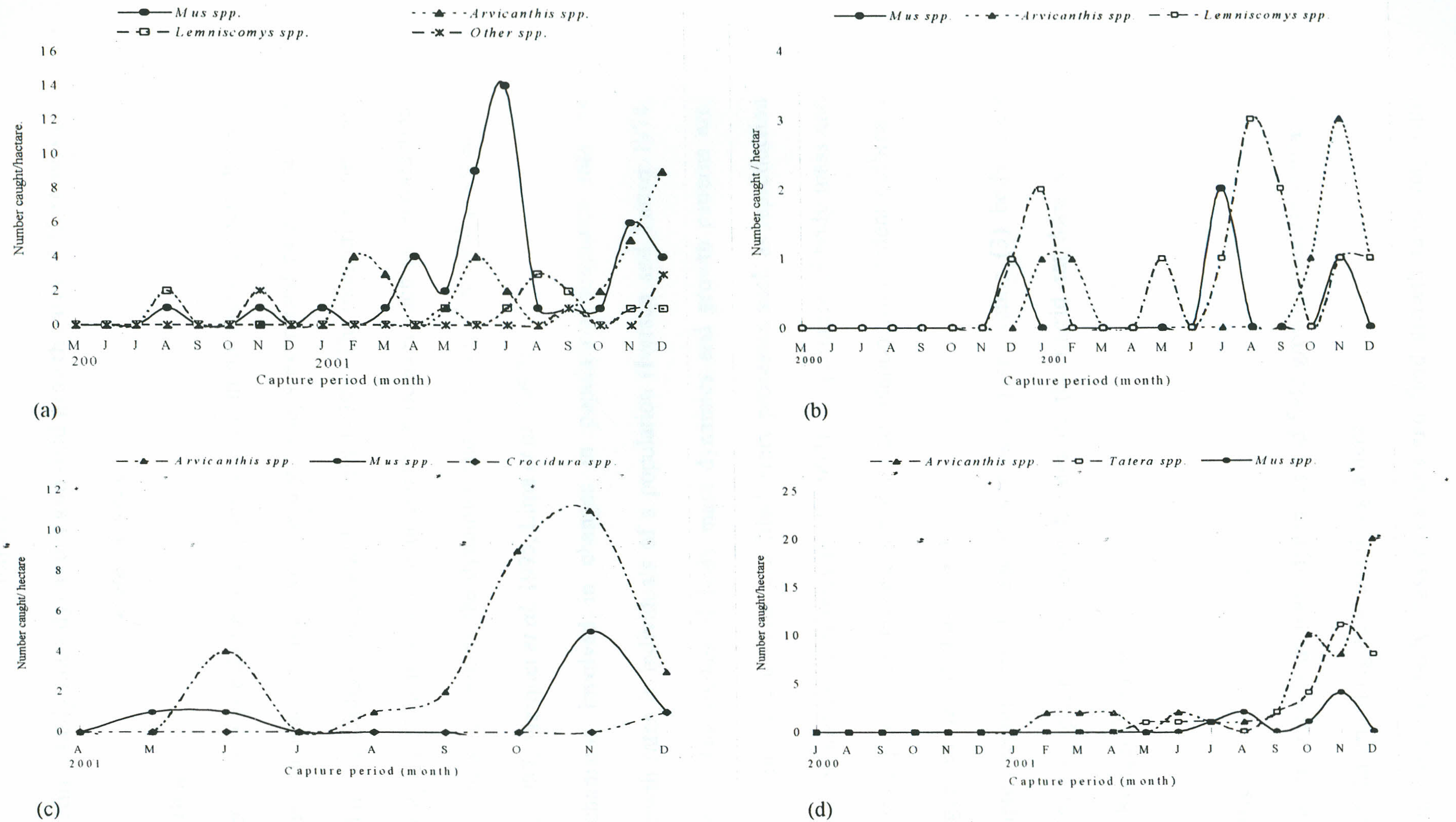


**Fig. 8.** Monthly relative abundance of small mammals other than *Mastomys* in (a) Mugo, (b) Beth, (c) Kurt and (d) Moto grids, May 2000 to December 2001 as estimated from Minimum Number Alive (MNA).

# Chapter 4

## Population structure, body mass dynamics and field growth rates of *Mastomys* cf. *erythroleucus*

### 4.1 Introduction

The structure of a population is its composition in numbers of individuals in each sex, and the frequency of their various age groups expressed categorically as juveniles, sub adults or adults (Delany and Happold 1979). The interactions between changes in environmental factors with demographic processes such as reproduction, survival and body mass determine the dynamics and structure of natural populations (Sauer and Slade 1987, Marquet *et al.* 1995, Lima *et al.* 1997).

The mechanisms involved in changes in population structures may be explained by growth rates in individuals of a population (Iverson and Turner 1974, Slade *et al.* 1984). The studies of body mass dynamics and growth patterns are, therefore, important in understanding how life history processes such as reproduction and survival affect population dynamics (Roff 1992). Importance of body mass and field growth rates on population processes and its correlation with rodent outbreaks has thus been suggested (Jaksic *et al.* 1996).

This chapter reports on (1) age structures, (2) sex ratios (3) body mass dynamics and (4) sex-specific field growth rates of the murid rat *Mastomys* cf. *erythroleucus* in Rongai Division.

### 4.2 Hypothesis

1). Population structure, body mass dynamics and field growth rates are similar in rodent populations along an altitudinal gradient.

2). Population structure, body mass dynamics and field growth rates vary with rainfall and population densities.

## 4.3 Objectives

1). To characterise the population structure, body mass dynamics and growth rates of *Mastomys* cf. *erythroleucus* in Rongai Division.

2). To determine any relationship of the above with rainfall and densities.

## 4.4 Methods

Animals were sampled using the Capture-Mark-Release (CMR) technique as detailed in section 2.5.1. Age compositions were determined by assigning body mass classes following the method described by Leirs (1995) for *Mastomys natalensis*. Thus animals less than 25g were considered juveniles; 25-39g sub adults and > 40g adults. Individual mass was measured to the nearest 0.1g using pesola (PESOLA Switzerland) spring balance. Body mass at first capture was used to determine mass class between successive periods of trapping. Adult body mass dynamics were calculated for both sexes each month in all study grids. Since some animals that were recaptured during a given trapping occasion experienced mass loss, only the first capture of each trapping period was used. Field growth rates were calculated by subtracting body mass of an individual during trapping period *p* from its mass in trapping period *p* + 1, dividing by the number of days elapsed during each period, and then multiplying by 7 to give a growth rate in g/week (Slade *et al.* 1984).

### Data analyses

Age classes were expressed as proportions of captures per month. Chi- square goodness-of-fit test was used to compare sex ratios. A three-way ANOVA was used to test for body mass and field growth rate differences in grids, sex and seasons. Regression analyses were used to determine the relationships between (i) body mass and (ii) field growth rates with population density and rainfall, respectively (Zhar 1999).

## 4.5 Results

### 4.5.1 Age structures

The age classes changed in varied proportions in all grids from month to month (Figs. 9a-d). Mugo grid -Juveniles formed 50.0% and 45.0% of the population in February and July 2001 respectively (Fig. 9a). The highest proportions for the other age classes were 42.9% for sub-adults in April 2001 and 89.0% for adults in June 2001. Conversely, the lowest proportions were 0% for juveniles in May and June 2001, 10.5% for sub-adults in June 2001, and 27.2% for adults in March 2001 (Fig. 9a).

Beth grid -Juveniles formed 31.6% and 33.3% of the population in March and October 2001, respectively (Fig. 9b). Sub adults formed 45.0% of the population in April 2001 while adults formed 72.0% of the population in November 2001. Conversely, the low proportions 3.7 and 0% were recorded for juveniles in May and November 2001. For sub-adults and low proportions of 18.8% were recorded in August while that of adults was 30. 0% recorded in April 2001 (Fig. 9b).

Kurt grid -Juveniles formed 73.1% of the population in September 2001. Sub adults formed 52.9% and 52.4% of the population in November and December 2001 respectively, while adults composed 95.2% of the captures in June 2001. Juveniles constituted 4.7% of the population in June and July 2001. No adults and sub-adults were recorded in April and June 2001 respectively (Fig. 9c).

Moto grid – Adults composed 100% of the captures in February, April, May and August 2001. A similarly proportion was constituted by sub-adults in March 2001. Juveniles composed 33.3% of the captures in June and November 2001. Sub-adults were not recorded in the population in February through April and August 2001. Juveniles were not recorded in the population in February through June and August 2001. No adults were recorded in March 2001 (Fig. 9d).

### 4.5.2 Sex ratio

Sex ratios were of the expected 1:1 in all grids (Tables 4 -11). Significant differences were, however, noted in the following grids, age groups and months:

Mugo grid -- new juvenile captures in March and total adult new captures over the study duration (Table 4) in which males were in higher proportion than females. Among the recaptured animals in this grid, the total individuals for the juveniles, sub adults and adults were significantly different with females forming higher proportions (Table 5).

Beth grid- adult males from the total new captures and recaptures over the study time (Table 6) and (Table 7) respectively, formed a significantly higher proportion than females.

Kurt grid- adult males formed a significantly higher proportion of new captures in May, November and in the total adult age group (Table 8). Among the recaptured population sex ratio was also significantly different with higher male adult proportions in September and sub adult females in December (Table 9).

Moto grid-no significant differences were detected within and over the months in all the age groups and totals (Tables 10 and 11).

### 4.5.3 Body mass dynamics

Seasonal effects on body mass was highly significant across the grids (F = 14.268, P = 0.0004, *n* = 48), with heavier animals captured during the wet season and lighter animals in the dry season (mean ± SEM: 55.05 ± 1.11g and 50.33 ± 1.20g), respectively (Figs. 10a-d). There was no significant effect of sex on body mass across the grids (F = 3.121, P = 0.033, *n* = 48), males weighing (53.42 ± 1.34g) and females (51.09 ± 2.52g), respectively (Fig. 11). No significant effects of grids were detected on body mass (F=1.549, P = 0.211, *n* = 48). There were no significant interactive effects between grids and sex (F=1.549, P = 0.211, *n* = 48), grids and seasons (F=1.549, P = 0.211, *n* = 48) or grid, sex and season (F=1.549, P = 0.211, *n* = 48).

Further analysis indicated no effect of population density on body mass distribution of either sex, at Mugo (male: $R^2 = 0.60$, P = 0.662, *n* = 7 and females: $R^2 = 0.375$, P = 0.392, *n* = 7). Beth's (male: $R^2 = 0.005$, P = 0.996, *n* = 10 and females: $R^2 = 0.841$, P = 0.407, *n* = 10). Kurt's (male: $R^2 = 0.096$, P = 0.855, *n* = 4 and females: $R^2 = 0.060$, P = 0.896, *n* = 4) and Moto's (male: $R^2 = 0.249$, P = 0.686, *n* = 3 and females: $R^2 = 0.796$, P = 0.106, *n* = 3).

### 4.5.4 Field growth rates

Seasonal effects in field growth rates were significant (F = 8.791, P = 0.005, *n* = 58), with the highest growth rates during wet season (2.775 ± 0.287g/week) and the lowest in dry season (1.214 ± 0.238g/week), respectively (Fig. 12). There were no significant differences (F = 0.037, P = 0.848, *n* = 34) in mean field growth rates between sexes, males being (2.364 ± 0.298g/week) and females (2.103 ± 0.339g/week) from all the grids (Fig. 13). No significant effects on body mass were detected between grids (F=1.549, P = 0.211, n =58). There were also no significant interactive effects between grids and sex (F=0.124, P = 0.945, *n* = 58), grids and seasons (F = 0.132, P = 0.940, *n* = 58) or between grid, sex and season (F=1.549, P = 0.211, *n* =58).

No significant relations were detected between field growth rates and population density in all grids: Mugo's (males: $R^2 = 0.03$, P = 0. 835, *n* = 5 and females: $R^2 = 0.473$, $P = 0.282$, $n = 5$). Beth's (males: $R^2 = 0.059$, $P = 0.879$, $n = 7$ and females: $R^2 = 0.279$ $P = 0.467$, $n = 7$). Kurt (males: $R^2 = 0.168$, $P = 0.784$, $n = 4$ and females: $R^2 = 0.292$, $P = 0.634$, $n = 5$) and Moto's (males: $R^2 = 0.396$, $P = 0.513$, $n = 4$ and females: $R^2 = 0.433$, $P = 0.471$, $n = 5$).

### 4.6 Discussion

#### Age structures

The distribution of age compositions differed at different times of the capture period (Figs. 9a-d). Same months of the years (2000-2001) did not have similar proportional distributions of age classes in all the grids. However, patterns of age distribution appeared similar across grids with time lags of one or two months. For instance, age structure at Mugo's was similar to Beth's and that of Kurt similar to Moto's. Between May and September 2000, no juvenile was captured in the study site. This may be attributed to prolonged drought, which may have affected reproduction (Figs. 9a-d). This is suggested since patterns in age distribution are a consequence of reproductive flexibility in response to the changing environmental conditions (Delany and Happold 1979, Sirrlero-Zhubiri 1995, Bekele and Leirs 1997). During this time no single capture had been made at Moto grid.

The first appearance of juveniles and sub adults in Mugo and Beth grids occurred in October 2000 in Mugo grid after a reproductive stimulating effect of 100 mm of rains falling between May and June 2000 (Figs. 9a and b). No females were captured in 2000 while only 35% of captured males were in reproductive condition in July, but none in the other months of the year. Consequently, no any significant change in population structure was realised in these grids during the year. The second appearance of juveniles followed a cumulative rainfall of 337.6mm between January and April 2001. This increased the proportion of pre-adults in February through

March, July, October and December at Mugo's. At Beth's, increased proportions of pre-adults were noted in February through April, October and December. Substantial proportions of pre - adults were recorded in April, September through December 2001 and March, July and September through December 2001 at Kurt and Moto grids, respectively (9a-d). These changes in population structure during the early part of the year 2001 were perhaps largely due to immigrants from refuges (Martin and Dickinson 1986) while changes later in the year were attributed to breeding.

However, the changes observed thereafter were partly from gradual maturation of young animals into older age groups or pre-saturation dispersal (Stenseth and Lidicker 1992). These findings are in concordance with other reports showing effects of habitat seasonality on rodent abundance and recruitment in savannahs (French *et al.* 1975, Happold and Happold 1986) and maize fields (Bekele and Leirs 1997).

### Sex ratio

The sex ratio among new captures in the study grids, except from a few notable occasions, was of the expected 1:1 within the months and over the entire sampling period, which suggested little difference in recruitment between sexes (Tables 4 - 11). The significant differences in sex ratio among new captures may be explained by differences in recruitment, leading to a temporary bias in sampling. The significant differences in sex ratio among the recaptured animal population, in favour of one sex to the other, suggests biases in differential mortality rates or dispersal.

### Body mass dynamics and field growth rates

This study found strong seasonal effects on body mass dynamics of *Mastomys* cf. *erythroleucus* (Figs. 10a-d). Body masses were smallest during the dry months and heaviest in the wet months. These changes in mean body mass may be the result of recruitment of lightweight individuals, differential mortality during the dry season or changes in individual body mass (growth rates) during the wet season (Lima *et al.* 1997). The allocation of energy by individuals to reproduction and maintenance during different seasons may be reflected in body mass (Marquet *et al.* 1995). In a related group of African savannah grassland rodent species, more fat is deposited around the kidney, and testes increase in size towards the end of the rains, but the reserves are exhausted at the end of the dry season (Taylor and Green 1976). Changes in body mass of rodents are related to energetic cost associated with food availability and quality (Delany 1982). This may have important consequences on survival and population mass dynamics. In this study, the prolonged drought preceding its commencement influenced poor survival of rodents in the year 2000, resulting in to inadequate or lack of captures in some months from which to estimate body mass. Rainfall during the early part of the year 2001 was associated with vegetation growth and abundant food. Its distribution in the rest of the year was important in causing the body mass dynamics as it is exhibited in Rongai region.

Body masses were similar between sexes across the grids (Fig. 11). This result is inconsistent with those of other small rodents, which have found strong sexual dimorphism in body mass with larger males than females (Lima *et al.* 1996). In my study, this difference could be accounted for by an increased presence of pregnant females in Kurt grid since biases from early pregnancy are not easily detectable from palpation (Gaines and Rose 1976). There was no relationship between body mass and population density in either sex. This confirms that body mass dynamics may be the result of several other demographic processes such as growth, survival, recruitment and reproduction. The existence of such trade offs may have masked the effects of density (Lima *et al.* 1996).

There was no significant difference in field growth rates of male and females in all the grids (Fig. 12a-d). This suggests that sex has no effect on growth rates. However, seasonal variations had strong influence on field growth rates of *Mastomys* (Fig. 13). The existence of seasonal effects on growth rates implies that the body mass dynamics observed in the rodent population were an individual characteristci. These patterns in field growth rates may be associated with availability and quality of food between seasons. High field growth rates coincided with months of high rainfall and luxuriant vegetation. This resulted into abundant food, which provided energy for somatic growth. Seasonal effects on growth rates have also been reported in other small mammal species (Iverson and Turner 1974, Sauer and Slade 1985). In addition, field growth rates did not show a significant positive correlation with density in all the study sites. Low field growth rates (negative in some months) coincided with months of medium precipitation where lactating females dominated captures.

In conclusion, this chapter has shown that *Mastomys* cf. *erythroleucus* population structure changes over time. Age distribution is largely influenced by the amount of precipitation. Sex ratio occasionally changes from equality and this could be influenced by biases in sampling arising from effects of recruitment, mortality and dispersal. Body mass dynamics and field growth rates were similar between sexes, however, they were strongly influenced by seasonal variations. Larger individuals and high growth rates were recorded during the wet season. This suggests higher growth rates may occur during unusually higher rainfall leading to population outbreaks. Density did not have any effect on body mass dynamics.

**Table 4.** Monthly sex ratios for new captures of *Mastomys* cf. *erythroleucus* by age groups in Mugo grid, data collated from May 2000 to December 2001.

| | **Juveniles** | | | | | **Sub-adults** | | | | | **Adults** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P |
| Jan | 0 | 0 | 0 | 0.000 | 1.500 | 0 | 0 | 0 | 0.000 | 1.000 | 2 | 0 | 2 | 2.500 | 0.114 |
| Feb | 1 | 1 | 2 | 0.500 | 0.479 | 1 | 0 | 1 | 2.000 | 0.157 | 2 | 0 | 2 | 2.500 | 0.114 |
| Mar | 4 | 0 | 4 | 4.250 | **0.039** | 2 | 0 | 2 | 2.500 | 0.114 | 1 | 0 | 1 | 2.000 | 0.114 |
| Apr | 0 | 0 | 0 | 0.000 | 1.000 | 4 | 2 | 6 | 0.833 | 0.361 | 4 | 1 | 5 | 2.000 | 0.157 |
| May | 0 | 1 | 1 | 2.000 | 0.157 | 1 | 1 | 2 | 0.500 | 0.479 | 3 | 1 | 4 | 1.250 | 0.264 |
| Jun | 0 | 1 | 1 | 2.000 | 0.157 | 1 | 2 | 3 | 0.667 | 0.414 | 5 | 2 | 7 | 1.429 | 0.232 |
| Jul | 3 | 6 | 9 | 1.111 | 0.292 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Aug | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 0 | 0 | 0.000 | 1.000 | 2 | 1 | 3 | 0.667 | 0.414 |
| Sep | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 2 | 1 | 3 | 0.667 | 0.414 |
| Oct | 5 | 4 | 9 | 0.222 | 0.637 | 2 | 2 | 4 | 0.250 | 0.617 | 2 | 3 | 5 | 0.400 | 0.527 |
| Nov | 0 | 0 | 0 | 0.000 | 1.000 | 2 | 3 | 5 | 0.400 | 0.527 | 8 | 6 | 14 | 0.357 | 0.550 |
| Dec | 5 | 3 | 8 | 0.625 | 0.429 | 9 | 3 | 12 | 3.083 | 0.079 | 11 | 5 | 16 | 2.313 | 0.128 |
| **Total** | 14 | 21 | 35 | 1.429 | 0.232 | 22 | 13 | 35 | 2.343 | 0.126 | 42 | 20 | 62 | 7.823 | **0.005** |

**Table 5.** Monthly sex ratios for *Mastomys* cf. *erythroleucus* recaptures by age groups in Mugo grid, data collated from May 2000 to December 2001.

| | Juveniles | | | | | Sub-adults | | | | | Adults | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P |
| Jan | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 1 | 2 | 2.000 | 0.157 |
| Feb | 1 | 0 | 1 | 2.000 | 0.157 | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 0 | 0 | 0.000 | 1.000 |
| Mar | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 2 | 2 | 2.500 | 0.114 | 2 | 0 | 2 | 2.500 | 0.114 |
| Apr | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 1 | 2 | 0.500 | 0.479 |
| May | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 1 | 1 | 2.000 | 0.157 | 3 | 2 | 5 | 0.400 | 0.527 |
| Jun | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 4 | 8 | 12 | 1.417 | 0.234 |
| Jul | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 4 | 4 | 4.250 | **0.039** | 2 | 5 | 7 | 1.429 | 0.232 |
| Aug | 0 | 2 | 2 | 2.500 | 0.114 | 2 | 4 | 6 | 0.833 | 0.361 | 2 | 3 | 5 | 0.400 | 0.527 |
| Sep | 0 | 2 | 2 | 2.500 | 0.114 | 1 | 0 | 1 | 2.000 | 0.157 | 1 | 2 | 3 | 0.667 | 0.414 |
| Oct | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 2 | 2 | 2.500 | 0.114 |
| Nov | 0 | 1 | 1 | 2.000 | 0.157 | 1 | 1 | 2 | 0.500 | 0.479 | 1 | 8 | 9 | 5.555 | **0.018** |
| Dec | 1 | 1 | 2 | 0.500 | 0.478 | 0 | 1 | 1 | 2.000 | 0.157 | 2 | 5 | 7 | 1.429 | 0.232 |
| **Total** | 2 | 9 | 11 | 4.545 | **0.033** | 4 | 15 | 19 | 6.421 | **0.011** | 18 | 37 | 52 | 6.582 | **0.010** |

**Table 6.** Monthly sex ratios for *Mastomys* cf. *erythroleucus* new captures by age groups in Beth grid, data collated from May 2000 to December 2001.

| | **Juveniles** | | | | | **Sub-adults** | | | | | **Adults** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P |
| Jan | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 2 | 2 | 2.500 | 0.114 |
| Feb | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 2 | 2 | 2.500 | 0.114 |
| Mar | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 4 | 4 | 4.250 | 0.039 | 2 | 1 | 3 | 0.667 | 0.414 |
| Apr | 1 | 0 | 1 | 2.000 | 0.157 | 3 | 2 | 5 | 0.400 | 0.527 | 5 | 0 | 5 | 5.200 | **0.023** |
| May | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 3 | 3 | 1.333 | 0.248 | 8 | 1 | 9 | 5.555 | **0.018** |
| Jun | 1 | 1 | 2 | 0.500 | 0.479 | 1 | 3 | 4 | 1.250 | 0.264 | 9 | 3 | 12 | 3.083 | 0.079 |
| Jul | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 3 | 1 | 4 | 1.250 | 0.264 |
| Aug | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 1 | 1 | 2.000 | 0.157 | 2 | 2 | 4 | 0.250 | 0.617 |
| Sep | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 1 | 2 | 0.500 | 0.479 |
| Oct | 0 | 0 | 0 | 0.000 | 1.000 | 2 | 0 | 2 | 2.500 | 0.114 | 1 | 1 | 2 | 0.500 | 0.479 |
| Nov | 0 | 1 | 1 | 2.000 | 0.157 | 2 | 0 | 2 | 2.500 | 0.114 | 2 | 3 | 5 | 0.400 | 0.527 |
| Dec | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 1 | 2 | 0.500 | 0.479 | 0 | 2 | 2 | 2.500 | 0.114 |
| **Total** | 2 | 4 | 6 | 0.833 | 0.361 | 13 | 11 | 24 | 0.208 | 0.648 | 33 | 19 | 52 | 3.988 | **0.050** |

**Table 7.** Monthly sex ratios for *Mastomys* cf. *erythroleucus* recaptures by age groups in Beth grid, data collated from May 2000 to December 2001.

| | **Juveniles** | | | | | **Sub-adults** | | | | | **Adults** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P |
| Jan | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Feb | 4 | 0 | 4 | 4.250 | **0.039** | 1 | 3 | 4 | 1.250 | 0.264 | 7 | 4 | 11 | 0.909 | 0.340 |
| Mar | 4 | 3 | 7 | 0.286 | 0.593 | 2 | 1 | 3 | 0.667 | 0.414 | 1 | 1 | 2 | 0.500 | 0.479 |
| Apr | 0 | 3 | 3 | 1.333 | 0.248 | 5 | 0 | 5 | 5.200 | 0.023 | 1 | 1 | 2 | 0.500 | 0.479 |
| May | 0 | 0 | 0 | 0.000 | 1.000 | 3 | 5 | 8 | 0.625 | 0.429 | 5 | 0 | 5 | 5.250 | 0.023 |
| Jun | 0 | 1 | 1 | 2.000 | 0.157 | 1 | 1 | 2 | 0.500 | 0.479 | 3 | 1 | 4 | 1.250 | 0.264 |
| Jul | 0 | 1 | 1 | 2.000 | 0.157 | 1 | 4 | 5 | 2.000 | 0.157 | 7 | 3 | 10 | 1.700 | 0.192 |
| Aug | 0 | 1 | 1 | 2.000 | 0.157 | 1 | 5 | 6 | 2.833 | 0.092 | 2 | 3 | 5 | 0.400 | 0.527 |
| Sep | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 0 | 1 | 2.000 | 0.157 |
| Oct | 7 | 3 | 10 | 1.700 | 0.192 | 3 | 6 | 9 | 1.111 | 0.292 | 6 | 2 | 8 | 2.125 | 0.145 |
| Nov | 0 | 0 | 0 | 0.000 | 1.000 | 3 | 3 | 6 | 0.167 | 0.683 | 7 | 6 | 13 | 0.154 | 0.695 |
| Dec | 3 | 3 | 6 | 0.167 | 0.683 | 5 | 0 | 5 | 5.200 | **0.023** | 4 | 5 | 9 | 0.222 | 0.637 |
| **Total** | 18 | 15 | 33 | 0.303 | 0.581 | 25 | 28 | 53 | 0.189 | 0.664 | 44 | 26 | 70 | 4.643 | **0.031** |

**Table 8.** Monthly sex ratios for *Mastomys cf. erythroleucus* new captures by age groups in Kurt grid, data from April to December 2001.

| | **Juveniles** | | | | | **Sub-adults** | | | | | **Adults** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P |
| Apr | 1 | 2 | 3 | 0.667 | 0.414 | 2 | 1 | 3 | 0.667 | 0.414 | 0 | 0 | 0 | 0.000 | 1.000 |
| May | 0 | 2 | 2 | 2.500 | 0.114 | 5 | 6 | 11 | 0.364 | 0.546 | 8 | 0 | 8 | 8.125 | **0.004** |
| Jun | 0 | 2 | 2 | 2.500 | 0.114 | 1 | 2 | 3 | 0.667 | 0.414 | 3 | 1 | 4 | 1.250 | 0.264 |
| Jul | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 0 | 0 | 0.000 | 1.000 | 2 | 3 | 5 | 0.400 | 0.527 |
| Aug | 3 | 2 | 5 | 0.400 | 0.527 | 1 | 1 | 2 | 0.500 | 0.479 | 1 | 1 | 2 | 0.500 | 0.479 |
| Sep | 9 | 4 | 13 | 2.000 | 0.157 | 1 | 0 | 1 | 2.000 | 0.157 | 1 | 2 | 3 | 0.667 | 0.414 |
| Oct | 5 | 3 | 8 | 0.625 | 0.429 | 3 | 2 | 5 | 0.400 | 0.527 | 0 | 2 | 2 | 2.500 | 0.114 |
| Nov | 2 | 2 | 4 | 0.250 | 0.617 | 7 | 3 | 10 | 1.700 | 0.192 | 10 | 2 | 12 | 5.417 | **0.019** |
| Dec | 1 | 6 | 7 | 3.714 | 0.054 | 8 | 8 | 16 | 0.063 | 0.803 | 7 | 3 | 10 | 1.700 | 0.192 |
| **Total** | 21 | 24 | 45 | 0.222 | 0.637 | 24 | 22 | 46 | 0.109 | 0.741 | 32 | 14 | 46 | 7.065 | **0.008** |

**Table 9.** Monthly sex ratios for *Mastomys* cf. *erythroleucus* recaptures by age groups in Kurt grid, data collated from April to December 2001.

| | **Juveniles** | | | | | **Sub-adults** | | | | | **Adults** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P |
| Apr | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 1 | 2 | 2.000 | 0.157 |
| May | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 1 | 1 | 2.000 | 0.157 | 1 | 0 | 1 | 2.000 | 0.157 |
| Jun | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 0 | 1 | 2.000 | 0.157 | 3 | 3 | 6 | 0.167 | 0.683 |
| Jul | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 1 | 2 | 0.500 | 0.479 |
| Aug | 0 | 1 | 1 | 2.000 | 0.157 | 0 | 0 | 0 | 0.000 | 1.000 | 2 | 4 | 6 | 0.883 | 0.361 |
| Sep | 0 | 2 | 2 | 2.500 | 0.114 | 0 | 3 | 3 | 1.333 | 0.248 | 5 | 0 | 5 | 5.200 | **0.023** |
| Oct | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 2 | 3 | 0.667 | 0.414 | 2 | 4 | 6 | 0.883 | 0.361 |
| Nov | 1 | 0 | 1 | 2.000 | 0.157 | 3 | 5 | 8 | 0.625 | 0.429 | 0 | 0 | 0 | 0.000 | 1.000 |
| Dec | 1 | 0 | 1 | 2.000 | 0.157 | 0 | 5 | 5 | 5.200 | **0.023** | 0 | 1 | 1 | 2.000 | 0.157 |
| **Total** | 2 | 4 | 6 | 0.833 | 0.361 | 6 | 15 | 21 | 3.905 | 0.048 | 18 | 20 | 38 | 0.132 | 0.717 |

**Table 10.** Monthly sex ratios for *Mastomys* cf. *erythroleucus* new captures by age groups in Moto grid, data collated from July 2000 to December 2001.

| | **Juveniles** | | | | | **Sub-adults** | | | | | **Adults** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P |
| Jan | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Feb | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 0 | 1 | 2.000 | 0.157 |
| Mar | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 0 | 1 | 2.000 | 0.157 |
| Apr | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 0 | 1 | 2.000 | 0.157 |
| May | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 2 | 0 | 2 | 2.500 | 0.114 |
| Jun | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 0 | 0 | 2.000 | 0.157 | 1 | 1 | 2 | 0.500 | 0.479 |
| Jul | 1 | 1 | 2 | 0.500 | 0.479 | 1 | 0 | 1 | 2.000 | 0.157 | 1 | 0 | 1 | 2.000 | 0.157 |
| Aug | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Sep | 3 | 1 | 4 | 1.250 | 0.264 | 1 | 0 | 1 | 2.000 | 0.157 | 3 | 1 | 4 | 1.250 | 0.264 |
| Oct | 3 | 1 | 4 | 1.250 | 0.264 | 2 | 4 | 6 | 0.833 | 0.361 | 3 | 6 | 9 | 1.111 | 0.292 |
| Nov | 7 | 10 | 17 | 0.588 | 0.443 | 1 | 3 | 4 | 1.250 | 0.264 | 7 | 8 | 15 | 0.333 | 0.715 |
| Dec | 5 | 4 | 9 | 0.286 | 0.593 | 2 | 7 | 9 | 2.889 | 0.089 | 5 | 6 | 11 | 0.364 | 0.546 |
| **Total** | 19 | 17 | 36 | 0.139 | 0.709 | 8 | 14 | 22 | 1.682 | 0.195 | 25 | 22 | 47 | 0.213 | 0.645 |

**Table 11.** Monthly sex ratios for *M.* cf. *erythroleucus* recaptures by age groups in Moto grid, data collated from July 2000 to December 2001.

| | **Juveniles** | | | | | **Sub-adults** | | | | | **Adults** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P | M | F | *n* | $\chi^2$-value | P |
| Jan | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Feb | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Mar | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Apr | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 0 | 1 | 2.000 | 0.157 |
| May | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Jun | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Jul | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 | 0 | 0 | 0 | 0.000 | 1.000 |
| Aug | 0 | 2 | 2 | 2.500 | 0.114 | 2 | 4 | 6 | 0.833 | 0.361 | 2 | 3 | 5 | 0.400 | 0.527 |
| Sep | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 1 | 2 | 0.500 | 0.479 | 0 | 3 | 3 | 1.333 | 0.248 |
| Oct | 1 | 0 | 1 | 2.000 | 0.157 | 0 | 1 | 1 | 2.000 | 0.157 | 1 | 4 | 5 | 2.000 | 0.157 |
| Nov | 0 | 0 | 0 | 0.000 | 1.000 | 1 | 0 | 1 | 2.000 | 0.157 | 4 | 5 | 9 | 0.222 | 0.637 |
| Dec | 0 | 1 | 1 | 2.000 | 0.157 | 8 | 6 | 14 | 0.071 | 0.789 | 6 | 4 | 10 | 0.500 | 0.479 |
| **Total** | 1 | 3 | 4 | 1.250 | 0.264 | 12 | 12 | 24 | 0.042 | 0.838 | 14 | 19 | 33 | 0.788 | 0.375 |

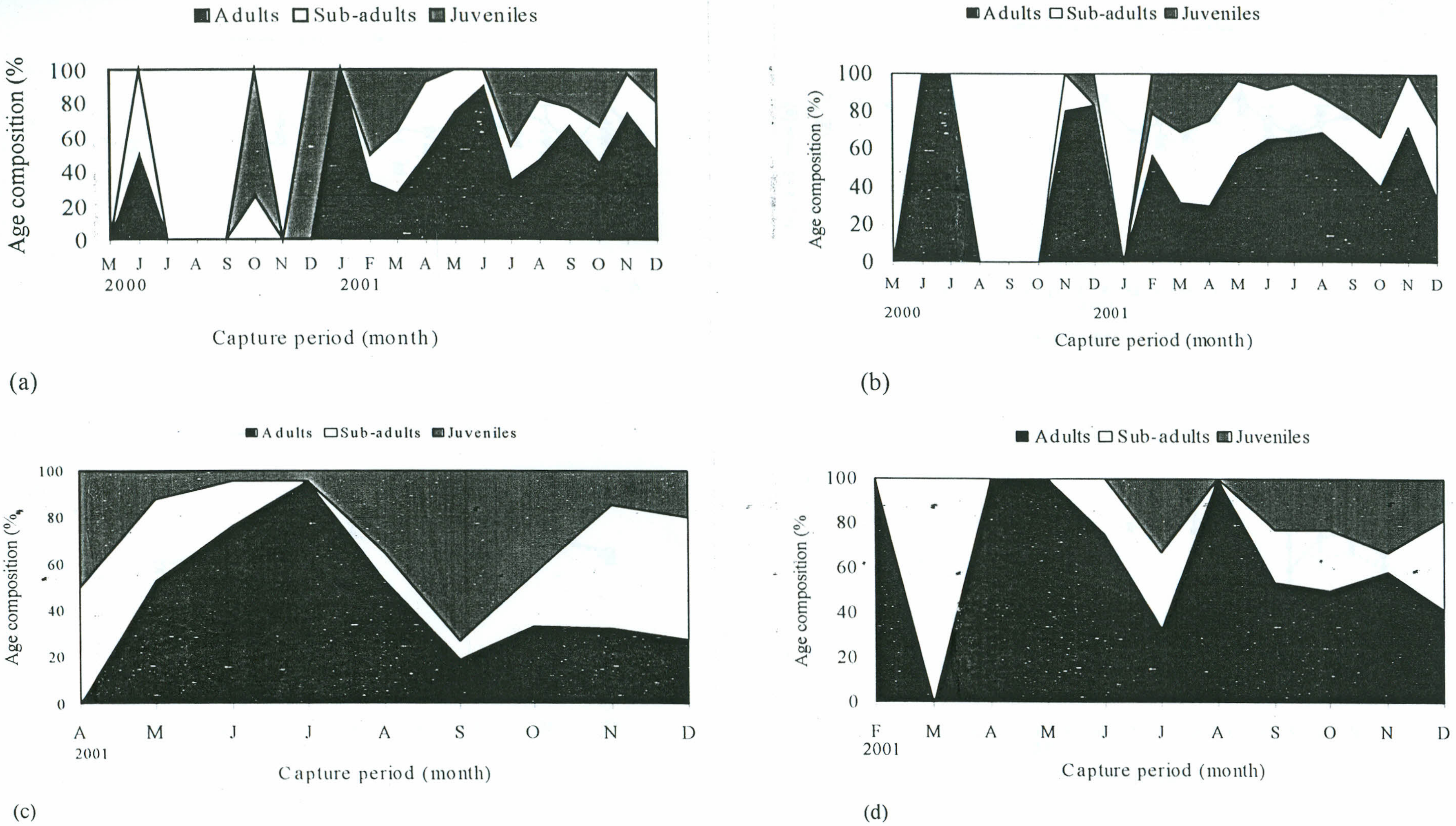


**Fig. 9.** Age structure in *M.* cf. *erythroleucus* population in (a) Mugo (b) Beth, (c) Kurt and (d) Moto grids located in maize fields of the Kenyan Rift Valley between May 2000 and December 2001.

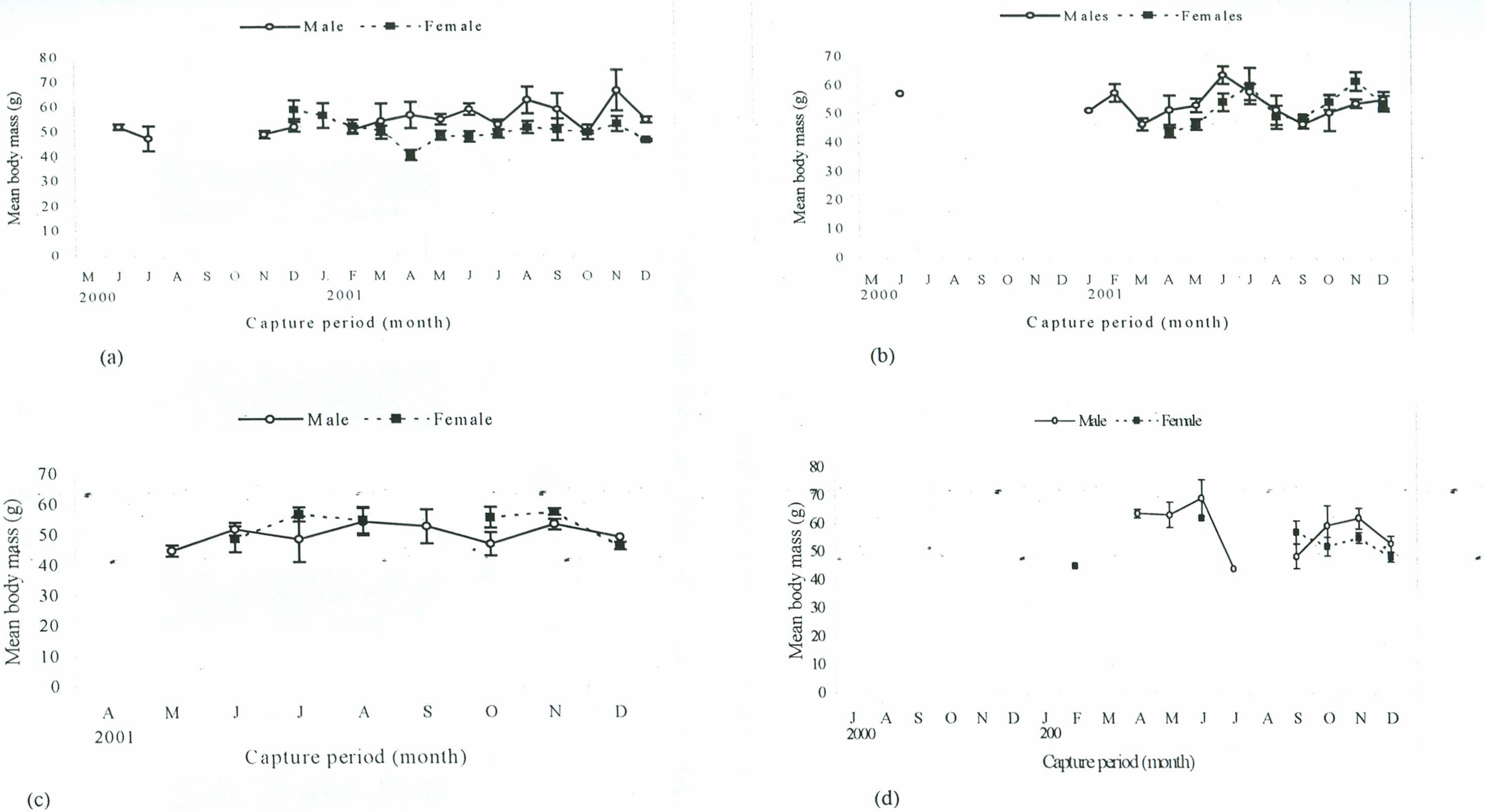


**Fig. 10.** Monthly mean (± SEM) body mass of *Mastomys* cf. *erythroleucus* from the entire study grids (a) Mugo, (b) Beth, (c) Kurt and (d) Moto. Data are between May 2000 and December 2001. The vertical bars are the standard errors.

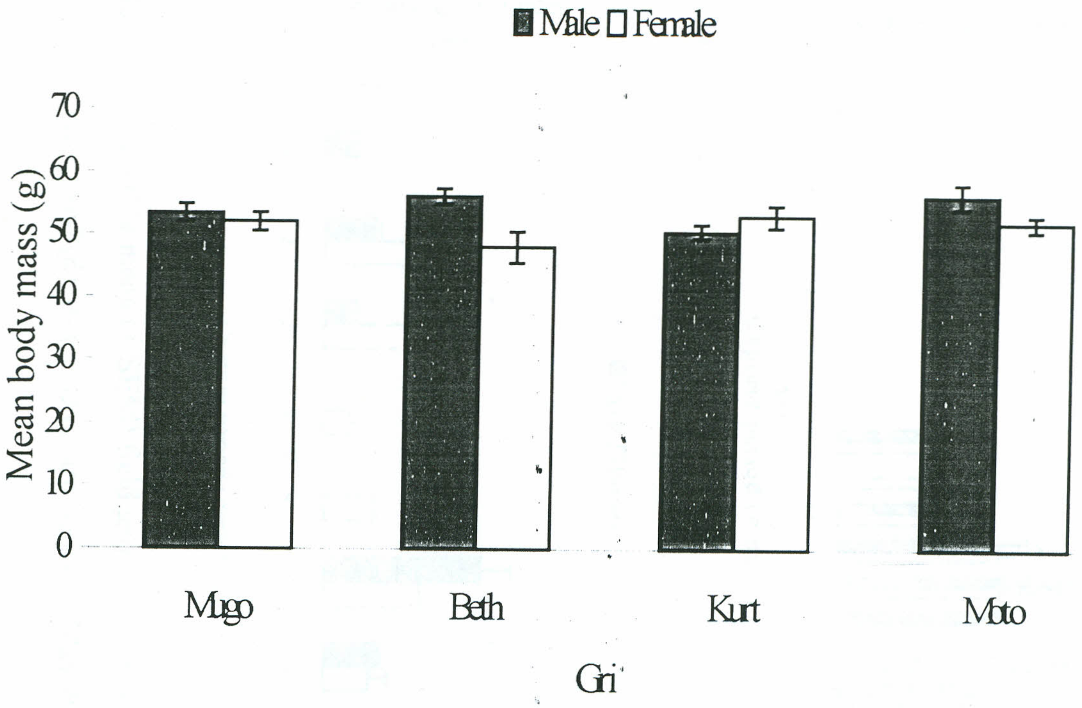


**Fig. 11.** Mean (± SEM) body mass of male and female *Mastomys* cf. *erythroleucus* from all the study grids.

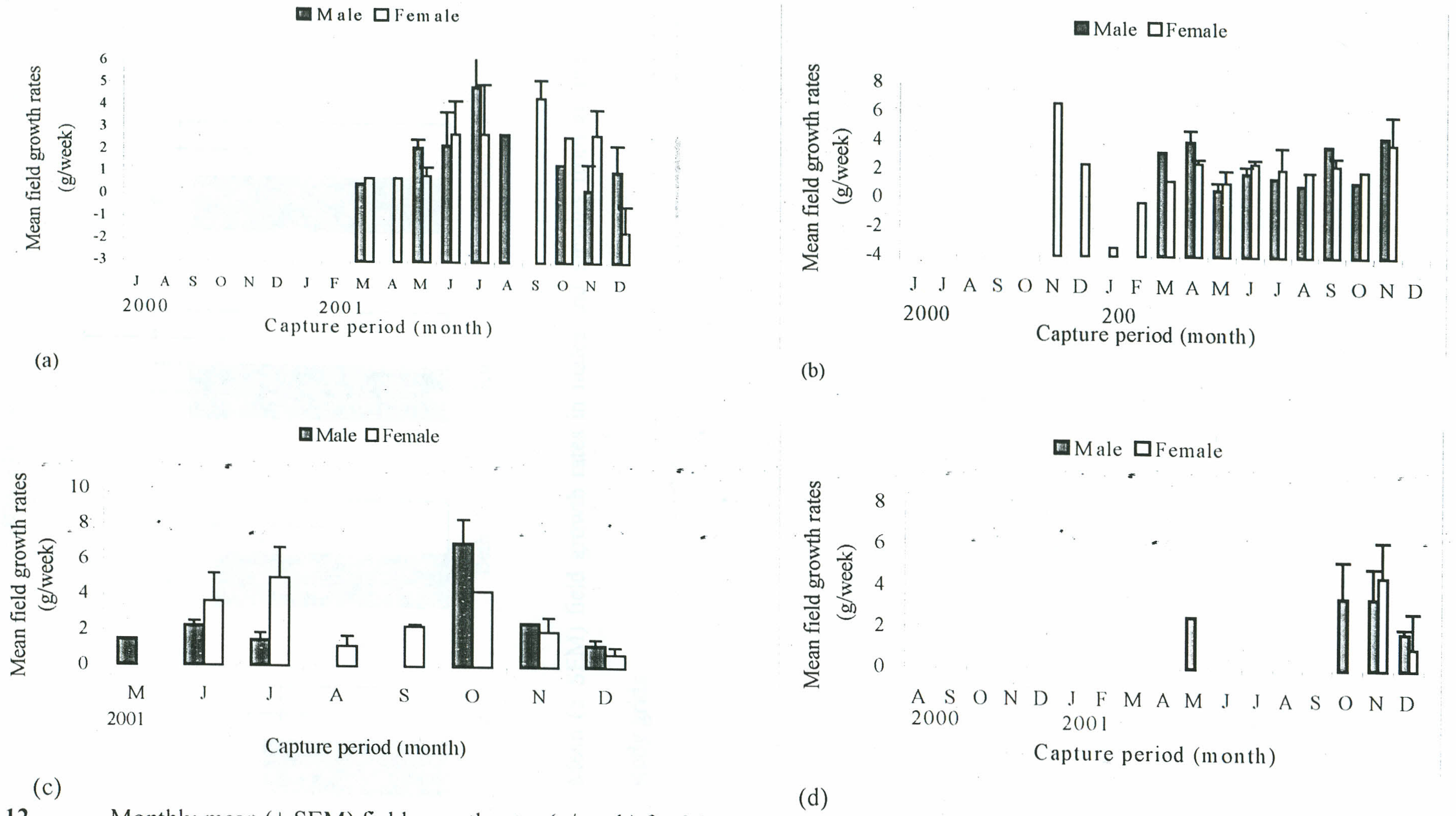


**Fig. 12.** Monthly mean (± SEM) field growth rates (g/week) for *Mastomys* cf. *erythroleucus* from the entire study grids (a) Mugo, (b) Beth, (c) Kurt and (d) Moto. Data are between May 2000 and December 2001. The vertical bars are the standard errors.

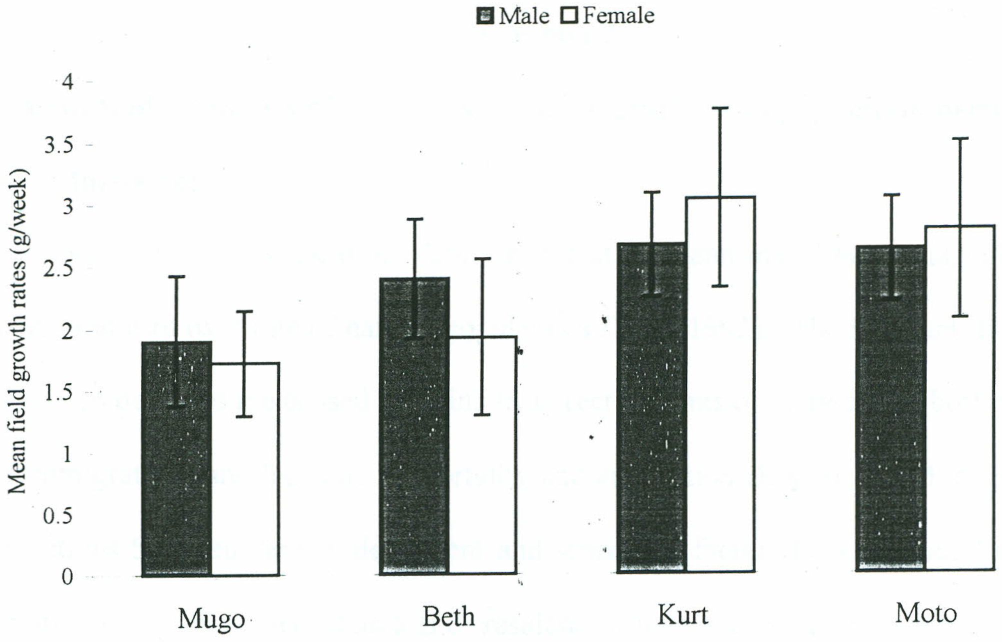


**Fig. 13.** Mean (± SEM) field growth rates in males and females from all the study grids.

# Chapter 5

## Aspects of *Mastomys* cf. *erythroleucus* demography and population persistence

### 5.1 Introduction

Reproduction is the basic form of recruitment and may have great influence on growth and turn over rate of natural populations (Leirs 1992). The resultant dynamics of population densities are caused by gains from recruitments of individuals (both from birth and immigration) and loss due to mortality and emigration (Begon and Mortimer 1981). Interactions between density-dependent and stochastic factors have profound effects on recruitment, survival, persistence (i.e. residency time) and maturation rates of rodents (Leirs *et al.* 1997, Keesing 1998, Julliard *et al.* 1999). Quantification of these processes is therefore important in understanding and explaining the causes of temporal variability in populations (Stenseth 1995, Lima *et al.* 1999).

In this chapter, I report on demographic patterns (reproduction, maturation, recruitment, and survival) and population persistence in *Mastomys* cf. *erythroleucus* in maize fields of Rongai Division in Nakuru District, Kenya.

### 5.2 Hypothesis

1). *Mastomys* cf. *erythroleucus* subpopulation in maize fields of Rongai is a metapopulation with similar demographic characteristics along an altitudinal gradient.

## 5.3 Objectives

1). To characterize reproduction, maturation, recruitment, survival and population persistence in *Mastomys* cf. *erythroleucus* in maize fields of Rongai Division in Nakuru District.

## 5.4 Methods

Reproductive changes reported here were based on external reproductive characteristics as indices of breeding activity (Leirs 1995). All adult males with scrotal testes and visible gybernaculum were considered breeding. Three sets of parameters were used for females; (1) condition of the vagina- perforate when breeding; (2) size of nipples – medium or large when lactating; (3) size of abdomen – females with bulging abdomens were considered gravid and (4) pregnancy was confirmed through palpation. Since this method generally detects embryos from the second trimester it has the tendency of underestimating breeding performance in females. Lactation is considered the most reliable index of breeding for females of all the parameters listed above (Krebs 1969, also reviewed in Gaines and Rose, 1976). The external reproductive characteristics though not as reliable as detailed autopsy, suffice in providing an index of reproductive changes in a population.

Survival ($\phi$), and recruitment ($1-\gamma$) rates were modelled following the CMR-methodology (Lebreton *et al.* 1992), using the program MARK (White and Burnham 1999). Demographic patterns were determined from the primary captures. Primary histories of capture were made from a 4-week trapping interval, a period considered sufficient to allow demographic processes to occur. Survival estimates were estimated

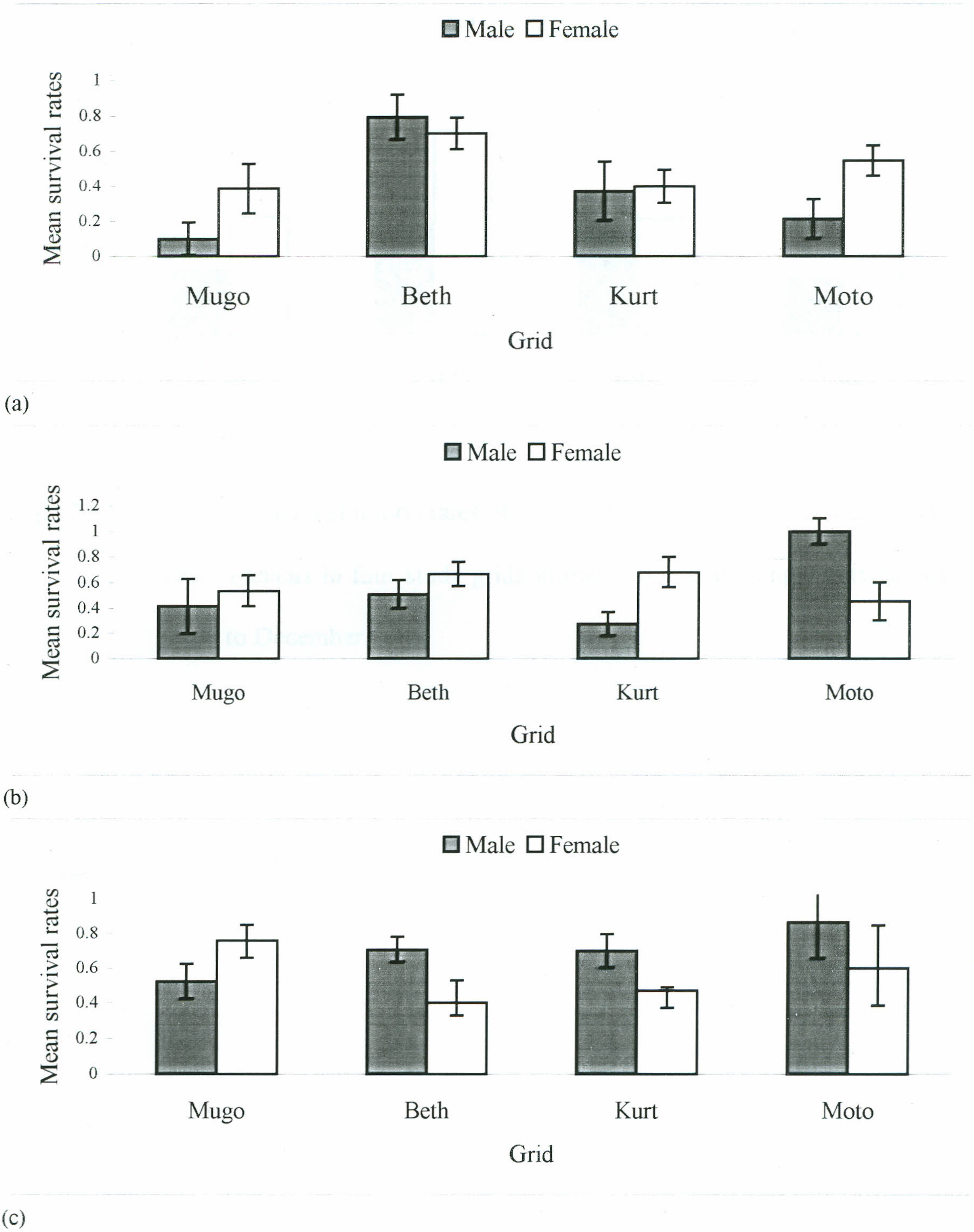


**Fig. 16.** Mean (± SEM) survival rates for (a) juveniles, (b) sub adult and (c) adult *Mastomys* cf. *erythroleucus* in four trapping grids in maize fields of Rongai between May 2000 and December 2001.

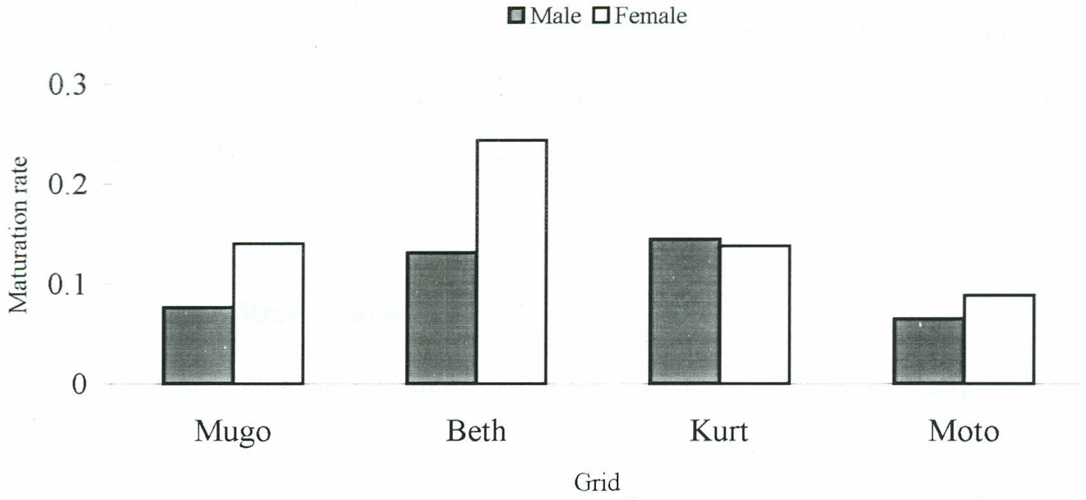


**Fig. 17.** Proportional maturation rates of sub adult males and females *Mastomys* cf. *erythroleucus* in four study grids in maize fields of Rongai between May 2000 to December 2001.

Moto grid- There were two breeding seasons in February through June, and in September to December 2001 (Fig. 14d). There were no breeding males in February and no breeding females in March and April 2001.

### 5.5.2 Recruitment rates

Recruitment rates did not show temporal variability. However, females showed significantly higher rates ($\chi^2 = 4.601$, P = 0.032, $n$ = 151) than males in the Mugo grid (Fig. 15). The proportion of male and female recruits did not differ significantly at Beth's ($\chi^2 = 0.429$, P = 0.512, $n$ = 151) or Kurt's ($\chi^2 = 0.182$, P = 0.669, $n$ = 164) grids. Male recruitment rates in Moto grid were significantly ($\chi^2 = 13.808$, P = 0.0002, $n$ = 122) higher than females (Fig. 15).

### 5.5.3 Survival rates

*Mastomys* survival rates in all the study grids did not show any time-specific variation. Significant heterogeneity in survival was noted between categorical (sexes and age) variables (Figs. 16a-c). In the Mugo grid, juvenile ($\chi^2$=4.31, P = 0.038, $n$ = 37) and adult ($\chi^2$=8.581, P = 0.014, $n$ = 74) female survival rates were significantly higher than those of their male counterparts. In the Beth grid, survival rates in adult males were significantly higher than those of adult females ($\chi^2$ = 12.874, P = 0.0003, $n$ = 68). In the Kurt grid, female sub-adult survival rates were significantly higher than those of sub-adult males ($\chi^2$ = 20.457, P <0.001, $n$ = 51). Male adults survival rates were also significantly ($\chi^2$=4.865, P =0.027, $n$ = 54) higher than those of adult females. In the Moto grid, survival rates of sub-adult males were significantly higher ($\chi^2$=17.588, P <

0.0001, *n* = 31) than those of females. Adult males survival rates were also higher than females ($\chi^2$=12.874, P = 0.035, *n* = 44). Female juveniles survived better than males ($\chi^2$=14.600, P = 0.0001, *n* = 34). In all cases where survival rates were significantly different among age classes, juveniles and sub-adults had lower survival rates than adults (Figs. 16a-d). Notable exceptions were from Beth and Kurt grids where female adult survival rates were least. Significant interactions between sex and age classes was detected in all the grids; Mugo (log likelihood ratio $\chi^2$=8.858, P = 0.014), Beth (log likelihood ratio $\chi^2$=13.787, P = 0.001), Kurt (log likelihood ratio $\chi^2$=21.194, P < 0.0001) and Moto (log likelihood ratio $\chi^2$=8.858, P = 0.014).

### 5.5.4 Maturation rates

A significantly lower proportion of sub-adults matured in the entire grids (Male; 0.111 and females; 0.182, $\chi^2$ = < 95.338, P = <0.00001, *n* = 287) during the trapping periods (Fig. 17). No significant differences in maturation rates were detected between sexes (Mugo; log likelihood ratio $\chi^2$=1.836, P < 0.1751, *n* = 82, Beth; log likelihood ratio $\chi^2$=3.439, P < 0.063, *n* = 87, Kurt; log likelihood ratio $\chi^2$=0.017, P < 0.895, *n* = 95 and Moto; log likelihood ratio $\chi^2$=0.335, P < 0.563, *n* = 65). Similarly, there was no significant difference (log likelihood ratio $\chi^2$=0.189, P < 0.941, *n* = 329) in maturation rates across the grids (Fig. 17).

### 5.5.5 Population persistence rates

The mean persistence rates did not show significant differences between sexes (F = 0.223, P = 0.638, *n* = 112) or between grids (F = 1.825, P = 0.147, *n* = 112). Similarly, there was no significant (F = 0.096, P = 0.962, $n$ = 112) interactive effect between sex and grids on population persistence rates (Fig. 18).

## 5.6 Discussion

In the year 2000, breeding was recorded only in December at Beth's grid (Figs. 14a-c) while reproductively active males were recorded in June in both Mugo's and Beth's grids following 100mm of rainfall between May and June. Males were also reproductively active in July (Mugo's) and November (Beth's). Low reproductive activity may be attributed to the prolonged drought in the period preceding the study. In addition, poor captures of females during this period may have biased records of their actual breeding activity.

In 2001, both sexes showed capacity for breeding with exception of January through April among males at Mugo grid. At Beth's, most adult animals were in breeding condition throughout the year. Intense breeding recorded at the early part of the year followed a 332mm rainfall between November 2000 and January 2002. In Kurt grid, males came in to breeding condition two months earlier than females with breeding season running from June through December 2001 (Fig. 14c). In Moto grid, there were two breeding seasons in February through June, and in September to December 2001 (Fig. 14d). There were no breeding males in February and no breeding females in March and April 2001. The patterns observed in breeding were a result of improved amount of rainfall. However, the few inconsistencies in the breeding patterns across the grids may be attributed to variations in the distribution of rainfall during the year and heterogeneity in habitat characteristics inherent between grids. Rainfall has been demonstrated to influence breeding in African rodents (Sirrlero-Zubiri 1995, Leirs *et al.* 1997). Taylor and Green (1976) did a more analytical study on climate and relations between food supply and reproduction on the Nile rat *Arvicanthis niloticus* in the Kenyan Highlands. Their findings showed that the Nile rat differed from *Mastomys* in having their maximum breeding at a different time of the year. In this study, increase in testes size and incidence of pregnancy were associated with the occurrence of large quantities of cereal and other seeds in the diet. Elsewhere in Mekong river Delta, Vietnam, Brown *et al.* (1999) demonstrated that 100% and 76% of adult female *Rattus argentiventer* were in breeding condition during the flowering and harvesting stages of rice respectively, but none in the vegetative growth stage. In this study, such changes in *Mastomys* were significant during the fallow stages of the cropping season when weeds and crop residues were most abundant in the fields.

In this study, precipitation may have led to availability of food leading to the recorded breeding patterns. These findings reiterate, as in other studies, the importance of rainfall in the dynamics of *Mastomys* cf. *erythroleucus* in Rongai.

Recruitment of males and females was similar at Beth's and Kurt's grids (Fig. 15). At Mugo's, female recruitment rates were significantly higher than males while at Moto's, males recruitment were significantly higher than females (Fig. 15). Female survived better than males, and juveniles and sub adults had consistently lower survival rates than adults did (Figs. 16a-c). No clear reason could account for such heterogeneity in recruitment and survival rates. Both density-dependent (Ostefeld and Canham 1995, Keesing 1998) and density-independent factors (Leirs 1995, Leirs *et al.* 1996, Julliard *et al.* 1999, Lima and Jaksic 1999, Lima *et al.* 1999) have been shown to affect the survival of small rodents. The significant interactions between sex and age classes indicate that survival was dependent on age categories. It appears mortality factors were on some occasions biased towards sex or age, and this perhaps explained the inter grid differences. The results of adult (Mugo) and juvenile females (Mugo and Kurt) surviving better than their female counterparts are in concordance to studies by Julliard *et al.* (1999).

Maturation rates were similarly low with no significant differences noted between sexes and across the grids (Fig. 17). *Mastomys* cf. *erythroleucus* exhibited low but similar population persistence rates (not more than 56 days) between sexes and across grids (Fig. 18). Dispersal (Lidicker 1975, Stenseth 1983, Stenseth and Lidicker 1992) or predation (Lima *et al.* 2001) may account for the low maturation and persistence rates.

In conclusion, breeding in *Mastomys* cf. *erythroleucus* is depressed by drought but where there is adequate distribution of rainfall through the year, reproductively active individuals are encountered in all the months. *Mastomys* survival and recruitment generally exhibited similar patterns although slight heterogeneity was noticed across grids. In addition, rodents' maturation and persistence rates were very low but similar in all maize fields. This is an indication of a metapopulation.

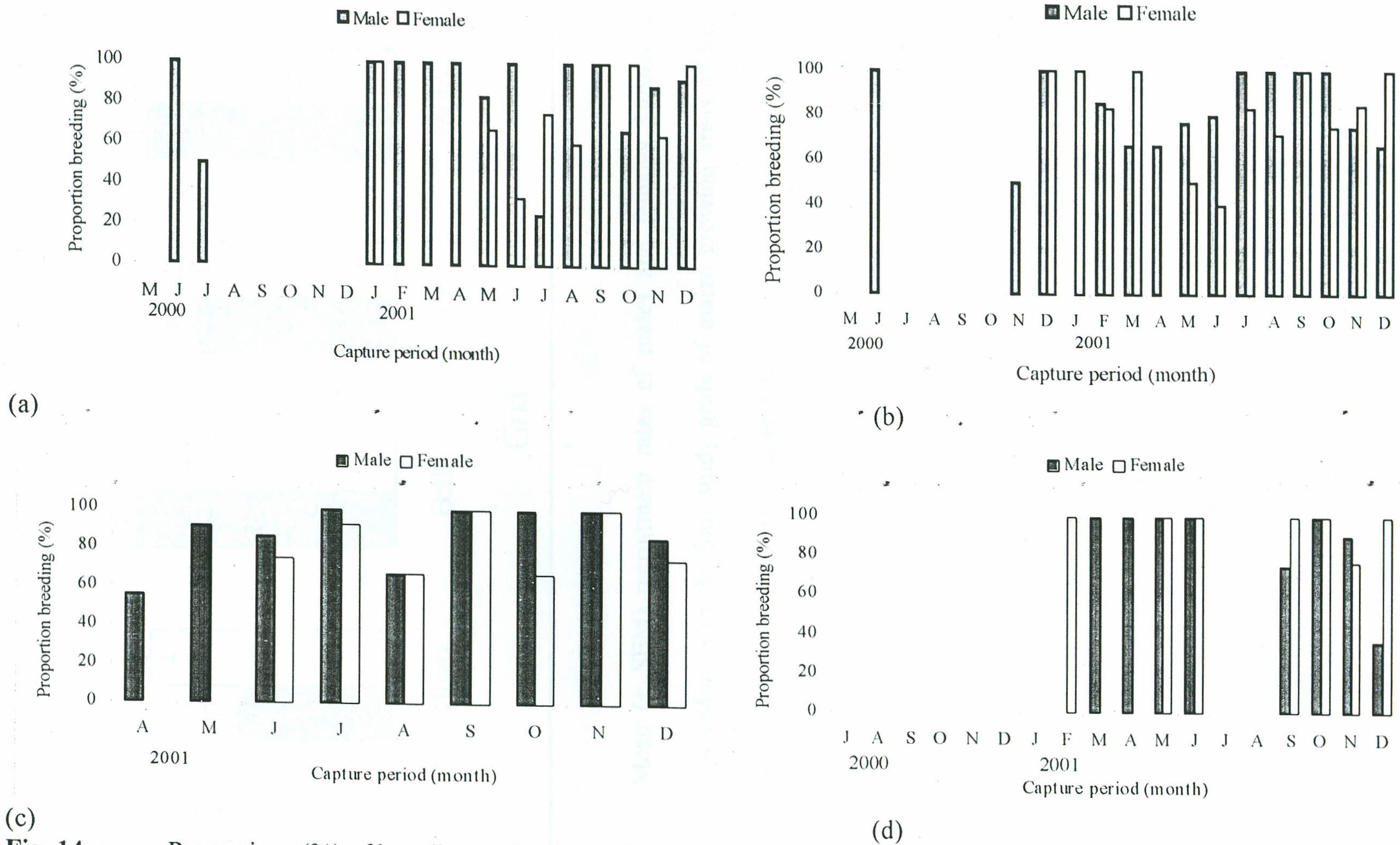


**Fig. 14.** Proportions (%) of breeding males (scrotal testes) and females (vagina perforate, lactating or gravid) from (a) Mugo, (b) Beth, (c) Kurt and (d) Moto grids trapped between May 2000 and December 2001.

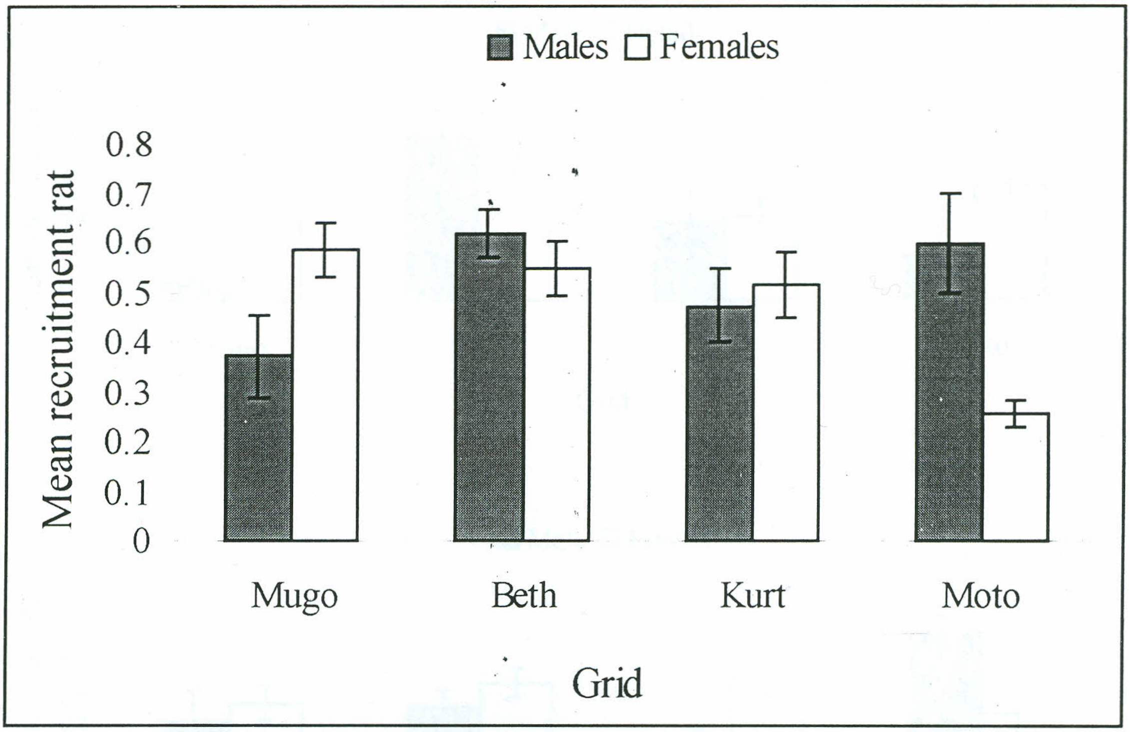


**Fig. 15.** Mean (± SEM) recruitment rates of males and females *Mastomys* cf. *erythroleucus* in the four study grids of maize growing areas of Rongai between May 2000 and December 2001.

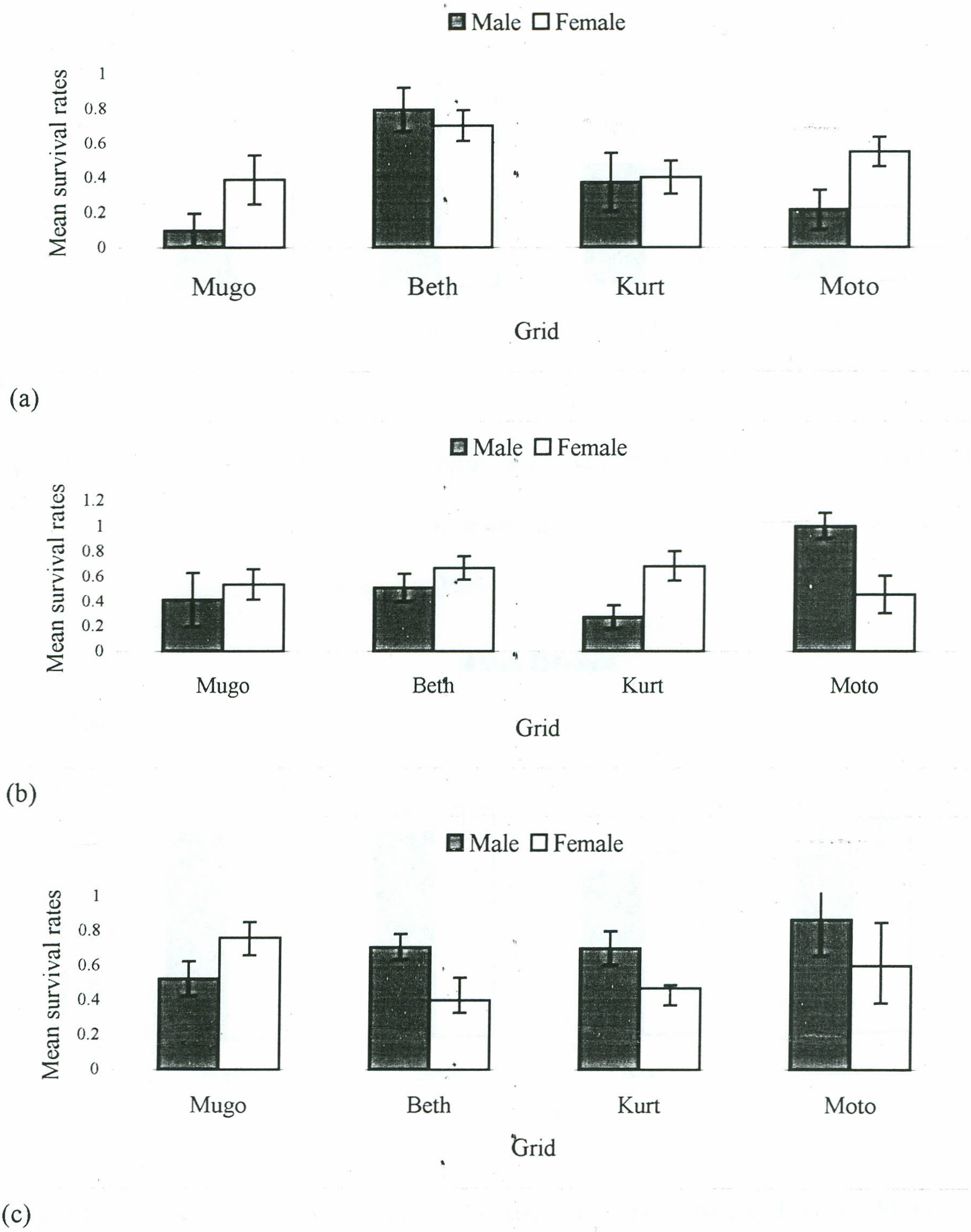


**Fig. 16.** Mean (± SEM) survival rates for (a) juveniles, (b) sub adult and (c) adult *Mastomys* cf. *erythroleucus* in the four trapping grids in maize fields of Rongai between May 2000 and December 2001.

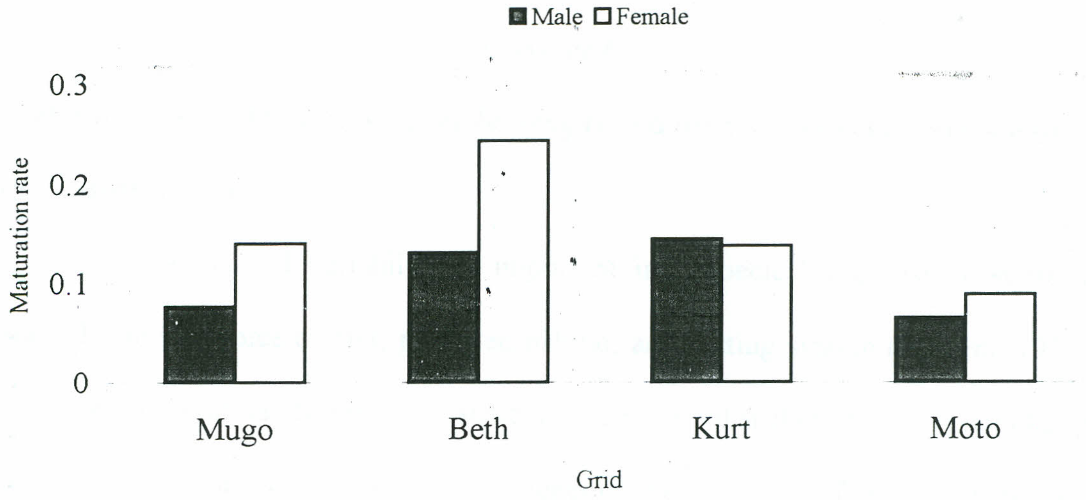


**Fig. 17.** Proportional maturation rates of sub adult males and females *Mastomys* cf. *erythroleucus* in the four study grids in maize fields of Rongai between May 2000 to December 2001.

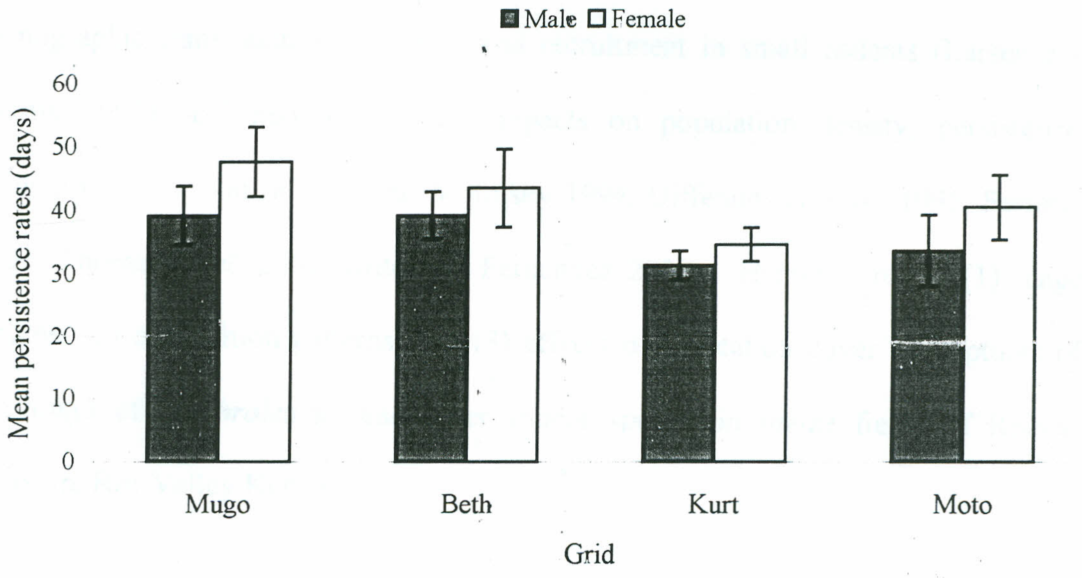


**Fig. 18.** Mean (± SEM) population persistence rates of male and female *Mastomys* cf. *erythroleucus* in the four study grids in maize fields of Rongai between May 2000 to December 2001.

# Chapter 6

## Habitat use by *Mastomys* cf. *erythroleucus* and other rodents in maize fields

### 6.1 Introduction

Spatio-temporal variability is important in a species' life history strategy, especially in its choice of diet, preferred habitat, and mating system (Fleming 1979). This may determine community structure, species distribution, and population dynamics (Johnson *et al.* 2002) by influencing the intensity of density-dependent factors (such as competition, diseases, and predation) and ultimately affecting various demographic parameters (Goldwasser 1994). Through dispersal, animals can reduce levels of competition for limited resources and utilise their habitat effectively (Stenseth and Lidicker 1992, Lambin 1994). Such movements are reflected in the demographic traits such as mortality and recruitment in small rodents (Larsen and Boutin 1994), and may have great impacts on population density, persistence, extinction, and colonization rates (Molofsky 1994, Diffendorfer *et al.* 1995, Ferreras 2001, Thomas *et al.* 2001, Brito and Fernandez 2002). Herein, I report (1) range lengths, (2) distribution patterns, and (3) effects of vegetation cover on captures of *Mastomys* cf. *erythroleucus* and other rodent species in maize fields of Rongai Division, Rift Valley Kenya.

### 6.2 Hypothesis

1). Male and female *Mastomys* show similar use of habitats in maize fields.

2). Habitat use by *Mastomys* in maize fields is similar across altitudinal gradient.

## 6.3 Objectives

1). To determine range lengths and distribution patterns of small murids in maize farms.

2). To determine the relationship between rodent captures and vegetation cover.

## 6.4 Methods

Information on habitat use was obtained from the Capture-Mark-Recapture (CMR) technique detailed in section 2.5.1. Range lengths were determined by calculating the maximum ranging distance over which rodents are trapped between the months (Delany and Monro 1985, Oguge 1995). Movements within the months were determined from the secondary capture histories. The XY reduced capture histories were used in the data input file of the program CAPTURE, in which range lengths were estimated. Distribution of individuals within maize fields was estimated using primary captures in the 100 trapping stations per grid. Only the first capture of each individual in a month was used as the point of reference to eliminate biases.

The method used for vegetation assessment is described in section 2.5.2. Because of homogeneity across grids (Njue 2000), the 100-vegetation sample plots were grouped in six main habitat categories by partial Detrended Canonical Correspondence Analysis (DCCA) using the program CANOCO (Ter Braak 1988). Thus the following physical and biological characteristics constituted the different habitat types:

**Habitat 1** Mixed dense ground cover of inter-crops (*Phaseolus vulgaris, Eleusine coracana, Ipomea batatum and Solanum tuberosum)* and herbaceous weeds (predominantly *Galinsoga parviflora* and *Tagetes minuta*). Approximate cover values of 100%.

| | |
|---|---|
| **Habitat 2** | Open ground patches with a few scattered *Commelina benghalensis*, *Rynchelytrum repens* and *Digitaria scalarum*. Approximate cover values of 20%. |
| **Habitat 3** | Open ground patches with a few scattered *Commelina benghalensis*, *Galinsoga parviflora* and *Tagetes minuta*. Approximate cover value of 40% |
| **Habitat 4** | Patches of thick grass cover mainly of *Digitaria scalarum*, *Aristida kiensis* and *Rynchelytrum repens* with *Bidens pilosa*. Approximate cover values of 80%. |
| **Habitat 5** | Largely bare ground (0% cover). |
| **Habitat 6** | Moderately covered ground with mixed stands of *Digitaria scalarum*, *Bidens pilosa* and *Trichodesma zeylanicum*. Approximate cover value of 60%. |

### Data analyses

Kruskal-Wallis test was used to determine the effects of sex, season and grid on movements during the trapping period. Range lengths between males and females within and across grids were compared using two-way ANOVA. An index of dispersion test was done for each grid using the chi- square log-likelihood ratio of Poisson distribution with Williams' correction, G-test (Krebs 1989). Monte Carlo test of significance of first canonical axis was used to assess the association between rodent captures with plant community and habitat structure. Rodent capture frequencies data was standardised using square roots (x + 0.5) transformation, thereafter, Student *t*-test was done to compare mean capture frequencies between patches of more than and less than sixty percent ground cover (Zhar 1999).

## 6.5.Results

### 6.5.1 Movements

Range lengths were statistically similar (H = 0.0019, P =0.763, *n* = 204) between sexes across the study grids (mean ± SEM: males 19.54 ± 1.87 and females 17.76 ± 1.41), respectively (Fig. 19). However, seasonal changes had a significant effect on monthly movements (H = 10.728, P = 0.011, *n* = 204), with the furthest range lengths (24.49 ± 3.44m) noted during wet weather and shortest range lengths (13.32 ± 2.10m) in dry weather (Fig. 20). There was no interactive effect of sex and season on the distances moved during the capture periods. Majority (65%) of rodents moved shorter distances (< 20m) between successive captures sessions (Fig. 21).

There was a significant effect of sex on range distances (F = 18.972, P = 0.00002, *n* = 136), with males (44.19 ± 3.82 m) ranging further than females (27.54 ± 2.41m) (Fig. 22). Ranging distances were similar across the grids (F = 1.302, P = 0.276, *n* = 136). No interactive effect was detected between sex and grids (F = 1.231, P = 0.301, *n* = 136).

### 6.5.2 Distribution of captures within grids

Rodents were not captured uniformly within maize fields (Figs. 23-26). *Mastomys* cf. *erythroleucus, Mus minutoides* and *Lemniscomys striatus* showed random dispersion with varying intensity while *Arvicanthis* cf. *neumanni* and *Tatera* cf. *robusta* were captured mainly on field edges. Total captures were highly aggregated in Mugo (G = 24.17, P=0.0001, *n* = 245), Beth (G = 47.82, P= 0.0001, *n* = 176) and Kurt (G = 19.93, P = 0.0006, *n* = 203) grids but were random in Moto grid (G = 0.631, P = 0.7339, *n* = 213) (Fig. 26).

In Mugo grid, 68.05% of the captures were from first row (A) and along the 5th, 6th, 7th, 8th columns (Fig. 23). In Beth grid, 75.12% of captures were made from the edges of the farm on the *j*th row and along the 2nd, 3rd, 9th, 10th columns (Fig. 24). In Kurt grid captures were mainly at the edges of the farms thus on the *j*th row and along the 1st column, constituting 43.63% of captures (Fig. 25). In Moto grid, no rows or columns of the trapping stations could be associated with significant proportions of capture (Fig. 26).

### 6.5.3 Effects of vegetation cover on rodent captures

Weak associations ($r$ = 0.927, P = 0.073, $n$ = 100) were recorded between rodent diversity indices and plant communities across the grids (Fig. 27). *Mastomys* cf. *erythroleucus* and *Aethomys* cf. *kaiseri* were attracted to habitat type 1; *Arvicanthis* cf. *neumanni*, *Lemniscomys striatus*, *Rattus rattus*, and *Mus minutoides* attracted to habitat type 4; and *Tatera* cf. *robusta* to habitat type 6. Nonetheless, these associations were not statistically significant (Eingenvalue = 0.089, F-ratio = 1.027, P = 0.190, $n$ = 100) (Fig. 28). No rodent species was attracted to habitat type 2, 3 and 5.

The numbers of *Mastomys* caught were similar on traps with cover values of equal to or less than 60%, respectively (Table 12). *Arvicanthis*, *Mus*, *Lemniscomys* and *Tatera* were captured significantly more on stations with vegetation cover over 60%.

## 6.6 Discussion

This study recorded similar range lengths in male (19.54 ±1.87m) and female (17.76 ±1.41m) *Mastomys* cf. *erythroleucus*, (Fig. 19). Range lengths were significantly different between seasons, with ranges of (24.49 ± 3.44m) during wet and cold weather and shortest distance (13.32 ± 2.10m) in dry and warm conditions, respectively (Fig. 20). Sixty five percent of recaptures were less than 20m from point of original capture (Fig. 21), suggesting that *Mastomys* had short home ranges during the sampling periods. Larger range lengths detected during wet and cold weather could be linked to increase in metabolism putting a higher demand for energy and search for food or search for mates since these seasons coincided with periods of intense breeding. Although ranging distances were similar across the grids, males ranged longer distances than females (44.19 ± 3.82m and 27.54 ± 2.41m, respectively) (Fig. 22). This is an indication that males have wider home ranges than females.

Concentration of *Mastomys* and other rodents captures at certain trapping positions (Figs 23-26) suggests that some parts of the maize fields were utilised more. This is of practical value in control since such areas once identified provides targets for ecological control. Two of the rodent species (*Aethomys* cf. *kaiseri* and *Rattus rattus*) recorded from Mugo grid were captured only along farm boundaries. Three individuals of *Aethomys* were captured at the side of the farm near a riverine forest while a single *Rattus* was trapped adjacent to a homestead. Most of *Arvicanthis* were captured in grass patches along the fence lines in all grids suggesting distribution along field edges. Similar results indicating site fidelity and edge effects have also been reported from the studies of *Arvicanthis niloticus* in Kenyan grassland (Delany and Monro 1985), and for other small rodents in forest and adjoining farmland habitats (Manson 1999). Changes in the distribution of food and vegetation cover have also been shown to correspond to changes in abundance and destruction of rodents (Zhong *et al.*, 1999). *Mastomys* cf. *erythroleucus* showed preference for certain parts of the fields suggesting that their captures were influenced by microhabitat type. Influence of microhabitat on distribution of *Mastomys* has been reported in Kenyan grasslands (Martin and Dickinson 1985, Oguge 1995). This implies an increased risk to crop depredation at such positions leading to the patchy nature of damage.

This study has shown that diversity of plant species *per se* had little effect on capture or distribution of rodents in these maize fields (Figs. 27 and 28). Vegetation cover values were, however, important in capture frequencies except for *Mastomys* (Table 12). These findings are not entirely in agreement with other studies that have shown that plant species composition and ground cover influence diversity and distribution of small mammal community (Zhong *et al.* 1999). These results would suggest that *Mastomys* cf. *erythroleucus* foraging in maize fields may not be greatly influenced by vegetation type or cover values. Other similar studies in the maize fields of Kitale in western Kenya captured *Mastomys* up to 50 m from edge of newly sown vegetation-bare maize fields (Martin *et al.* 1989).

Sharing of habitats by closely related species with the same ecological demands can result in competition for limited resources. Co-existence of different rodent species in the same trapping positions suggests little overlap in niches. Diversification of niche is achieved in many ways among rodents, one of, which is separation of activity periods using similar resources in the same habitat at different time's i.e. nocturnal-diurnal species (Kingdon 1997). *Mastomys* have nocturnal tendencies, but may become diurnal especially during high population densities (Oguge 1996). *Lemniscomy* and *Arvicanthis* are diurnal, while *Mus* and *Tatera* are crepuscular (Kingdon 1997). One characteristic feature in all the study grids is mixed cropping and weeding done manually in patches. Many diurnal species were attracted to patches of dense weeds and cover crops. Thus rodents may be utilising these patches when foraging to hide away from aerial predators. These results are consistent with those of other rodent studies, which have demonstrated preference for dense cover in reducing risk of predation (Bowne *et al.* 1999, Swilling and Wooten 2002). Patch sizes and its resource availability have also been shown to influence the community structure and distribution of small mammals in the coastal site of south-west Mauritania (Granjon *et al.* 2002).

In summary, male and female *Mastomys* cf. *erythroleucus* have similar range lengths. However, there is a strong sexual dimorphism in range distances in which males range wider than females. Although seasonal changes have a strong influence in range lengths of this species with farther distances covered during wet and cold weather, most rodents in the farm prefer to stay near their home ranges. Distribution of rodents is aggregated at the edges of the farm and crops at these points are likely to get damaged. Ground cover has a stronger influence than habitat structure on distribution of captures among small farm rodents.

**Table 12.** Mean (± SEM) capture frequencies of individual rodent species captured on 400 trapping stations in four grids. Data have been collated from May 2000 to December 2001. Values of *t* test the significance of the difference in mean frequency numbers of rodents with less than and more than 60% cover. Data were transformed as square root (x + 0.5).

| | **Cover** | | | |
|---|---|---|---|---|
| **Species** | Less than 60% (*n*) | More than 60% (*n*) | *t* | P |
| *Mastomys* cf. *erythroleucus* | 3.50 ± 0.29 (31) | 4.04 ± 0.35 (51) | 2.19 | n.s |
| *Arvicanthis* cf. *neumanni* | 1.41 ± 0.22 (11) | 2.52 ± 0.16 (21) | 5.23 | <0.005 |
| *Mus minutoides* | 1.36 ± 0.26 (9) | 2.71 ± 0.35 (14) | 4.54 | <0.005 |
| *Lemniscomys striatus* | 1.00 ± 0.00 (4) | 2.33 ± 0.21 (6) | 6.32 | <0.005 |
| *Tatera* cf. *robusta* | 1.11 ± 0.22 (8) | 1.93 ± 0.40 (6) | 4.13 | <0.005 |

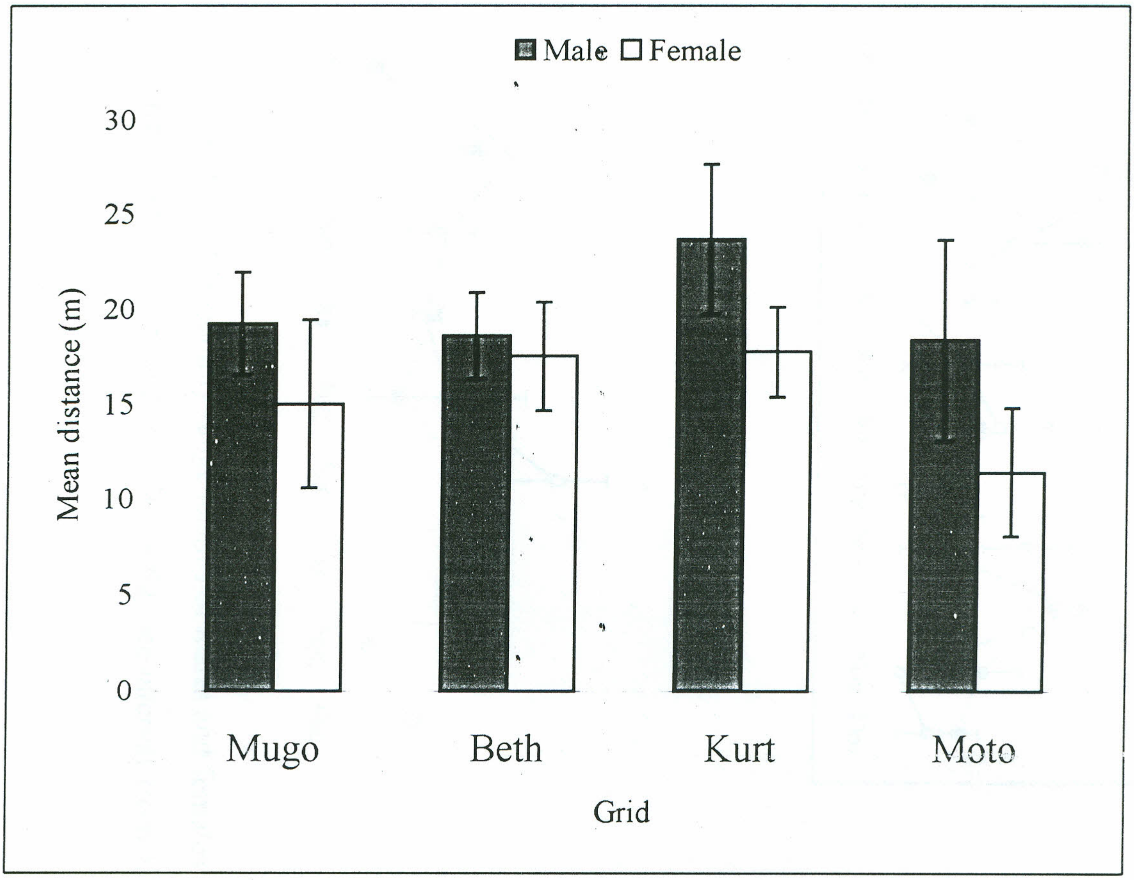
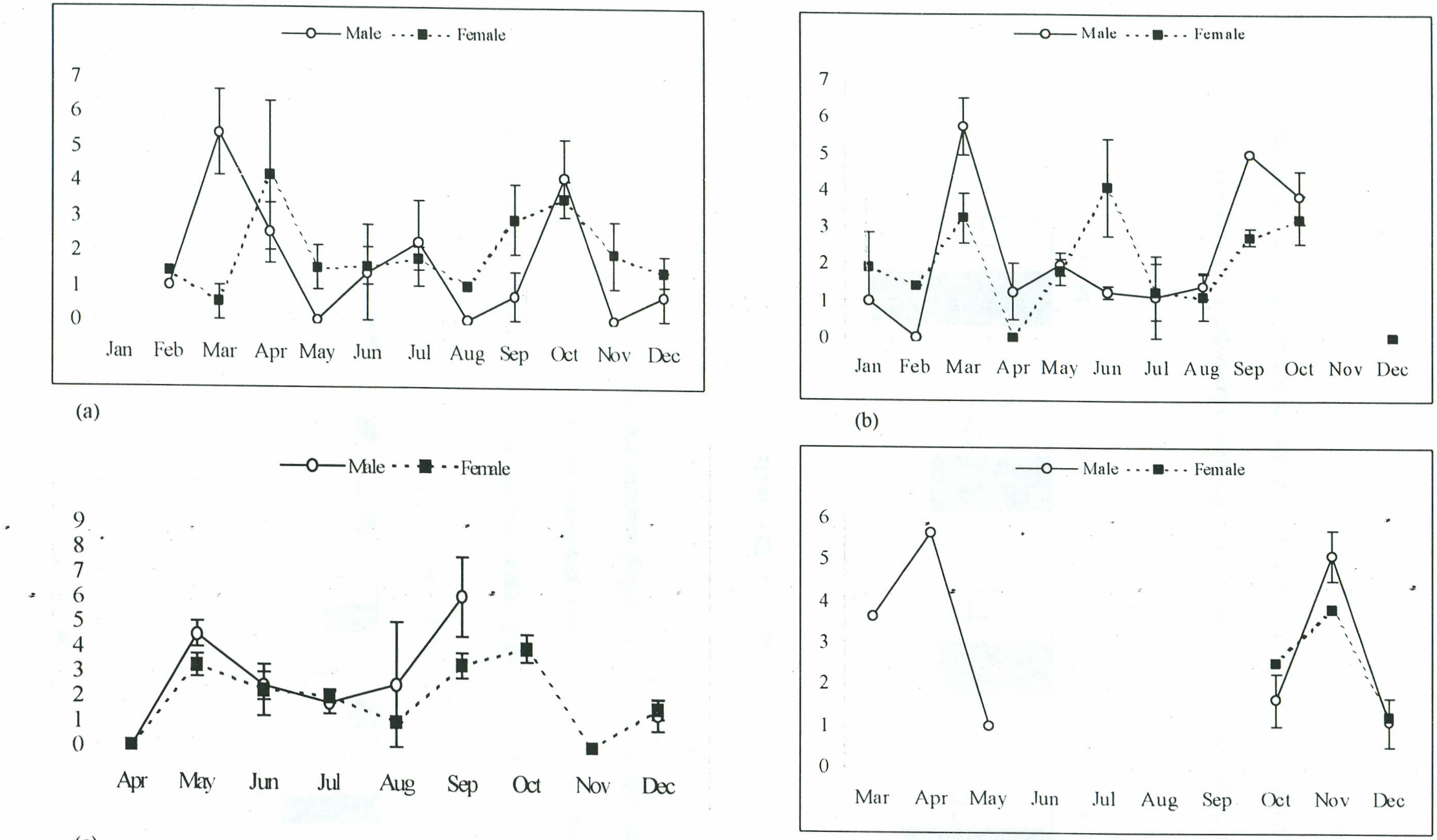


**Fig. 19.** Mean (± SEM) distances moved by male and female *Mastomys* cf. *erythroleucus* in each of the four grids estimated at 95% confidence level using secondary capture histories from the program CAPTURE. The data are derived from those animals sampled at least twice in every capture period between May 2000 and December 2001.



(a)

(b)

(c)

(d)

**Fig. 20.** Mean (± SEM) monthly range lengths of males and females *Mastomys* cf. *erythroleucus* from (a) Mugo, (b) Beth, (c) Kurt and (d) Moto grids as estimated at 95 % confidence interval from XY reduced secondary capture histories using the program CAPTURE.

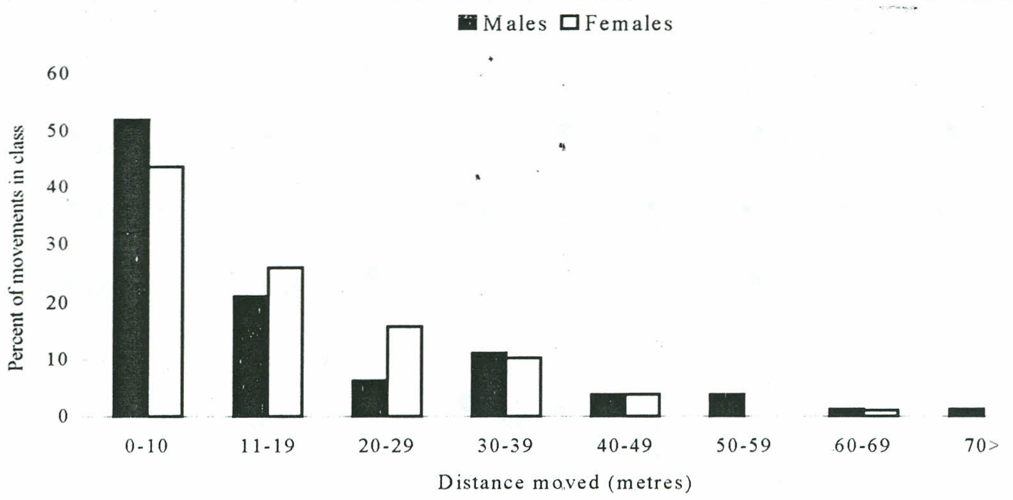


**Fig. 21.** Distances moved by adult males and females *Mastomys* cf. *erythroleucus* between successive capture positions following release. Only animals caught within the three sampling sessions are included.

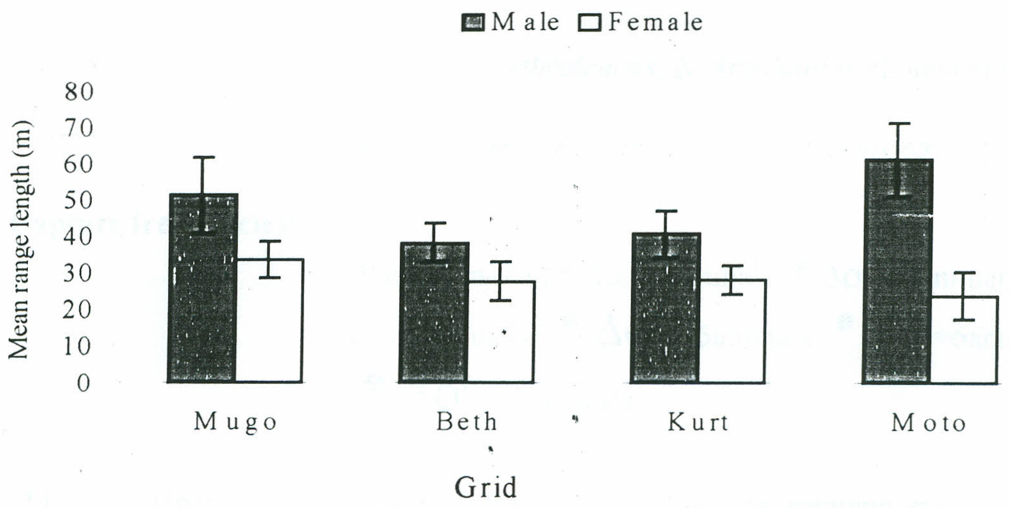
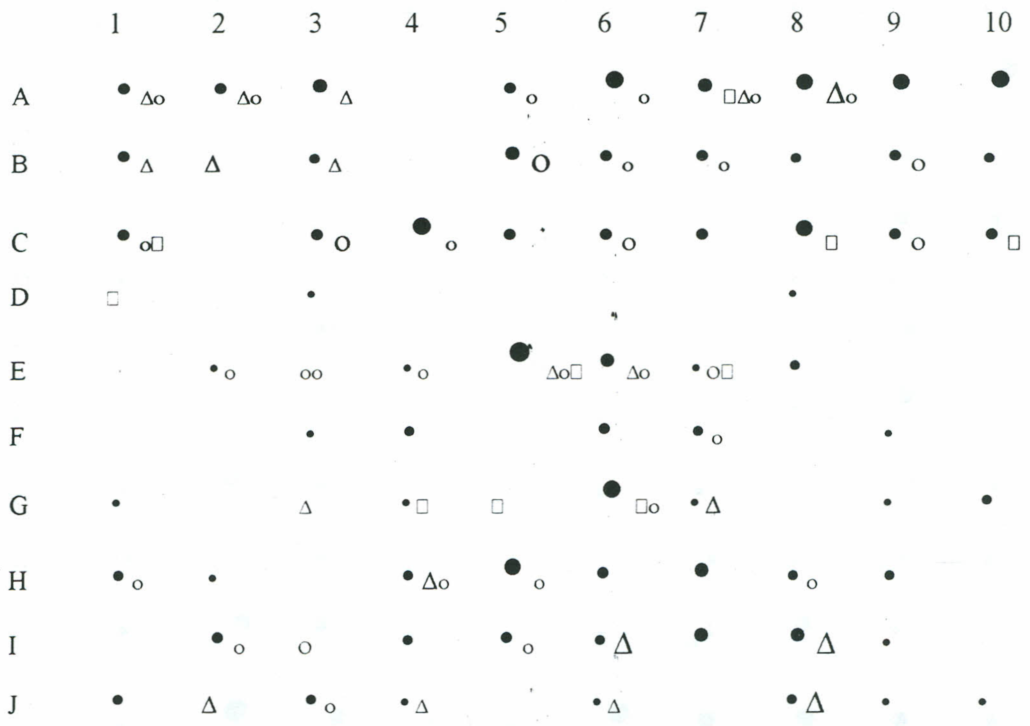


**Fig. 22.** Mean range distances of males and females *Mastomys* cf. *erythroleucus*. Data were obtained from those individuals recaptured between trapping periods.



**Legend:**

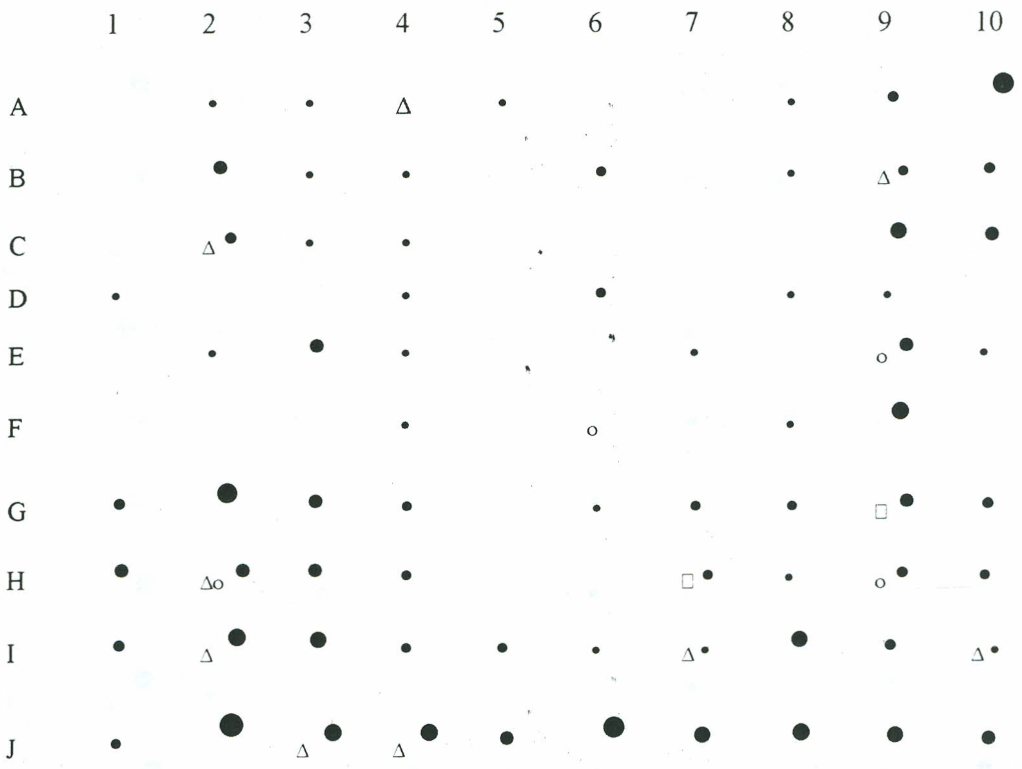
**(1) Species:** • *Mastomys* cf. *erythroleucus*, Δ *Arvicanthis* cf. *neumanni*,

o *Mus minutoides* and ☐ *Lemniscomy striatus*

**(2) Capture frequencies:**

• Δo☐=1animal, • Δo☐=2animals, ● Δo☐=3animals, ● Δ o☐=4animals, ● Δo☐=5animals, ● Δo☐=6animals, ● Δo☐=7 animals

**Fig. 23.** Distributions of capture frequencies in all the trapping stations for the common rodent species within Mugo grid.



**Legend:**

**(1) Species:** • *Mastomys* cf. *erythroleucus*, Δ *Arvicanthis* cf. *neumanni*,

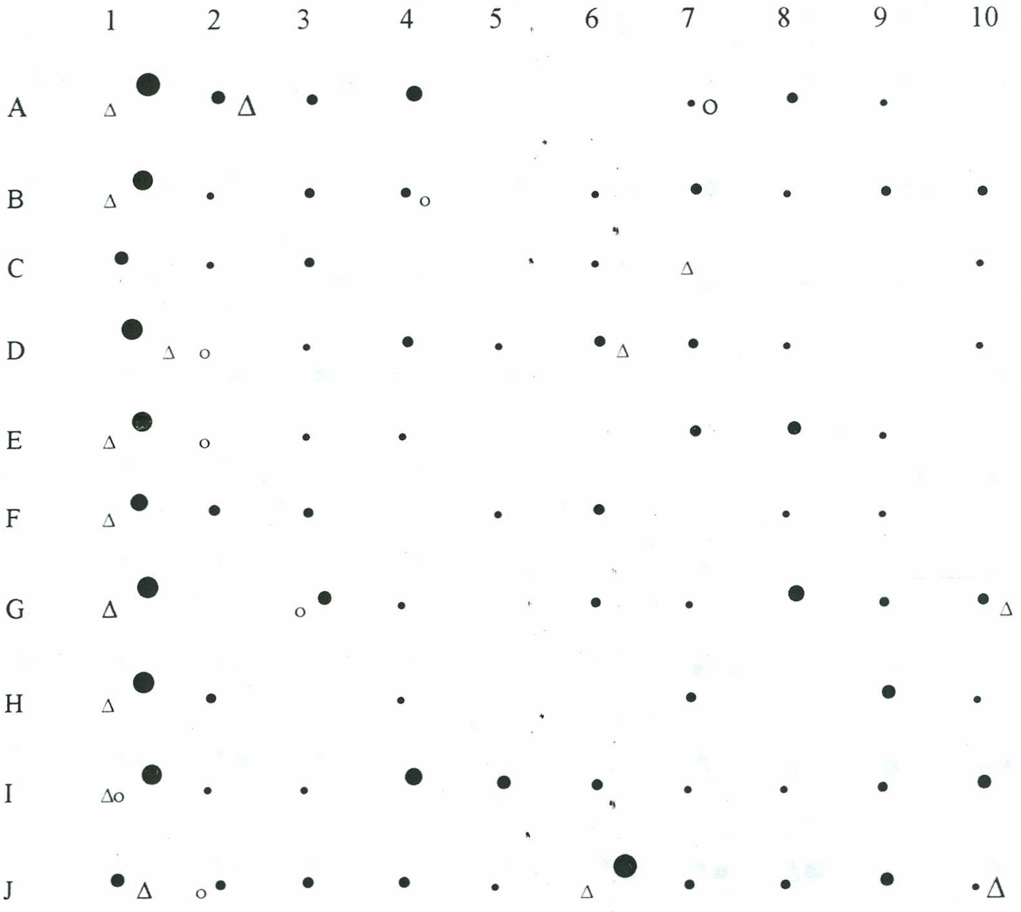
o *Mus minutoides* and □ *Lemniscomys striatus*

**(2) Capture frequencies:** • Δo□=1 animal, • Δo□=2 animals, • Δo□=3 animals,

• Δo□=4 animals, ● Δo□=5animals, ● Δo□=6animals,

● Δ□=7 animals, ● Δo□=8 animals, ● Δo□=9 animals

**Fig. 24.** Distributions of capture frequencies in all the trapping stations for the common rodent species within Beth grid.



**Legend:**

**(1) Species:** • *Mastomys* cf. *erythroleucus*, Δ *Arvicanthis* cf. *neumanni* and o *Mus minutoides*.

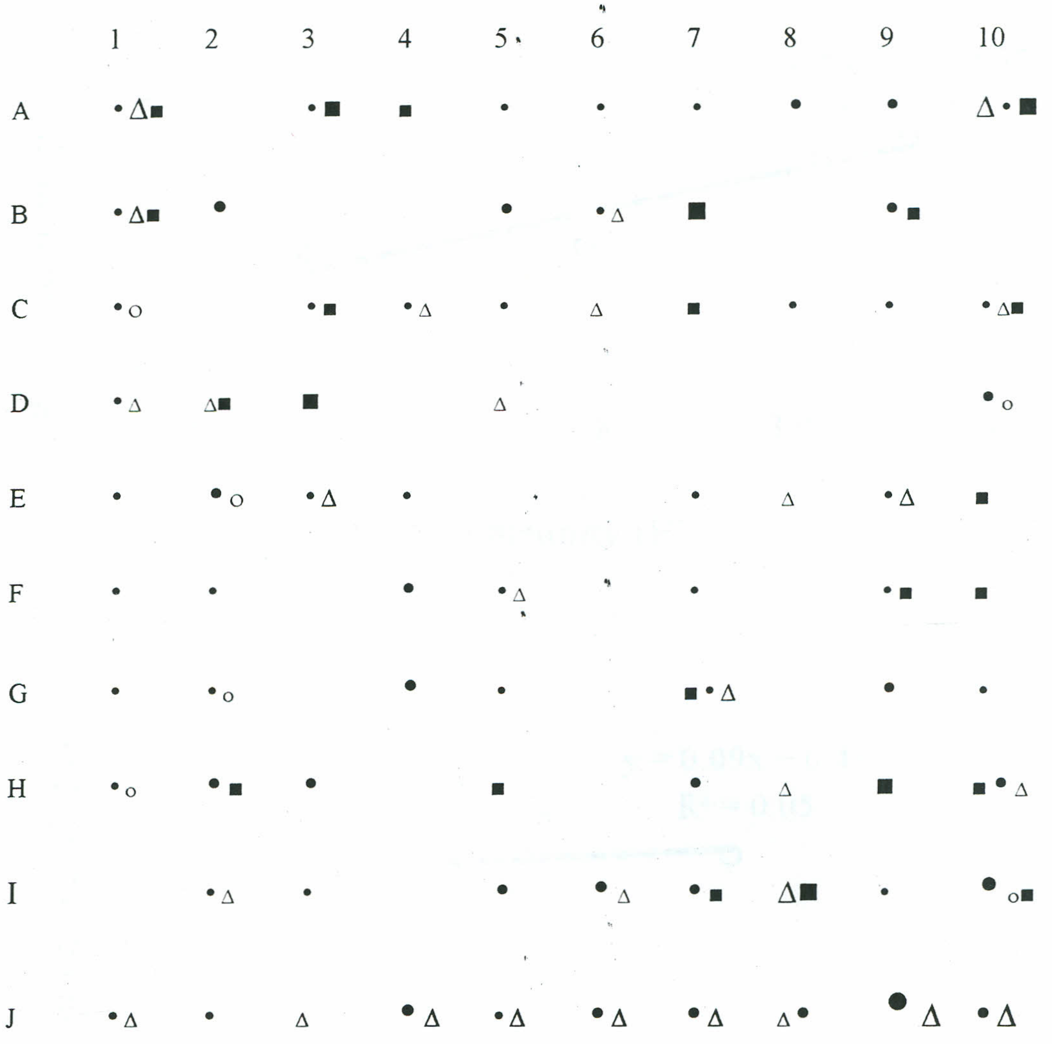
**(2) Capture frequencies:**

•Δo=1 animal, ●Δo=2 animals, ●Δo=3animals,

●Δo=4 animals, ●Δo=5animals, ●Δo=6animals,

●Δo=7 animals, ●Δo=8 animals, ●Δo=9 animals

**Fig. 25.** Distributions of capture frequencies in all the trapping stations for the common rodent species within Kurt grid.



**Legend:**

**(1) Species:** • *Mastomys* cf. *erythroleucus*, Δ *Arvicanthis* cf. *neumanni*,

o *Mus minutoides* and ■ *Tatera* cf. *robusta*

**(2) Capture frequencies:**

•oΔ■=1 animal, •oΔ■=2animals, •oΔ■=3 animals,

•oΔ■ = 4animals, •oΔ■ = 5animals.

**Fig. 26.** Distributions of capture frequencies in all the trapping stations for the common rodent species within Moto grid.

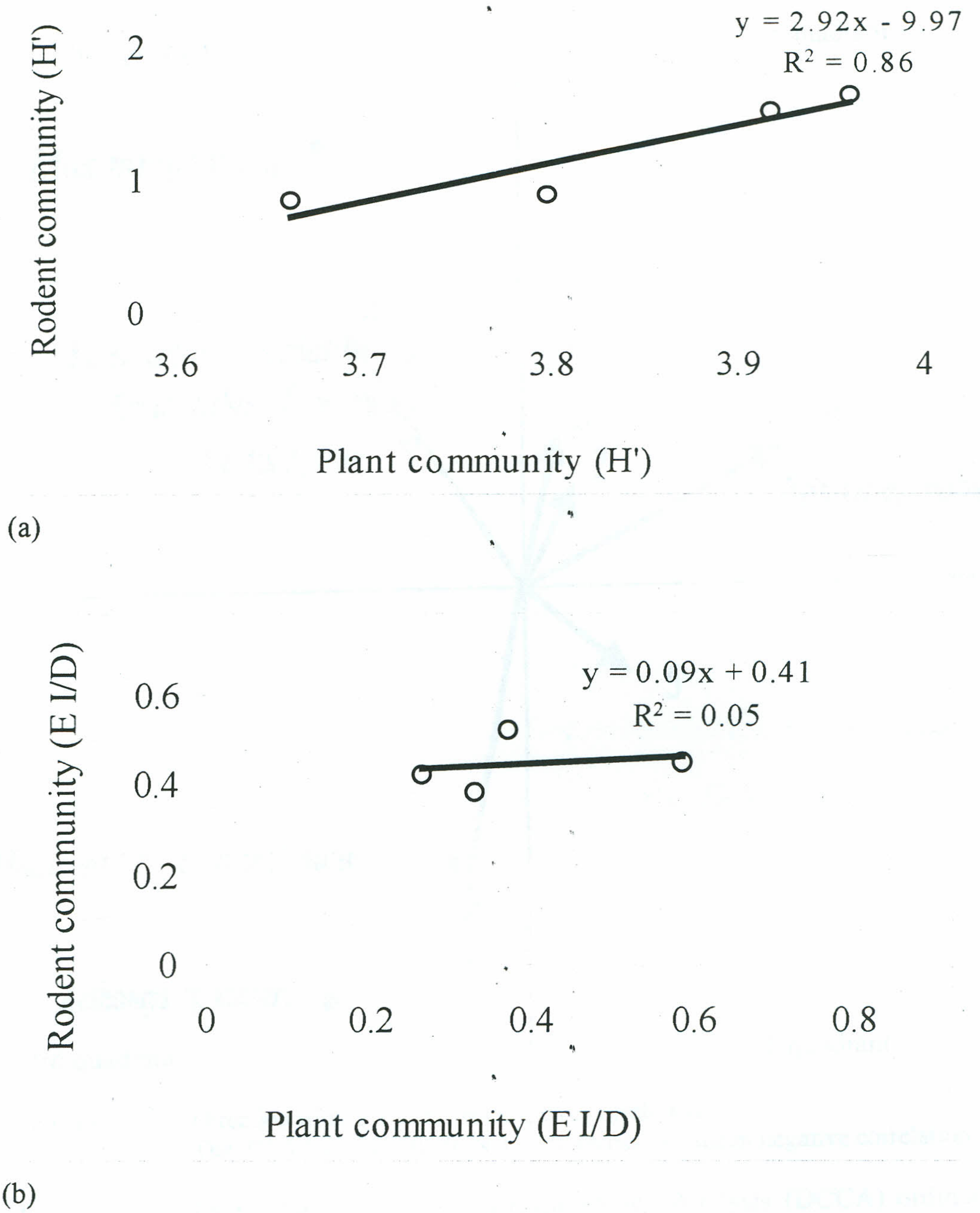
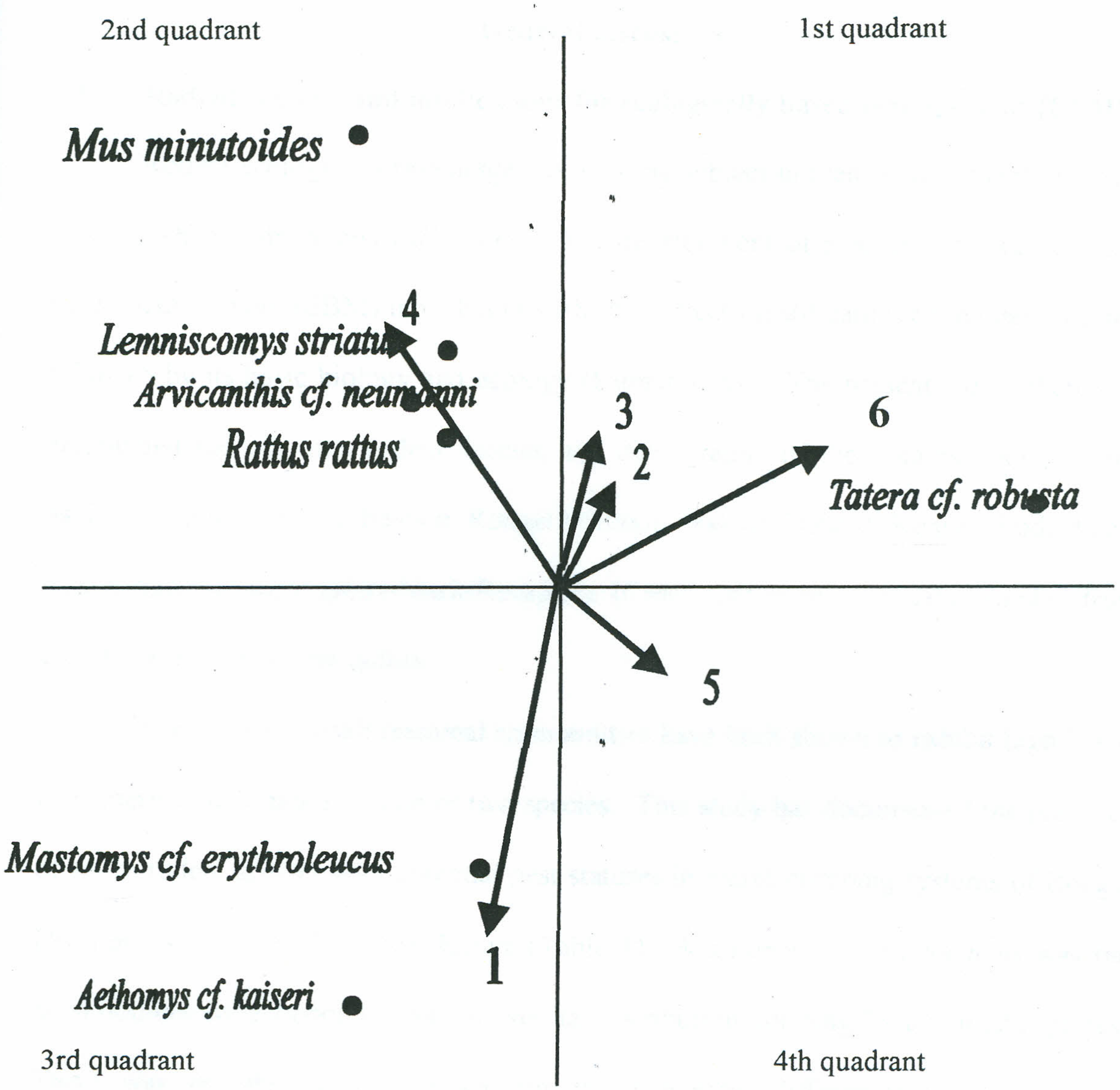


**Fig. 27.** Correlation between rodent and plant communities in the all the four trapping grids, from May 2000 to December 2001. (a) is the Shannon-Wieners' diversity index, H' and (b) is the Simpson's evenness index, E I/D.



Legend: Direction of arrow indicates positive correlation.
The 2nd, 3rd and 4th quadrats do not necessarily mean negative correlation.

**Fig. 28.** Detrended Canonical Correspondence Analysis (DCCA) ordinations of incidences of capture frequencies and the five rodent species from six distinct habitat categories as estimated from the program CANOCO. All the study grids are combined and data collated for May 2000 to December 2001.

# Chapter 7

## General discussion

### 7.1 Rodent ecology and implications for ecologically based management (EBM)

Rodent ecology has re-emerged as a strong subject in their management in Africa and elsewhere (Singleton *et al.* 1999). The development of a meaningful ecologically based management (EBM) must begin with the correct identification of the pest species, followed by its basic biology and ecology (Kumar 1987). The present study, therefore, determined the common rodent species, the demography of the dominant species and habitat use in maize crop fields in Rongai Division, Nakuru District, Kenya. Rodent data was sampled using Capture-Mark-Recapture (CMR) and vegetation data sampled from circular quadrants of 5m radius.

In the tropics, small mammal communities have been shown to exhibit high levels of numerical abundance by one or two species. This study has documented the presence of seven rodent species with potential pest statuses in maize cropping systems of Rongai Division, Rift Valley Province, Kenya (Table 1). *Mastomys* cf. *erythroleucus* was the most dominantly common rodent with similar distribution, forming 71% of total captures. There was no obvious explanation for the numerical differences among species. *Mastomys* species complexes are the dominant pest species and disease reservoirs in cultivated areas of Africa (Bekele and Leirs 1997, Granjon *et al.* 1990, Leirs 1995, Mwanjabe 1990). This study did not, nonetheless, investigate the dietary aspect to confirm the type of food material preferred and thus pest status of this species.

Rodents from the highest altitude point (Mugo grid) had the greatest number of individual species recorded followed by (Moto grid). Beth grid, on the second highest point, had the least number of species records. Diversity indices were similar across the entire grids. These findings do not concur with those of Delany (1982), that indicated an inverse relationship between altitude and cumulative frequencies of encountered species at Rwenzori Mountains, Uganda. Here, the numbers of rodent species recorded were high on the low lands but reduced gradually reaching zero on the highest altitude point. This inconsistency may be explained by similarity in distribution and proportions of rodent fauna and plant flora in the entire study grids as influenced by replacement of original vegetation with food crops.

### Small mammal demography

There is a considerable amount of literature explaining the causal mechanisms for rodent demographic dynamics. Several population models have shown the synergistic effects of both density-independent and density-dependent factors in determining the resultant dynamics (Leirs *at el.* 1997, Lima *et al.* 1999, 2001, Merritt *et al.* 2001). Studies have shown both the effects of rainfall and density on survival and maturation in African rodents (Julliard *et a.l* 1999, Stenseth *et al.* 2001). In this study, *Mastomys* density fluctuations were similar across grids (Figs. 7a-d and 8a-d). A gradual recovery followed by rapid increases and declines were observed in all the grids. Other rodent species populations also had similar dynamics though in very low number. Rodent populations at Mugo and Beth grids have a unique decline with densities falling to very low levels following a recovery in numbers above the previous peak density. Possible explanations for this decline could either be lower intensity of breeding, low survival or emigration of individuals during the year 2000 (Figs 7a-b).

High intensity of breeding (Mugo; January 2000 and Beth; December 2000 to March 2001) was responsible for the recovery and earlier increase of population. These occurred following months of high amount of precipitation averaging above 300mm. Rainfall can therefore be incorporated in population models of *Mastomys*. The demographic patterns of *Mastomys* cf. *erythroleucus* were similar across the grids suggesting the existence of a metapopulation.

The *Mastomys* cf. *erythroleucus* population structure changed over time in regard to the amount of precipitation. There were significant changes in sex ratio of new and recaptured animals did not change from the expected 1:1 ratio except in a few occasions. Body mass dynamics and field growth rates were similar between sexes, indicating absence of sexual dimorphism in these parameters. However, seasonal variations had strong effect on body mass dynamics and field growth rates. Larger individuals and high growth rates were recorded during the wet season. In addition, breeding in *Mastomys* cf. *erythroleucus* is depressed by drought but where there is adequate distribution of rainfall throughout the year, reproductively active individuals are encountered in all the months. This suggests that higher growth rates coupled with intense breeding activity during unusually higher rainfall may lead to pest population outbreaks.

Distributions of rodents were aggregated at the farm edges in patches of dense grass cover and a majority of rodents staying near their home ranges. Rodents were also captured largely along farm edges, and crops at these points are likely to get damaged. Neither ground cover nor habitat structure could entirely explain the distribution of *Mastomys* cf. *erythroleucus* captures. However, diurnal species capture frequencies increased with the dense vegetation cover values. It appears these rodents use dense weed cover to avoid the risk of predation, leading to the patchy nature of damage. Diurnal rodent species exhibited zero persistence and maturation rates in maize fields throughout the study period. This is likely due to increased dispersal or predation. This indicates, therefore, that habitat manipulation by removal of cover is worth giving considerations in ecologically based rodent management in Kenya.

## 7.2 Conclusion and recommendations

This study reports on population dynamics and habitat use by rodents in maize cropping fields of Kenya. Small mammal community structure and distribution was found to be similar across the grids set along altitudinal gradient. *Mastomys* cf. *erythroleucus* population structures, demography and persistence rates were also similar across the entire grids. Body mass dynamics and field growth rates, though similar in all grids, were strongly influenced by rainfall seasons. Rodents exhibited aggregated spatial distribution in the maize fields. Field edges may, therefore, be important target areas during chemical control operations. It is hoped that the results of this study would bridge some of the information gaps on rodent ecology that hinder successful management.

Although basic ecological information has been provided here, the following areas on rodent ecology require further investigations;

1). Rodent community structures and the functional role of the dominant species in crop fields.

2). The causes and effects of demographic fluctuations: (a) the degree of correlation among these factors and (b) the factors that explain the most variations in demographic processes.

3). Factors triggering dispersal and the fate of dispensers after they leave the population.

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**Appendix 1**

**CMR:** ________________ Grid: ____________________________________________ Date: ________________

Name: ________________ Traplines: _______ # trap/station: _______ Wheather during the night: ____________________

| Species | Code | Trap station | Weight | Sex | Reproductive condition | Remarks |
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♂♂: **T**estes **A**bdominal or **S**crotal; **G**ybernaculum **N**on-visible or **V**isible

♀♀: **V**agina **C**losed or **P**erforated; **S**mall nipples or **L**actating; **P**regnant (**N**o or **Y**es)

Appendix 2

# Vegetation sample data entry sheet for Rongai Division

Grid name:…………………………………… Date:………………………..

Collector:……………………………………Data sheet No:……………..

| Trap Station | Plant sp. Identification. | Vegetation Height (cm). | | | | | | | | | | Vegetation Cover Est. (%) |
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