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The Small Animals of Maasai Settlements: Ethnoarchaeological Investigations of the Commensalism Model

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THE SMALL ANIMALS OF MAASAI SETTLEMENT: ETHNOARCHAEOLOGICAL INVESTIGATIONS OF THE COMMENSALISM MODEL

by

Lior Weissbrod

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ABSTRACT OF THE DISSERTATION

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Ethnoarchaeological Investigations of the Commensalism Model

by

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Doctor of Philosophy in Anthropology

Washington University in St. Louis, 2010

Professor Fiona B. Marshall, Chairperson

Changes in mobility have long been considered a critical factor affecting social and economic change during transitions from hunting and gathering to food production. Archaeologists have relied on a wide range of indirect indicators of sedentism and the intensity of site occupation such as site size and structural complexity. One of the key problems has been how to ascertain more precisely how change in mobility combined with other factors of economic and social intensification. More than 40 years ago, Tchernov (Bar-Yosef and Tchernov 1966) first proposed the idea that remains of commensal species that today coexist with humans in settlement environments could be used to detect early sedentism in the archaeological record. Subsequent studies of the earliest occurrence of commensal house mice (*Mus musculus domesticus*) in sites of complex Natufian hunter-gatherers of southwest Asia established a link between pronounced levels of commensalism and what is generally believed to have been one of the first sedentary cultures in the world. The commensalism model related increasing populations of commensal species and decreasing biological diversity to changes in the intensity of human site occupation. It was expressly developed to test assumptions about decreasing mobility among Natufian hunter-gatherers and their role in the subsequent domestication of plants and animals and emergence of agricultural villages. The validity of the model was later questioned, however, due to the lack of empirical knowledge on commensalism in a wide range of settlement environments including sedentary and more mobile ones.

This research was designed to test Tchernov's commensalism hypothesis through a study of seasonally occupied settlements of Maasai pastoralists in East Africa. Methods from ecology, ethnography, and archaeology were used to document the impact of Maasai settlements on associated communities of small rodents and shrews (micromammals), to measure the intensity of human occupation in settlements, and to relate settlement intensity to micromammalian communities. Taphonomic approaches were also used to evaluate the potential for accumulation and preservation of evidence on commensalism in the substrate of the settlements.

The results of the study showed that, in contrast to what we might expect in highly sedentary settings, Maasai settlements increased rather than decreased the biological diversity of local micromammalian communities. Along a gradient of decreasing settlement mobility, but continued seasonal use of settlements, there was no manifest increase in the population of any single species that would amount to pronounced commensalism. This supports the commensalism/sedentism linkage but also suggests more broadly that it should be possible to demarcate distinct contexts of commensalism and related levels of biological diversity in relation to varying intensities of site occupation. These results call for greater investment in systematic fine-recovery and study of variability of micromammalian assemblages at archaeological excavations.

CHAPTER 1

INTRODUCTION

Mobility is a critical component of adaptation among all human societies. It represents a fundamental mechanism through which human groups respond to external and internal environmental and political forces. Furthermore, it is well known as a strategy for gaining access to resources that are widely distributed in space and time. Early hunter-gatherers who populated the world for most of human history are believed to have been highly mobile and only under special circumstances of spatially concentrated and abundant resources are they expected to have remained for long periods at a single settlement location (e.g., Niederberger 1979; Nadel 2004). The majority of hunter-gatherer open-air sites that are known worldwide are relatively small in spatial extent. Such sites typically consist of shallow sedimentary deposits, contain low artifact densities, and lack elaborate stone constructions and installations. Research among some of the contemporary hunter-gatherers who today occupy relatively isolated and environmentally marginal regions shows that high degrees of mobility are generally associated with small group size, low social cohesion, and lack of social hierarchy (Yellen 1977; Woodburn 1982; Binford 1980). Woodburn (1982) and others have also argued that limited division of labor, immediate utilization and consumption of and equal access to procured resources, and low levels of site occupation often limited to no more than a few days are also common among hunter-gatherers living in arid regions of Africa.

Complex hunter-gatherers with markedly different social characteristics and patterns of mobility are well known in several regions of the world that saw climatic amelioration at the end of the Pleistocene and beginning of the Holocene. This includes parts of North Africa, southwest Asia, and Japan (reviewed in MacDonald 2000; Bar-Yosef 2002; Pearson 2006). The relatively abrupt appearance of sites with unprecedented scale and extent of elaboration in structural complexity has suggested to researchers a marked reduction in mobility and a transition to a more sedentary way of life. In southwest Asia, this development occurred in the context of hunter-gatherers of the Natufian culture (c. 13,000-10,250 bp [uncal.]) and is widely believed to have had far-reaching and long-term consequences for patterns of social and economic organization (for recent reviews see Belfer-Cohen and Bar-Yosef 2000; Bar-Yosef 1998, 2002).

Social and economic systems of complex hunter-gatherers that evolved in the context of more sedentary habitation of sites such as those of the Natufian culture may have promoted use and management of resources in a manner that led to domestication and the development of food production. Recent research on the Natufian and beginnings of food production in southwest Asia points to non-linear changes in economy and mobility in the Natufian and subsequently to the existence of mosaics of hunter-gatherers and food-producing communities (Belfer-Cohen and Goring-Morris 2009; Goring-Morris and Belfer-Cohen in press). It is less well understood, in this context, with absence of monolithic clear-cut stages, what forms of social and economic variability existed among populations moving towards food production. In spite of the stark transformation in the material culture record of southwest Asia with the emergence of the Natufian and indications for considerable sedentism, there is also substantial evidence for increasing mobility in the later Natufian (Late and Final Natufian periods c. 11,500-10,250 bp) (Belfer-Cohen and Bar-Yosef 2000; Bar-Yosef 2002; Byrd 2005; Weinstein-Evron 2009: 110-113). Some of the key sites of the Early Natufian in northern Israel such as el-Wad Terrace in the Carmel Mountain and Hayonim Terrace in the Galilee Mountains became considerably smaller in the Late Natufian. This was associated with reduced investment in construction, transition from group to individual burial, and less elaboration in burial practices and adornment of the dead. Reasons for this are unclear, but researchers have pointed to climatic and social stresses during the later part of the Natufian that may have driven formerly sedentary groups back to mobility just prior to the appearance of the earliest farming villages (Bar-Yosef 2002; Byrd 2005).

The relationship between economic change and reduced mobility is also not well understood in other world regions where the beginnings of food production have been studied in detail. In the American southwest, for example, there is some evidence for early sedentism (Fish et al. 1990) although significant mobility persisted long after the introduction of domesticated plants or animals (Wills 1988; Dean 2005). In the American southeast there is also considerable evidence for long-term existence of mosaics of adaptations with varying levels of dependence on wild and more closely managed or fully domesticated resources (Fritz 1990; Smith 2001). The situation is particularly complex in the African continent. Here, in spite of early movement towards sedentism and intensified use of plant resources among complex hunter-gatherers, initial domestication was of animals and involved transitions to herding and more mobile ways of life (Marshall and Hildebrand 2002). Furthermore, in Africa herding of domesticated animals has coexisted side by side with continued hunting and gathering and for the last few thousand years also with shifting cultivation and farming. Marshall and Hildebrand (2002), Neumann (2005) and others have argued that the mobility of early food producers had a critical influence on late domestication of African plants and on the social organization of early food producing societies. Without more precise ways of looking at mobility, however, it remains difficult to assess the degree to which the course of economic change was influenced by different factors. These include internal differences in social organization among early complex hunter-gatherers in different regions and external environmental and climatic factors.

In spite of the theoretical centrality of the question of mobility for modeling trajectories of cultural complexity and understanding regional and worldwide variability in pathways to food production, limited progress has been made in approaches to measuring mobility. At the landscape level spatial patterns of mobility can be broadly reconstructed from site distributions and through ecological modeling of where and when resources would have been available. Understanding of more nuanced aspects of mobility, however, including group size and periodicity of movement has proved more elusive. This stems in part from the lack of sufficiently specified definitions of how and to what resolution mobility and its various components should be described (see Rafferty 1985; Kelly 1992). It is widely accepted that there are significant methodological challenges facing archaeologists in the study of mobility. Human mobility is a highly complex and multi-dimensional phenomenon involving spatial and temporal aspects of movement as well as aspects of group size and composition. These factors vary along multiple axes and may be related to a wide variety of rationales (Rafferty 1985; Kelly 1992).

Binford (1983: 109) has observed that our view of the past is restricted to points on the landscape and immutable material evidence whereas past behavior was highly mobile. This fundamental disjunct is expressed most vividly in the way in which evidence on the mobility of ancient societies has been obtained, for the most part, from archaeological sites representing fixed locations and the stationary component of the mobility cycle. As an artifact of the fragmentary nature of the archaeological record, mobility, which in actuality encompasses both a dimension of movement across the landscape and the occupation of particular sites along the mobility cycle, is often described only in terms of aspects of site occupation such as ephemeral, temporary, seasonal, short- or long-term, and permanent. In general, archaeologists have failed to mobilize direct and independent evidence for the length of time people occupied ancient sites.

Indirect archaeological indicators for varying levels of site occupation and degrees of mobility have included site size, thickness of deposits, density of artifacts, and extent of elaboration in site structure. It has generally been assumed, however, that a reduction in mobility and growing intensity of site occupation necessarily leads to proportionate increases in these proxy measures. Although such an assumption may be broadly correct, it has been pointed out that it is not true under all circumstances. In a critical evaluation of a wide range of indicators of sedentary site occupation, Edwards (1989) provided examples from the ethnographic record showing that large sites and thick deposits of occupation debris can be formed by people practicing a significant degree of systematic mobility with periodic returns to occupation sites in fixed locations. He goes on to emphasize that distinguishing between truly sedentary sites with large size, thick deposits, and high artifact density and other sites that were formed as a result of multiple repeated short-term visits is a basic methodological dilemma. This realization also prompted Fish et al. (1990) to suggest a more skeptical approach to the use of material culture correlates for recognizing sedentary site occupation.

Other scholars have emphasized the value of more direct biological indicators of site occupation and mobility (e.g., Bar-Yosef and Belfer-Cohen 1989). Thus, plants and animals utilized as subsistence resources and for other purposes can also furnish evidence for seasonality where there is marked seasonality in patterns of abundance, diet, or reproduction of such resources (Monks 1981; Lieberman 1998). The utility of such approaches is limited, however, to regions where seasonality is marked, especially in temperate latitudes. They are also complicated by cultural factors such as the storage of resources from season to season, which can mask the true extent of the seasonal cycle through which a particular site was inhabited (see Edwards 1989).

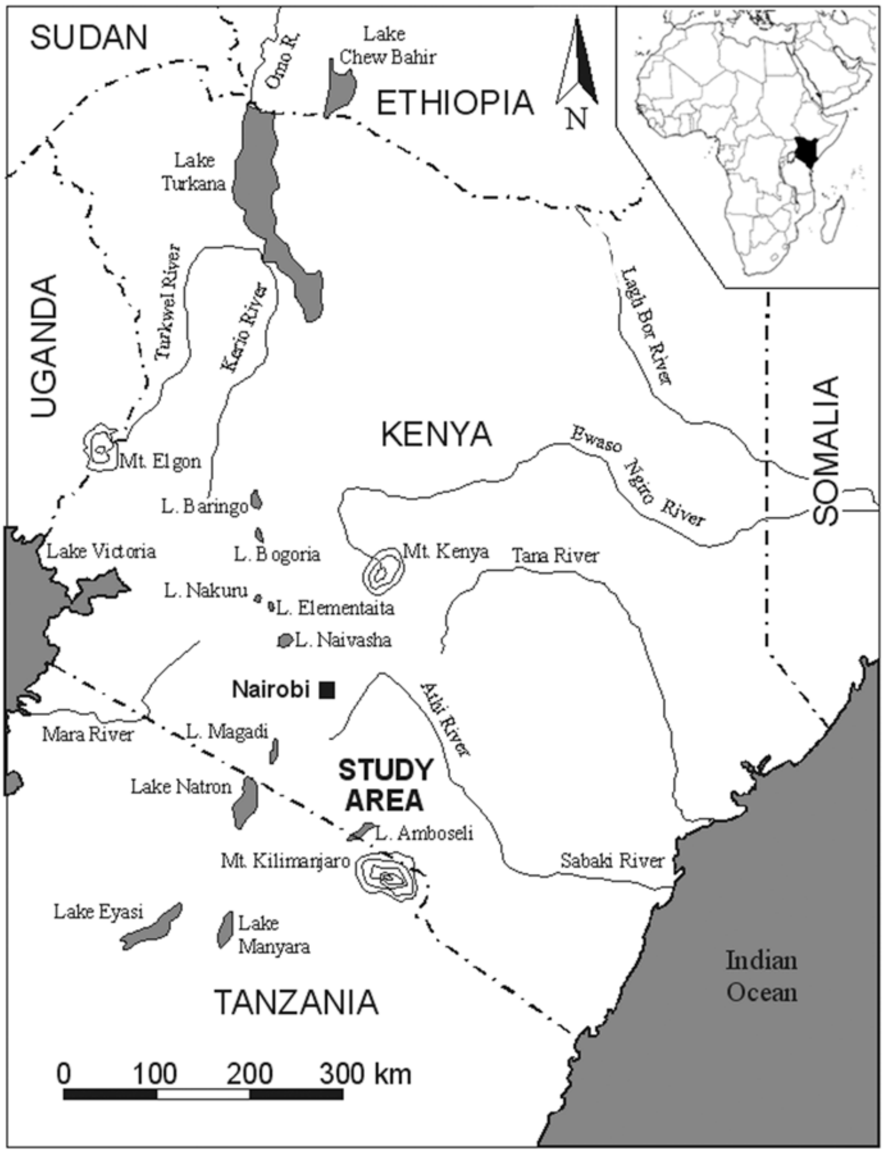
The remains of small species of animals that have long coexisted as non-domesticates with humans in settlements provide an additional line of evidence for examination of site occupation and mobility or sedentism. The ecology of such animals, it is argued, would have been directly impacted by the level of human site occupation including the length and intensity of stay and the size and growth rate of the human population. This ecological relationship between humans and small animals in their immediate environment is known as commensalism. Tchernov (1984) has used archaeological remains of commensal species such as the house mouse (*Mus musculus domesticus*) and house sparrow (*Passer domesticus*) to reconstruct varying levels of site occupation and degrees of mobility in the Late Pleistocene of southwest Asia. He linked early and relatively small-scale fluctuations in frequencies of such commensal species to variability in duration and intensity of settlement occupation through time and emphasized a marked increase in frequencies at the end of the Pleistocene associated with complex Natufian hunter-gatherers. Tchernov (1984) argued that such marked increases in frequencies of commensal species are strong indications of significant sedentarization in the Natufian (see also Bar-Yosef and Tchernov 1966; Hesse 1979; Bar-Yosef and Belfer-Cohen 1989).

Other authors have since challenged this argument due to lack of empirical data on the range of settlement contexts, from sedentary to more mobile, in which commensalism can be expected to develop (Edwards 1989; Tangri and Wyncoll 1989). In other words, it is unclear precisely what magnitude of increase in frequency of commensals will be related to significant sedentism. More broadly the question is what the overall quantitative relationship is between the process of commensalization and changes in the level of human site occupation. These authors also consider the introduction of food storage practices and large-scale accumulation of organic refuse as alternate causes for the increase in frequencies of commensal species in the Natufian.

To test the validity of Tchernov's (1984, 1991a) commensalism model and its utility for identifying varying levels of human site occupation in archaeology I collected empirical data on commensalism and human site occupation in an ethnoarchaeological study of seasonally mobile pastoralists. This research focuses on small mammals or micromammals from the taxonomic orders Rodentia and Insectivora. The study was conducted among Maasai pastoralists in southern Kenya who depend on the keeping of herds of cattle, sheep and goats and maintain a system of seasonal use of settlements and regional mobility (Figure 1.1). This pattern of land-use allows people and their herds access to water and pasture, which are unevenly distributed across the landscape in relation to rainfall seasonality (Jacobs 1975; Western and Dunne 1979).

I chose Maasai settlements as an appropriate context for testing Tchernov's model because they represent a contrast to what we might expect in highly sedentary settings where occupation is long-term and year-round and there is increase in the size of the human population over time. Maasai settlements often remain in use for many years but are occupied on a seasonal basis. In addition, the human population of settlements is relatively small and constant. People rely to a great extent on food obtained from their herds, day-to-day, and supplement this with small amounts of market-purchased products such as grain. There is little or no cultivation of crops, storage of foodstuffs, accumulation of organic food refuse, or foraging of wild game, either small or large.

Figure 1.1. Map of East Africa showing the location of the study area in southern Kenya (map adapted from Shahack-Gross et al. 2003: Fig.1).



The basic argument of this study and formal logic employed in testing Tchernov's model is as follows:

> The commensalism model would be supported if under long-term settlement use with seasonal occupation and steady human populations there is no indication of reduced biological diversity or pronounced increases in the frequencies of commensal species at the expense of other species.

Commensalism is only expected to develop in highly sedentary situations. To gauge both the specific magnitude and direction of change or lack thereof I monitored the characteristics of micromammalian communities of Maasai settlements along a series of settlements representing a gradient of increasing duration of human occupation with continued seasonal use. Micromammals in settlements were also compared to control sites outside settlements. An additional key component of the study was the examination of taphonomic pathways for incorporating micromammalian remains into settlement substrates and the archaeological record.

The organization of the volume is as follows. In Chapter 2, I address questions of mobility and sedentism in the two archaeological contexts that are most directly relevant to the development and testing of the commensalism model: complex Natufian hunter-gatherers of southwest Asia; and pastoral societies of Africa. Here, I expand on Tchernov's model of commensalism in the context of Natufian sedentism. In this chapter I also discuss varying concepts of mobility and sedentism and practical ethnoarchaeological approaches to these. Chapter 3 reviews the concept of commensalism in ecological theory, empirical studies that demonstrate the ecological dynamics of commensal environments, and previous applications of commensalism in archaeological research.

The study area and ethnographic background on economic, social, and ecological aspects of Maasai pastoralism are presented in Chapter 4. Details of the research design, methods of data collection, and quantitative approach to data analyses are covered in Chapter 5. This chapter outlines the combination of ethnographic, ecological, and archaeological field techniques that I employed in examining the research question in the living context of Maasai settlements. Chapter 5 also addresses taphonomic aspects of the research question.

I present the results of the study in Chapters 6, 7, and 8. The first of these, Chapter 6 describes ethnographic data on patterns of occupation of the study settlements based on observations and interviews on settlement histories. I then use this data to quantify the level of occupation of the study settlements. This forms the basis for quantitative assessment of the ecological impact of the settlements. In Chapter 7, I present ecological data on the organization of micromammalian communities in relation to the study settlements. In this chapter I examine patterns of variability in populations of individual species and employ the richness and biological diversity of species to characterize communities. Data on the taphonomy of micromammalian communities in Maasai settlements and an assessment of the potential for preservation of archaeological evidence is presented in Chapter 8.

The discussion is divided into two chapters (9 and 10). In Chapter 9, I asses ecological results in light of the question of commensalism. In order to do this I discuss ecological mechanisms that account for the observed associations of micromammalian communities with the study settlements of varying durations and intensities of occupation. In the second discussion chapter (Chapter 10), I use the study to examine the validity of the Tchernov's commensalism model and the commensalism-sedentism linkage. In this analysis I also employ a comparative approach using data on micromammalian communities from more sedentary African farming villages. The results of the Maasai study together with the comparative analysis demonstrate that a pattern of pronounced commensalism is absent in Maasai seasonal settlements. Biological diversity in all Maasai settlements studied is greater than in outside control habitats and does not diminish along a gradient of increasing duration of settlement occupation with continued seasonal use. This finding supports Tchernov's (1984, 1991a) commensalism model. It also suggests that biological indicators from micromammalian remains may be used by archaeologists to demarcate varying levels of site occupation and degrees of mobility beyond those of sedentism alone. Moreover, although micromammalian species will differ from region to region, findings from this study can be applied to analysis of micromammalian assemblages and questions of mobility and sedentism in different regions of the world by focusing on patterns in community structure, biological diversity, and species that can potentially fill varied commensal niches and benefit from settlement environments.

I go on to examine broader implications of the present study for environmental engineering. I argue that the mode of creation and maintenance of Maasai settlements creates a unique context for human/animal interactions. I also address the broader implications of this for archaeological research on a wide range of biotic interactions. In the final chapter (Chapter 11) I briefly summarize the main results of this study and consider directions for future research on commensalism in archaeology.

CHAPTER 2

SEDENTISM, MOBILITY, AND THE COMMENSALISM MODEL

2.1 Sedentism and Complex Natufian Hunter-gatherers

Long-standing models of the emergence of food producing agricultural societies in southwest Asia have emphasized the role of development of pre-agricultural sedentism among complex Natufian hunter-gatherers as one of the key factors triggering change in both economic and social systems (Binford 1968; Henry 1985; Bar-Yosef and Belfer-Cohen 1989). Scholars working on the Natufian have brought together evidence from some of the key occupation sites for remarkable elaboration in burial practices, industries of art and decorative objects, and long-distance trade in a variety of materials (Flannery 1972, 2002; Kaufman 1992; Belfer-Cohen 1995; Weinstein-Evron et al. 2001; Byrd 2005). They use these data to argue for an increasingly bounded territoriality, evolving group nucleation, and overall intensification in social interactions, possibly involving initial differentiation in status within groups.

Studies of subsistence patterns at the inception of the Natufian culture also show intensification in use of hunted resources that include increasing pressure on the demography of herds of abundant wild ungulates such as gazelles and heightened utilization of lower-ranked small-bodied pray such as tortoises and hares (Cope 1991; Davis 1991; Munro 2004). Other evidence for intensified use of plant resources includes proliferation of ground stone mortars and flint sickle blades indicating increased harvesting and processing of cereals (Unger-Hamilton 1991; Wright 1994) and in sites with conditions for preservation of botanical remains also an especially high variety of plant foods (Hillman 1996). In terms of the evolution of human subsistence in southwest Asia, sedentary Natufian hunter-gatherers have been seen to represent a pivotal threshold phenomenon that put in motion social and economic developments heralding the subsequent emergence of food producing societies at the beginning of the Holocene (Binford 1968; Henry 1985; Bar-Yosef and Belfer-Cohen 1989).

Larger numbers of people living together for longer periods of time at a single location supposedly necessitated adjustments in aspects of social organization that ensured peaceful long-term coexistence and in subsistence strategies that were tied to and limited by resources available at a particular locality (Flannery 1972, 2002). More recently, however, the focus has shifted from the early phase of the Natufian and associated evidence for significant sedentism to a relatively short period towards the end of the Natufian culture known as the Late Natufian (c. 11,500-10,500 bp) when there is mounting evidence for a marked return to mobility (Belfer-Cohen and Bar-Yosef 2002; Byrd 2005). At this time the size of a number of sites decreased and there was reduction in the scale of construction activities and investment in burial practices. The Late Natufian appears to have coincided with a period of climatic stress and decreasing temperatures and rainfall known as the Younger Dryas. It remains unclear, however, precisely how climatic and social developments came together to influence the course of economic change that culminated in the emergence of food production.

One of the ways to further improve the resolution of data on changing patterns of mobility associated with social, economic, and climatic change is by obtaining direct evidence on levels of site occupation and degrees of mobility that is independent of other data on subsistence. There is currently a need to develop approaches that would allow us to test expectations for both sedentism and mobility more directly and to examine variability in systems of mobility within and between different regions where food production developed.

2.2 Mobility and African Pastoralism

Of particular interest in the context of the present study is the impact of the development and spread of pastoralism in Africa on patterns of mobility and settlement occupation. Pastoralism based on the keeping of cattle, sheep, and goats was the earliest form of food production in Africa and is thought to have emerged in the eastern Sahara in the beginning of the Holocene in the African Neolithic period (Figure 2.1a) (reviewed in Close and Wendorf 1992; Smith AB 1992: Ch.2; Marshall 1998; McDonald 1998; MacDonald 2000; Marshall and Hildebrand 2002; Gifford-Gonzalez 2005). Important contributing factors in the development of African pastoralism would have included a prolonged and punctuated process of aridization of the Sahara during the first half of the Holocene following an extended period of favorable conditions as well as social preadaptations among hunter-gatherers of the region that had become increasingly sedentary and dependant on intensified use of subsistence resources. Marshall and Hildebrand (2002) have argued that in this marginal context of the eastern Sahara, animal herding and increased mobility rather than plant cultivation, would have constituted predictable responses to overall diminishing resources and reliable access to them. With extensive drying of the Sahara after c. 7,000 bp pastoralism spread west and south to sub-Saharan regions and was adapted to varying environmental conditions and social contexts by combining livestock keeping with hunting, gathering, or fishing, in some cases retaining only one or two of the domesticates, or intensifying reliance on livestock (Marshall and Hildebrand 2002; Gifford-Gonzalez 2005). Domestication of plants and settled village farming developed late in Africa mainly in better-watered areas on the southern margins of the present day Sahara after c. 4,000 bp and may have been delayed by the success of pastoralism and mobile ways of life (for recent review see Neumann 2005).

Based on data from subsistence remains and indirect indicators such as site size, structural complexity, and stratigraphy a wide range of hypotheses have been developed for characterizing degrees of mobility in different regions and varying social, economic, and environmental circumstances. These include the hypotheses that 1) early adoption of cattle in the relatively dry environment of the Eastern Sahara would have increased the mobility of earlier more sedentary hunter-gatherers (Marshall and Hildebrand 2002); 2) Increasing aridity during the middle Holocene and the addition of sheep and goats from the Near East resulted in short-term visits to Saharan rockshelters (Gautier 1987); 3) African domestication of donkeys and their use as pack animals, possibly as early as 6,000 bp, would have further facilitated flexible mobility (Marshall 2007; Rossel et al. 2008); and 4) in contrast, economic diversification and the incorporation of pastoral economic activities into hunting and foraging systems, as documented in the middle Nile region of Sudan c. 5,000 bp, would have reduced mobility and induced the development of a nomadic system with more regular seasonal moves between fixed locations (Haaland 1992).

Figure 2.1. Map showing: the area of origin of African pastoralism in the eastern Sahara (a) and the distribution of Pastoral Neolithic sites in the central Rift Valley region of southwest Kenya and northwest Tanzania and in relation to the study area (b) (based on Gifford-Gonzalez 1998: Figs.1-3). Legend: ● Eburran ▲ Savanna Pastoral Neolithic ◇ Elmenteitan.

In East Africa where this study is located, an especially complicated mosaic of economic adaptations resulted from the spread of pastoralism. In the central Rift Valley region of Kenya (Figure 2.1b) the introduction of livestock from the north occurred during the period known as the Pastoral Neolithic (c. 4,000-1,250 bp). The Pastoral Neolithic followed an extensive period during which the central Rift Valley was populated only by hunter-gatherers with broad-spectrum exploitation of resources and mobile ways of life (Ambrose 1984, 1998). The introduction of livestock was a markedly gradual process and may have been conditioned by the slow advance of migrating pioneer pastoralists who lacked established networks of mutual aid (Ambrose 1984, 1998; Marshall 1994, 2000; Gifford-Gonzalez 1998, 2000). Gifford-Gonzalez (1998) has also emphasized the effect of widespread occurrence of various disease threats to livestock in the more vegetated environment of the Rift. East African archaeologists have also documented a prolonged period during which local hunter-gatherers incorporated livestock in their subsistence systems (Ambrose 1984, 1998; Marshall 1994, 2000; Gifford-Gonzalez 1998, 2000). Livestock finally became common and widespread in the central Rift Valley by c. 3,000 bp when a mosaic of economic adaptations with varying levels of reliance on herding as well as hunting and gathering is believed to have emerged in the region.

Evidence for predominance of the remains of cattle, sheep, and goats in faunal assemblages from the later part of the Pastoral Neolithic in the same regions of East Africa indicates that pastoralism was intensified (Marshall 1990a, b, 1994, 2000). For example, in the site of Ngamuriak in southwestern Kenya (Figure 2.1b) dated to c. 2,000 bp Marshall (1990a, b) has identified evidence for a subsistence economy based on specialized pastoral production. This includes the near absence of remains of hunted game, which is remarkable given the high densities of large wild mammals in the region in historic times. Livestock age profiles also suggest culling at the age of optimal weight gain and an emphasis on herd growth as seen among many contemporary African pastoralists. The physical environment of this site and other sites further indicates that the welfare and grazing needs of livestock were important considerations in choosing settlement locations. The transient nature of the structure of the Ngamuriak site, it is argued, also indicates seasonal occupation.

Marshall (1990a, b) suggested that a critical factor in the intensification of pastoralism in East Africa was the establishment after c. 3,000 bp of a climatic regime characterized by bi-seasonal distribution of rainfall which would have enhanced the productivity of grazing environments and made it possible to depend on livestock products such as milk year-round. Relations with hunter-gatherers are also thought to have contributed towards pastoral specialization by providing herders with opportunities to supplement their diet focused on the milk, meat, and blood of livestock with hunted and gathered resources. These wild foods could be used as fallback resources during periods of stress from drought or disease (Marshall 1990a, b; Gifford-Gonzalez 1998).

Regional variability in material culture during the East African Pastoral Neolithic period is considerable (Bower et al. 1977; Ambrose 1984, 2001; Bower 1991). Particular traits such as technological aspects of lithic reduction sequences distinguish among contemporary pastoralists and hunter-gatherers. Three coexisting groups – Elmenteitan and Savannah Pastoral Neolithic (SPN) herders and Eburran phase 5 hunter-gatherers and in some cases herders – exhibit stable preferences for sources of lithic raw material, specific ceramic wares, and ecological location of sites (Ambrose 1984, 2001). The Savanna Pastoral Neolithic and Elmenteitan (Figure 2.1b) pastoralists spread into the central Rift Valley in two separate events and may represent distinct linguistic groups (Ambrose 1982). They are, nevertheless, contemporary in southwestern Kenya. The Eburran phase 5 (Figure 2.1b), represented for example in the key site of Enkapune Ya-Muto, designates hunter-gatherers who continued previous Later Stone Age traditions and depended mainly on wild animal resources (Marean 1992; Ambrose 1998, 2001). Some Eburran groups, though, also used domestic animals. Extensive regional surveys and excavations have shown that the SPN is the most widespread among these cultural traditions. It may also have appeared in the central Rift Valley earlier than other pastoral traditions c. 3,300 bp. SPN sites are distributed in semiarid areas in the open savanna plains of the floor of the Rift and the stratigraphy and quantity of material culture on sites suggests higher mobility in these locales than in Elmenteitan sites in wetter areas (Bower et al. 1977; Ambrose 1984, 1998, 2001; Robertshaw et al. 1990). Elmenteitan sites occupy some of the same areas in central and southwestern Kenya but also occur in more humid environments of higher elevation in mountains within the Rift and adjacent escarpments. Both of these pastoral traditions utilized large open sites as well as smaller rock shelter or cave settings whereas hunter-gatherers of the Eburran phase 5 tradition occur strictly in circumscribed rock shelter sites and exhibit the most restricted ecological distribution. These hunter-gatherers appear to have mainly exploited more forested and high elevation areas, which were not suitable for herding. This pattern is similar to that of contemporary Okiek hunter-gatherers of the region who have historically moved among sites at different altitudes on the mountains in order to take advantage of staggered tree flowering and honey production (Ambrose 1986).

Archaeologists interested in understanding the social mechanisms involved in the establishment of pastoralism in East Africa have put forward a number of scenarios to account for the variability in patterns of subsistence and material culture. These include the gradual adoption of livestock keeping by hunter-gatherers, hunting by herders who became impoverished due to livestock disease or droughts, and interactions among groups of herders and hunter-gatherers through exchange or theft (Gifford-Gonzalez 1984; Marshall and Steward 1994). Moreover, it has been argued, based in large part on the presence of ground-stone implements in some sites of this period that in certain circumstances where ecological conditions allowed farming was combined with herding and would have influenced the distribution and intensity of use of sites (Robertshaw and Collet 1983; Robertshaw 1990).

A wide range of expectations have been developed for degrees of mobility and levels of site occupation during the Pastoral Neolithic based on considerable variability among sites in economic activities, environmental and ecological setting, volume and extent of archaeological deposits, and density of artifacts. On this basis sites such as Ngamuriak in the Loita Mara region of southwestern Kenya have been considered occupied for longer periods than smaller sites in the same region with relatively small amounts of material such as Sambo Ngige (Marshall 1990a, b). These sites that contain faunal assemblages dominated by remains of livestock and are thought to represent groups of specialized pastoralists may be contrasted with other Pastoral Neolithic sites in Kenya with substantial frequencies of both domestic and wild fauna. Sites such as Prolonged Drift (SPN) where livestock are outnumbered by wild animal remains are thought to represent groups of hunter-gatherers that also used some pastoral resources or groups of pastoralists that have lost their herds (Gifford-Gonzalez 1984). Ambrose (1984) suggested different mobility strategies for hunter-gatherers that occupied sites containing a predominance of wild fauna such as Enkapune Ya-Muto. Such economic factors would have greatly affected site occupation by different groups during the Pastoral Neolithic.

The ability to test hypotheses regarding the precise nature of economic activities and patterns of mobility in specific situations is limited, however, precisely because of the potential for considerable fluidity of livestock and artifacts among diverse groups. Recent geoarchaeological studies by Shahack-Gross et al. (2003, 2004, 2008) have shown that sedimentological analysis can provide direct and independent evidence for livestock keeping and the accumulation of residues from livestock dung in corrals of ancient sites based on the chemical, mineral, and phytolith composition of the sediments. This is helping to resolve some of the fundamental questions regarding the exact nature of economic activities of groups that utilized both wild and domesticated resources. Such independent types of evidence based on the 'byproducts' of human activities associated with site occupation substantially enhances the ability of archaeologists to assess the feasibility of alternative social explanations for observed patterns of subsistence. Commensalism fits within this framework of more direct and independent evidence on the level of site occupation and degree of mobility. Models explaining social and economic change in the East African Pastoral Neolithic period could be tested using data on variability in micromammalian assemblages. Currently we know very little, however, about how the adoption of food production in East Africa may have influenced associations between humans and small animals in their immediate environment.

2.3 The Commensalism Model

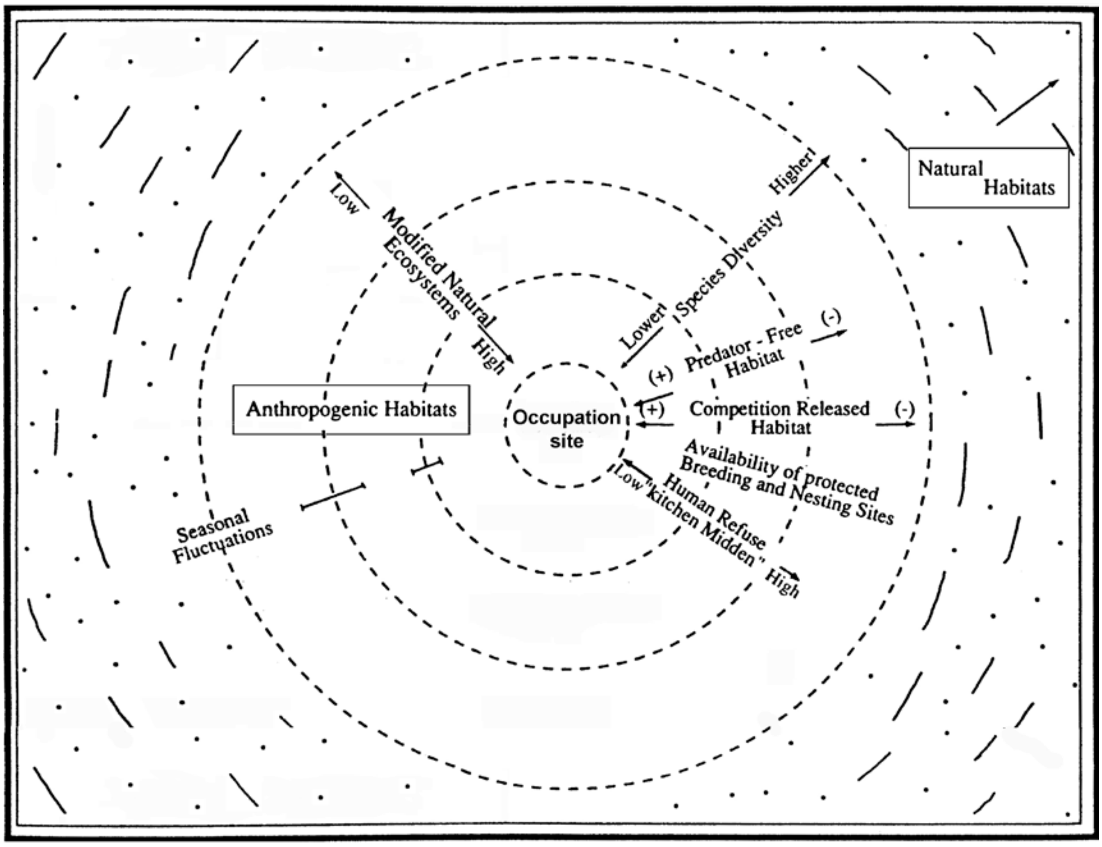
The significance of Natufian sedentism for modeling subsistence intensification and its role in the development of food production has prompted researchers to turn to more direct sources of evidence on site occupation which are independent of food procurement or material culture-related behaviors (e.g., Bar-Yosef and Belfer-Cohen 1989; see also Lieberman 1998). In developing the commensalism model, Tchernov's (1984, 1991a) main concern was with the historical trajectory of southwest Asia and establishing direct biological evidence for identifying the beginnings of sedentism and significant permanence in site occupation among complex Natufian hunter-gatherers. Tchernov (Bar-Yosef and Tchernov 1966) first invoked the concept of commensalism to account for his observation on a marked increase in the frequency of common mice, which are the ancestors of today's cosmopolitan house mice (*Mus musculus domesticus*), in deposits of one of the key Natufian sites – that of Hayonim Cave in the Galilee Mountains of northern Israel. On a taxonomic note, this subspecific designation of the Mediterranean and West European house mouse is accepted by some (see Auffray et al. 1990a) whereas others have used the species designation *Mus domesticus* (see Marshall and Sage 1981). Additional subspecies of house mouse (e.g., *M. m. musculus*) are recognized in Eastern Europe and Asia. House mice became the most abundant taxon in the Natufian micromammalian assemblage of Hayonim Cave, in stark contrast to their absence or rarity in underlying deposits from earlier periods.

Tchernov (Bar-Yosef and Tchernov 1966) linked this phenomenon to the development of significant sedentism among Natufian groups by drawing on the archaeological evidence as well as a consideration of the present day ecology of commensal species: "In all probability, *Mus musculus*, was a commensal of man, as it is now, and this testifies to a wide, dense and persistent human settlement at this site" (Bar-Yosef and Tchernov 1966: 125). It can plainly be deduced that this statement is based on the strong association between certain species of animals such as the house mouse and the highly sedentary environments of present day areas of human occupation including villages, towns, and cities, contemporary observations, or analogical reasoning. This analogy received further support in a later study by Tchernov (1984), in which he showed similar increases in abundance or the abrupt appearance of a number of other species that are well known commensals today including two other species of rodents, the black rat (*Rattus rattus*), and Mediterranean spiny mouse (*Acomys cahirinus*), and one species of bird – the house sparrow.

Tchernov (1991a) also developed a formal model of the ecological dynamic underlying the process of commensalization in the context of sedentarizing Natufian settlements (Tchernov 1991a). Here he argues that aspects of human site occupation, namely the duration of occupation, intensity of seasonal occupation, and human population size and growth rate affect the ecology of local animal communities in patterned and predictable ways (see Tchernov 1984: 112, 1991a: Figs.1 and 2). The model predicts that in the context of sedentarization increasing occupation duration and intensity and large and growing human populations will reduce local biological diversity and lead to an enhanced association between people and a few species of animals centered on the occupation site (see Tchernov 1984, 1991a).

Figure 2.2 modified from Tchernov (1991a: Fig.2) illustrates this dynamic. The diagram represents two gradients of the ecological effect of occupation sites, a spatial and a temporal one. The occupation site is situated in the center of the diagram surrounded by concentric bands that signify a spatial gradient emanating from the habitation area where the impact is most intense and gradually declining with distance. In addition, a temporal gradient is also expected, in which the effect of the occupation site increases with the intensity and duration of occupation. Tchernov predicted that biological diversity would consequently decrease with proximity to the habitation area and with increasing intensity and duration of occupation (see Figure 2.2). A theoretical understanding of ecological interactions provides the basis for the further prediction that in situations of human/micromammalian commensalism, growth in the human population of occupation sites in conjunction with sedentarization will instigate corresponding growth in populations of the commensal species and eventually lead to dominance of one or a few commensals within the environment of the occupation site (Tchernov 1991a). As a result, although commensalism is conceived of and detected as a population phenomenon, it has direct consequences for biological diversity. The model thus explicitly links the development of commensal populations to reduced biological diversity in the context of pronounced sedentism.

Figure 2.2. A model of the environmental and ecological effect of site occupation in the context of sedentarization (modified from Tchernov 1991a: Fig.2). Effects considered in the model are marked as vectors emanating from the occupation site in the center. The model also considers the influence of seasonal fluctuations.



In his discussion of the commensalism model Tchernov (1991a) also suggested a link between site occupation and ecological consequences, as well as with other closely related factors including subsistence resource extraction and mobility. In this framework increasing permanency in site occupation can be associated with reduced mobility and enhanced and spatially constrained extractive effort leading to localized decrease of utilized biotic resources and species that depend on them. In developing his model Tchernov (1991a) drew on mammalian behavioral ecology and optimal foraging concepts that predict a linkage between mobility and extractive efficiency in subsistence resource use (see also Hamilton and Watt 1970). Among human societies mobility and resource use are also expected to affect site occupation.

The commensalism model, as it stands, does not take cultural dynamics in settlement occupation below the sedentism threshold into account in discussions of ecological dynamics and consequences for biological diversity. This theoretical shortcoming hampers attempts to identify precisely what levels of commensalism are uniquely associated with sedentism. In addition, a major drawback of the commensalism model and the linkage of sedentism and commensalism is its dependence on empirical data on the ecology of commensal micromammals in present day towns and cities which differ significantly from the environments of occupation sites of both modern and ancient smaller-scale non-urban societies. In the debate over sedentism among Natufian hunter-gatherers this problem has particular significance. A number of authors have argued that given the present evidence on commensalism some level of heightened but still seasonal site occupation is just as likely as year-round sedentary occupation (Edwards 1989; Tangri and Wyncoll 1989). Tangri and Wyncoll (1989) have pointed particularly to the context of seasonal settlements of transhumant pastoralists as one likely to support populations of commensal species because such settlements may be used for many years but on a seasonal rather than permanent basis. In order to examine this proposition and to test Tchernov's model, data have long been needed on the ecology of small animal communities in pastoral settlements and those of other mobile societies. Consideration of the ecology of small animal communities in seasonal settlements of mobile pastoralists should contribute to assessing the validity of the commensalism-sedentism linkage as well as to broader applicability of the commensalism model to the archaeology of a broad range of societies from sedentary to more mobile.

2.4 The Measurement of Mobility, Sedentism, and Site Occupation

The goal of this study is to assess the impact of Maasai pastoral settlements on micromammalian communities in a manner that will also ensure comparability with impacts of more sedentary settlement contexts. This hinges on the ability to reliably quantify degree of mobility and the level of occupation of the study settlements. In this section, therefore, I review literature on the way that mobility, sedentism, and site occupation have been conceptualized in archaeological research. There have been few attempts to address the issue of mobility in archaeology by obtaining more precise and quantitative indications of the level of site occupation. In contrast, ethnoarchaeological studies especially those conducted among hunter-gatherer societies often provide detailed information on aspects of site occupation including numbers of people, the duration of stay in numbers of days or months, and the periodicity of reuse of particular locales. My review of ethnoarchaeological approaches to describing site occupation provides an important basis for this study because the main objective is to develop a method for obtaining more precise indications of site occupation in archaeology. I use this review to establish appropriate measures for the study of seasonal mobility in Maasai settlements occupied for both the short and the long term.

Current understanding of the ways in which site occupation is related to physical and material manifestations of site formation is rudimentary and often contingent on interpretations of subsistence data. Information from studies in different ethnographic contexts ranging from hunter-gatherers to agricultural societies demonstrates that the economy and mode of use of subsistence resources does not necessarily constitute a straightforward predictor of patterns of site occupation. Simple trends linking economic strategies to the manner and intensity in which occupation sites are used should not be expected especially among societies pursuing a wide range of economic options including farming, herding, foraging, and even involvement with external markets through wage labor and trade (Kent and Vierich 1989; Hard and Merrill 1992; Kelly et al. 2005). A number of scholars have demonstrated that especially complex relationships can exist among such factors as economic strategy, social organization, and degree of mobility (Stone 1997; Kelly et al. 2005). Such factors in turn can be expected to affect the level of site occupation. The above discussion suggests that any attempt at describing mobility or settlement occupation in ethnographic contexts must be as explicit and specific as possible regarding the qualities of mobility being described. Specificity is needed regarding spatial and temporal dimensions and group size and composition. In cases of cross-cultural and diachronic comparisons, such as when relatively mobile groups are compared to more sedentary ones through time, the standardization of terms used by archaeologists to describe modes and degrees of mobility is especially important.

The length of time that settlements have been occupied and the practical limitations on collection of data on settlement occupation have affected the level of precision with which archaeologists have characterized settlement occupation in ethnographic or ethnoarchaeological studies of contemporary settlements. Thus, Yellen and Hitchcock, in their studies of Kalahari Desert foragers, are able to provide the number of days of occupation for settlements occupied for less than a month (Yellen 1977: Table. 5; Hitchcock 1982: Table 8.3). For settlements that are occupied longer than a month, Hitchcock provides only the number of months of occupation. Kent and Vierich (1989) in their study of Kalahari settlements adopt an even less precise approach classifying settlements into three groups according to length of occupation in months: short = < 2.9, medium = 3-5.9, and long = > 6 (Kent and Vierich 1989: Table 9.1). This approach of placing all of the settlements in the study on a single scale of measurement and using a uniform unit of measurement allowed Kent and Vierich (1989), however, to quantitatively assess the effects of settlement occupation on other settlement characteristics. Kent and Vierich (1989) were also able in this way to make cross-cultural comparisons among groups of foragers and agro-pastoralists with different patterns of social and economic organization and mobility.

The main difficulty in applying some of the above approaches to this study is that in comparison to the Kalahari settlements, contemporary Maasai settlements in the study area are used for considerably longer periods and throughout their history occupation is intermittent and follows a systematic seasonal pattern. This means that a simple enumeration of the number of years of use of the study settlements would not account for the fundamental property of intermittent occupation in Maasai settlements. Nor would this method account for variability among the study settlements in the proportion of each year during which they are occupied (i.e., the distinction between long- and short-term seasonal settlement occupation). Ethnographic and ethnoarchaeological studies typically discuss pastoral settlements in terms of general qualitative categories such as permanent *versus* temporary or long- *versus* short-term in relation to particular portions of the year, or wet and dry seasons (e.g., Jacobs 1975; Western and Dunne 1979; McCabe 1994; Chang 2006). Such concepts are useful for describing different patterns of land use such as transhumance (see Cribb 1991: 15-22, 58-64) but provide only a vague idea of the range of variability and impact of settlements. An assessment of the overall level of occupation in Maasai or other pastoral settlements must take into account the extent of seasonal occupation in conjunction with the number of years that this seasonal pattern is repeated. For example, we would expect that a settlement that has been occupied for six months each year would have a greater overall level of impact than a settlement that has been occupied for three months each year, for the same overall number of years.

The length of settlement use in years and the extent of seasonal occupation have both been incorporated into the archaeological literature on sedentism, which also provides a number of useful perspectives for thinking about degrees of mobility (see reviews by Rafferty 1985; Edwards 1989; Kelly 1992; Bar-Yosef and Rocek 1998 and references therein). Recent definitions of sedentism embody the notion of degrees of permanence expressed in numbers of years of occupation (Rafferty 1985: 115) or 'year-on-year' occupation (Edwards 1989: 9). Such definitions also stipulate that sedentary occupation should be year-round, implying that the proportion of the year through which the settlement is occupied is an important aspect of the overall level of occupation. A third important point stemming from definitions of sedentism concerns the proportion of the human population of the settlement that is present during a given proportion of the year. Thus, in the case of sedentism Edwards (1989: 9) and others explicitly state that the majority of the people should be present throughout each year. Perhaps most importantly, Rafferty (1985: 114) has noted that mobility and settlement occupation as aspects of sedentism should be measured at the societal rather than individual level.

In applying lessons from the above analytical approaches to documenting the level of occupation in the study settlements I have a number of specific considerations. First, I take Maasai systematic seasonal mobility and its effect on levels of settlement occupation to represent, in Rafferty's (1985) terminology, the societal aspect of Maasai settlement use. From this perspective Maasai settlement occupation and its ecological consequences are expected to be influenced by the seasonal coming and going of settlement inhabitants as a group and in response to the requirements of herding. Second, it follows from the previous statement that at the societal level of analysis two aspects of settlement occupation – proportion of the 'year occupied' and of the 'population occupying' – should be seen as closely linked components of a single dimension of settlement occupation. Third, in terms of the unit of measurement of the dimension of seasonal settlement occupation, a focus on a societal level of analysis suggests that a basic distinction between seasons of occupation and lack of occupation is more appropriate than specific numbers of individuals per period of time. Moreover, it should be possible to reconstruct the seasons of occupation and lack of occupation year-by-year in a relatively reliable manner through a combination of observations and detailed interviews. Maasai settlements are used for so many years that this would not be the case using specific numbers of individuals.

CHAPTER 3

RODENT COMMENSALISM: ECOLOGIAL AND ARCHAEOLOGICAL APPROACHES

3.1 The Ecology of Commensalism

Although Tchernov's (1984, 1991a) commensalism model was developed to provide an additional line of evidence with which to examine hunter-gatherer mobility and has been mainly applied in the context of the Natufian culture of southwest Asia, the underlying ecological mechanism is universal. The model has, however, never been systematically tested in the field. Studies of rodent biology and ecology have focused on contexts relatively distant from human habitation or on the effects of agricultural systems or cities on rodents (e.g., Dickman 1987; Pocock et al. 2004). To accurately evaluate archaeological evidence on commensalism, therefore, archaeologists need to critically consider the ecological basis of Tchernov's model. The term commensalism literally means "sharing the table" and is sometimes used this way in archaeology (Janusek 2006). In ecology the term has been applied broadly to describing the relationship between human societies and a host of non-domesticated species of small animals. Scholars consider indirect supply of food in areas of human habitation and agriculture to be the foundation of this relationship (e.g., Macdonald and Fenn 1994). Such commensalism has been defined as a formal type of ecological interaction. The underlying ecological mechanisms of commensalism detailed by Tchernov (1984) accord with theoretical ecological understanding of this concept (Dickman 1992, 2006a). By definition commensalism between two species involves a positive effect for one partner and a neutral effect for the other and is denoted as a +/0 interaction. Such effects are measured at the level of specific populations, refer to characteristics such as size of the population when at equilibrium, and comprise net outcomes of the interaction that outweigh all others. Commensalism is generally understood to occur when one species indirectly increases the availability of food or shelter and/or reduces pressure from competing species and predators for a second species (Dickman 1992, 2006a).

The concept of environmental engineering or niche construction also provides a useful context for understanding the effects of commensalism. Environmental engineering refers to the creation, modification, or maintenance of environments through alterations in physical conditions that ultimately lead to control of the supply of certain critical resources to affected organisms (Jones et al. 1994, 1997). Research in this area provides a theoretical breakthrough in the study of the ecological basis for interactions of facilitation in biological systems and is based on the understanding that numerous interactions in all ecosystems occur indirectly through alterations in the suitability of species' environments (Jones et al. 1994, 1997; Dickman 2006a). Because of the positive effect of commensalism it may also be referred to as facilitation. Mutualism is another type of ecological interaction with positive effects that may be considered in the framework of environmental engineering. This interaction differs from commensalism, however, because it involves positive effects for both of the interacting species (+/+). It is important to emphasize that the framework of environmental engineering explicitly excludes direct effects of resource exploitation such as through predation or competitive interactions. Environmental engineering is typically identified in situations where the activities of environmentally more dominant species alter physical conditions in the environment and indirectly affect the supply of resources to a host of other species. Jones et al. (1994, 1997) discuss a wide range of examples of engineering with largely positive effects. These include trees in forests that transform the microclimatic conditions for numerous species through their own physical structure (autogenic engineering) and beavers that contribute to the creation of wetlands supporting a wide range of species through their dam building activities (allogenic engineering). They (Jones et al. 1994, 1997) argue that humans are highly specialized environmental engineers capable of widely varying modes and levels of environmental modification with positive effects for commensals but negative effects for other species. The mode and level of environmental modification in varying settlement contexts may be related to specific ecological consequences such as commensalism. In light of this, it is especially significant that commensalism can be conceptualized to involve a contribution by the unaffected interactant to the suitability of the environment for its commensal partner (Tchernov 1984, 1991a).

The biological and ecological characteristics of commensal species in human environments are an important consideration if we are to establish a better understanding of this phenomenon and reliable methods of identifying commensalism in archaeological situations. Tchernov (1991a) observed that the traits of successful human commensals may be equivalent to those of adept colonizers (i.e., invading species) and that a colonizing ability may represent a preadaptation to commensalism. Such traits are identified in recent research on invasive species and summarized by Sakai et al. (2001). These include tolerance of environmental stress, disturbance, and heterogeneity based on behavioral and/or phenotypic plasticity and adaptive propensities; high productivity and reproductive flexibility (i.e., r-selected life-history strategies); competitiveness through aggressive behavior; broad dietary preferences; and wide distribution across varied habitats. To these may be added high genetic diversity and ability for rapid genetic change within areas of human habitation, which have been extensively researched in the house mouse (e.g., Britton-Davidian et al. 1989; see also Pergams and Lacy 2008).

The relevance of such traits to commensalism is also widely supported by studies of the population biology and ecology of micromammalian species in human environments. Braithwaite (1980) has examined the question of commensalism by focusing on what he considered to be a set of co-adapted life-history characteristics in a population of native Australian rats (*R. lutreolus*) in a commensal situation. The study compared the rat population inhabiting a zoo in a rural area of southeast Australia to a wild-ranging population of the same species. The results of this study indicated a switch to a more omnivorous and varied diet, increased rates of reproduction and growth, greater population density, and more extensive and generalized spatial use of habitat in the zoo situation. Braithwaite (1980) linked the effect of the zoo on the rat population to the heightened availability of food in the form of animal feed during the local season of food stress (winter) and of moisture through irrigation during the dry season (summer). There was also evidence to suggest that the increased population of native rats excluded other species of exotic rats and mice. Similar dynamics in human settlement environments have been demonstrated in a range of other case studies (Andrzejewski 1978; Berry 1981; Ganem 1991, 1993; Canova and Fasola 1994; Tchernousova 2001, 2002; Pocock et al. 2004). Taken together these studies indicate that the conditions provided by human settlement environments can mitigate limitations on population size that pertain in non-commensal habitats but that only species with suitable preadaptations and a competitive advantage can benefit from such environments. It is especially significant in the context of this study that Braithwaite (1980) saw the ecological process of commensalism as a function of the continuation of human activities.

The only ecological study I am aware of to date that has specifically examined the influence of short term human occupations on micromammalian communities was conducted in the garbage dump of a seasonal holiday retreat in Canada (Courtney and Fenton 1976). In this study micromammals were monitored through a standard trapping technique within the dump area and in an offsite control area. Trapping revealed that some species were more abundant in the dump whereas others were more abundant in the outside control. Greater abundance in the dump was also associated with higher levels of female fecundity and juvenile survival that could be tied to increases in population size. The data were collected throughout one season in which the dump was in use and also showed that the early colonizers of the dump from the indigenous micromammalian community were later excluded to some extent following the introduction of exotic house mice.

Courtney and Fenton (1976) argued that the omnivorous feeding habits of certain local species allowed them to colonize the dump and to take advantage of the availability of the food and shelter that it provided. These species were subsequently out-competed by house mice, which showed greater levels of aggression in inter-species encounters and tolerated higher population densities. Perhaps the most significant finding of the study was that the house mouse population of the dump died out once use of the dump ceased following the end of the holiday season. Courtney and Fenton (1976) argued that the seasonal and discontinuous use of the dump prevented house mice from establishing stable populations. This study also demonstrated that the intensity of human occupation influenced the structure and composition of the micromammalian community. This would appear to support Tchernov's (1984, 1991a) hypothesis and the inference that a high abundance of commensals in an archaeological context indicates relatively continuous human occupation (e.g., Hesse 1979).

3.2 Commensalism in Archaeology

Archaeologists conducting research on human/animal commensalism have drawn heavily on principals and basic empirical data from ecology. As a result of the complexity of social, environmental, and ecological factors that have affected commensalism historically, however, there is a need for such theoretical and empirical knowledge on commensalism from a variety of cultural contexts in present day settlement settings. To date, the remains of commensal species of micromammals have been used by archaeologists in varied ways. The appearance or increase in frequency of commensals or of species that are commonly known to occur in humanly modified habitats (i.e., "disturbance species") have been tied to processes of sedentarization (Bar-Yosef and Tchernov 1966; Hesse 1979; Tchernov 1984, 1991a; Dean 2005), early urbanization (Ervynck 2002), or urban intensification (O'Connor 2003: 197-198) in Asia, Europe, and North America. The geographic and genetic distribution of commensals have also been linked to human migrations, colonization events, and expansion of trade (Plug et al. 1979; Auffray et al. 1990a; Vigne 1992; Armitage 1993, 1994; Boursot et al. 1993; Morales Muñiz et al. 1995; Audoin-Rouzeau and Vigne 1997; Matisoo-Smith et al. 1998; Cucchi et al. 2002; Wilmshurst et al. 2008).

The earliest hypothesized case of commensalism in the archaeological record is that of the house mouse in Natufian sites of southwest Asia. The argument for the existence of commensalism in the Natufian has been based on the combination of data on material culture, osteological remains, and the ecology of commensal house mice.

Remains of the now cosmopolitan western European house mouse (*M. m. domesticus*) have been identified in sites of complex Natufian hunter-gatherers and associated with other evidence for sedentarization and increasing permanence in site occupation including large site size, high artifact densities, and durable construction (Bar-Yosef and Tchernov 1966; Tchernov 1984). Tchernov (1991a, b) argued that the appearance of such a new commensal species presupposed the creation of a highly modified anthropogenic environment in the context of sedentarizing habitation sites, conditions for isolation from wild-ranging populations, and rapid *in situ* speciation. This is supported in part by analyses of mitochondrial DNA (mtDNA) that show that the western European subspecies of house mouse originated in eastern parts of western Asia and underwent a post-glacial westward expansion at the end of the Pleistocene coinciding, it is thought, with the timing of the Natufian culture (Auffray et al. 1990a; Auffray and Britton-Davidian 1992; Boursot et al. 1993; Rajabi-Maham et al. 2008).

Archaeologists and paleoanthropologists have also employed data on the present day ecology of this commensal species to argue that the development of sedentary habitation sites played a major role in the origins and expansion of house mice during the terminal Pleistocene. Auffray and colleagues (Auffray et al. 1990b) demonstrated that in southwest Asia today house mice are sympatric in a part of their range with a wild-ranging con-genre (*Mus macedonicus*) (formerly *M. spretoides*; see Auffray et al. 1990a) and that in the zone of sympatry in relatively humid Mediterranean areas they are mainly restricted to commensal habitats associated with human settlements and agricultural fields (Auffray et al. 1990b). Given that outside the zone of sympatry in drier areas commensal house mice can also occur as feral populations, Auffray et al. (1990b) argued that where sympatric the two species occupy separate commensal and non-commensal habitats and maintain habitat separation (i.e., habitat partitioning) through competitive exclusion. The fossil record of mice of the genus *Mus* in southwest Asia suggests, furthermore, that such habitat partitioning between wild-ranging and house mice may have existed since the terminal Pleistocene. Auffray's (Auffray et al. 1988) analysis of morphometric variability in cranial characters of fossil material has shown that the wild-ranging form occurred in southwest Asia since the Middle Pleistocene and confirms the introduction of house mice during the terminal Pleistocene or in Natufian times. Tchernov (1991a, b) has argued that given what is known about interspecies interactions, the availability of a commensal habitat would have been necessary for the initial colonization of southwest Asia by house mice. Due to the lack of data on the association of house mice with a variety of settlement settings, from more sedentary to more mobile (see Edwards 1989; Tangri and Wyncoll 1989) the precise degree of sedentariness that would have been required for colonization of settlement habitats remains an open question.

A different ecological scenario has been put forward to account for the continued westward expansion of house mice into parts of Europe during the Holocene. A recent revision of the available fossil data on house mice in European archaeological sites reveals how ecological, climatic, and cultural-historical factors have combined to shape their expansion (Cucchi et al. 2005; see also Auffray et al. 1990a). According to the study by Cucchi et al. (2005) an initial wave of expansion during the terminal Pleistocene and early Holocene (c. 14,000-8,000 bp) seems to have been restricted to the Eastern Mediterranean encompassing the regions of southwest Asia, Asia Minor, and the island of Cyprus. This was associated first with sedentarization and later with the further establishment of early farming communities of the succeeding Neolithic cultures. Archaeologists have identified remains of house mice in secure chronological contexts from more western regions of Europe only from much later periods of the European Iron Age after 3,000 bp. Cucchi et al. (2005) argue that the significant lag in the spread of house mice into Europe can be accounted for through a combination of factors that affected opportunities and constraints for the diffusion process. In spite of the early spread of farming into Europe and extensive maritime traffic across the Mediterranean, successful colonization by house mice appears to have been prevented by the colder climate, presence of better-adapted native commensals such as the wood mouse (genus *Apodemus*), and late intensification of human settlement in conjunction with the development of urban communities. Archaeologists have argued (Cucchi et al. 2005) that under colder climatic conditions than in their original area of distribution in western Asia house mice would have become dependant to a greater extent (i.e., obligatory commensalism) on the insulating conditions of human occupation sites for providing conditions for permanent establishment and a competitive advantage vis-à-vis indigenous commensal species.

Accurate interpretation of such sequences in terms of developments in mobility and intensification in settlement occupation depends on the availability of detailed knowledge from the present day regarding the biology, ecology, and relationship of the suspected commensals with humanly modified environments. This can be demonstrated on the basis of the research of Dean (2005), O'Connor (2000), and others (Somerville 1999). Dean (2005), in a recent study based in the southwest US, used remains of a range of small, wild, non-prey animals from sites representing a record of over 4,000 years to track ongoing developments in site occupation and related subsistence change. Samples ranged from sites of early hunting and gathering through later fully agricultural societies of the region. Her results indicated gradual increase though time in the frequency of species thought to have been attracted to sites as a function of increasing environmental disturbance and intensity of site occupation. Dean (2005) built her case on knowledge regarding the contemporary association of such species with a variety of humanly disturbed environments.

Similarly, in their endeavor to reconstruct early urban environments of medieval sites in England, O'Connor and students (O'Connor 1992, 2000; Mulkeen and O'Connor 1997; Piper and O'Connor 2001) have relied on fundamental ecological concepts including the nature of interspecies interactions and the ecological niche. Their findings suggest the development of urban communities of small animals as a result of urban intensification and the reorganization of refuse disposal. Analysis of the micromammalian remains from the Coppergate site at the medieval city of York, for example, showed that deposits from the ninth century included native species of rodents (*Apodemus sylvaticus* and *Clethrionomys glareolus*) whereas during the succeeding century these were replaced by introduced house mice and rats (O'Connor 2003: 197-198).

The above examples highlight the way that complex ecological scenarios relate to important developments in culture-history. Commensalism, interactions between native and introduced species, and the opening up of unique ecological niches in relation to the nature and scale of specific human activities all play a role in changing relations among people and rodent communities during times of social changes and settlement reorganization. Although these studies rely on general ecological principals there have never been any field studies designed to examine relations between human mobility or sedentism and rodent communities.

To infer varying degrees of mobility and different levels of site occupation using small animal remains archaeologists need a detailed understanding of corresponding changes in the composition and structure of small animal communities. These relationships can only be investigated in present day situations. The niche is an especially useful concept for archaeologists wishing to reconstruct past human environments based on modern analogues because, although particular species are often restricted in geographic range or may become locally extinct through time, their ecological roles are expected to be filled by other species with equivalent habitat requirements (O'Connor and Evans 2005: 29; see also Dickman and Murray :2006 331). The niche or ecological role of animal species within a given community of coexisting species is a description of the resource space that animals occupy or the spatial, temporal, and trophic aspects of their utilization of the habitat (see Krebs 1999: 455-458; Morin 1999: 53-59; New 2006). The ecological role of species determines their abundance in various circumstances and should also be closely linked to the likelihood of incorporation of their remains into various types of archaeological contexts.

More broadly, the concepts of commensalism and environmental engineering also resonate in recent thinking regarding the mechanisms responsible for the development of plant and animal domestication. B.D. Smith (2007) has argued that the ways that humans have engineered their own environment and affected associated species of plants and animals represent a general behavioral context for processes leading up to domestication. O’Connor (1997), Zeder (2006, in press) and others (Masseti 2006) have also called to the forefront consideration of a wide spectrum of ecological relationships among humans and animal species in humanly modified environments that may have played an important role in initiating the processes that eventually culminated in the more direct exploitative interactions of domestication. Rindos (1984: 139) has already advanced similar ideas with regard to plant domestication in terms of symbiotic relationships wherein humans contributed to dispersal and protection of economically useful species in areas of habitation (see also Anderson 1952: 136-150; Smith B.D. 1992: 23). It is clear that the human occupation site constitutes a highly localized spatial locus for the concentration of human social activities. The diversity of related forms of environmental modification has undoubtedly been an especially significant setting for a broad range of forms of environmental engineering. This realization calls for greater investment in development and testing of archaeological models of environmental and ecological processes specifically associated with human occupation sites. In this context, consideration of the positive contributions of human settlement environments to populations of associated species of small animals is especially relevant.

CHAPTER 4

THE STUDY AREA AND MAASAI PASTORALISM

4.1 The Study Area

The study area is located within the current residential territory of Maasai pastoralists in the administrative district of Kajiado, Kenya. This is a semi-arid region of southern Kenya roughly 50 km north of the foothills of Mt. Kilimanjaro (Figure 4.1). It is part of the Amboseli Plains ecological zone characterized by relatively gentle topographic gradients and bisected by water courses with seasonal flow. The plains are flanked by hilly regions of higher elevation to the west, north, and east (de Leeuw 1991). The study area lies at c. 1,200 masl and receives 447-625 mm of annual rainfall on average (Touber et al. 1978a, b). The vegetation is dominated by *Acacia-Commiphora* bush which is associated with a shallow red sandy soil. There are two rainy seasons that occur during October-December and March-May and are followed by the short and long dry seasons, respectively. Prolonged droughts are a recurring phenomenon and have occurred once or twice in each decade of the last century. Mobile pastoralism is the predominant land use and rainfed farming is not sustainable in most years due to the localized and highly variable nature of rainfall, relatively high rate of evaporation, and nature of the soil (de Leeuw 1991; de Leeuw et al. 1991). The study area was confined to the Maasai locality of Eselenkei (Figure 4.1), which is used communally by three sub-clans of the Kisongo section. Such Maasai localities today are also state registered territorial units known as group ranches and are administered by locally elected officials (Grandin 1991).

Figure 4.1. Map of the general region encompassing the study area showing important geographic features including higher elevation areas and water courses and local administrative boundaries surrounding the study area.

Within group ranches such as Eselenkei, settlements are today clustered into "neighborhoods" and separate clusters are maintained for main residences (sing. *emparnat,* pl. *imparnati*) that are occupied during wet seasons and for short-term dry season camps (sing. *enkaron*) (Grandin et al. 1991; Worden 2007: 32; see also Western and Dunne 1979). I use Maasai terminology of settlement types in the remainder of this volume. In years of substantial rainfall *emparnat* settlements may be occupied during the dry season as well. Settlement neighborhoods are strategically located so as to allow access to permanent sources of water such as riverbed wells and more recently bore holes and pipelines as well as to designated pasture areas for both wet- and dry-season grazing (Grandin et al. 1991). It is important to note that in contrast to some adjacent areas of Maasai territory to the north, in Eselenkei locality land continues to be used and managed communally and households extensively cohabit settlements and cooperate in herd management (Worden 2007: 25). In contrast, territories to the north that receive greater amounts of rainfall are undergoing rapid privatization of land and individual herders now manage animals which has considerable implications for settlement patterns.

This region falls archaeologically within the general area of distribution of the Savannah Pastoral Neolithic tradition (see Chapter 2: Fig. 2.2b). The climate zone is drier, however, and of lower elevation than many other parts of the Rift Valley where Pastoral Neolithic sites have been uncovered. It also has not been subjected to systematic archaeological survey (M. Muia pers. comm., 2006). A localized surface survey in a section of the study area that was conducted in cooperation with Mulu Muia of the National Museums of Kenya (Weissbrod and Muia n.d.) uncovered a single diagnostic piece of ceramic ware (Figure 4.2) that was identified as Narosura ware, of the ceramic traditions of the SPN (S. Wandibba pers. comm., 2006). Given the relatively arid conditions in the general region of the study area it seems likely that SPN pastoralists used the area on a sporadic basis during wet seasons when temporary water holes became filled. This pattern of pastoral land use was documented in the 1970's among Maasai herders occupying the region (Western and Dunne 1979).

Figure 4.2. Ceramic fragment from the study area with band of incised lines that is often found on ceramic wares of the Narosura ceramic tradition of the SPN (e.g., Odner 1972: Fig. 24a). Scale: 5 cm.

4.2 Ethnographic and Ecological Aspects of Contemporary Maasai Pastoralism

Data from linguistic studies, oral histories, and archaeological investigations suggest that Nilotic Maasai pastoralists migrated into East Africa and the central Rift Valley in recent centuries and possibly as late as the seventeenth and eighteenth centuries (Jacobs 1975; Lamprey and Waller 1990; Sutton 1990: 49). They are thought to have displaced previous populations of pastoralists in the open plains of the floor of the Rift Valley mainly through force. Their superior military power has been attributed to the acquisition of technologically advanced iron spears and efficient mobilization of warriors (Sutton 1990: 52). Prior to the institution of British colonialism in East Africa Maa speakers constituted a dominant political element among societies of the region and occupied extensive and contiguous tracts of the most productive savanna areas of the central Rift Valley from Kenya to northern Tanzania (Galaty 1993; Lamprey and Waller 1990; Hughes 2006: 3-5). Since the end of the nineteenth century as a result of internal conflict, large scale livestock disease outbreaks, and colonial land annexation, though, Maasai populations in Kenya have been displaced from a large portion of their previous range and concentrated in reserved areas of southern Kenya (Hughes 2006: 5-7). Since independence in the 1960's the development agendas of the state have emphasized tenure reform through land privatization and have placed continued pressure on land in Maasai territories (Galaty 1980; Grandin 1987, 1990). Encroachment by neighboring agricultural peoples in areas with sufficient rainfall or availability or water for irrigation has been an additional source of pressure on Maasai land.

Still, the social and economic phenomenon of specialized pastoralism that characterizes Maasai society in the study area is distinctive to East Africa and aspects of this system developed in southern Kenya as early as the Pastoral Neolithic period c. 3,300 bp (Marshall 1990a, b, 1994, 2000; Smith AB 1992: xii). Maasai social and economic organization as well as that of other linguistically related (Nilotic) East African groups such as the Samburu and Turkana revolves around the keeping of livestock. This influences subsistence, social structure, relations with neighboring groups, external markets and state administration, and land use and mobility patterns (Jacobs 1975; Dyson-Hudson and Dyson-Hudson 1980; Smith AB 1992: Ch.7; Sperling and Galaty 1990; McCabe 1994; McCabe et al. 1999). As with many pastoral societies across Africa and around the world Maasai pastoralism represents a combination of three critical factors including economic dependence on livestock, occupation of relatively arid environments that typically do not support long-term agricultural pursuits, and mobility in response to seasonal and geographic variability in rainfall and the distribution of pasture and water resources necessary for the maintenance of people and livestock. There is, however, great variation within East Africa, as there is worldwide, in the social and mobility strategies that different groups of pastoralists employ in coping with the conditions of their environment (Dyson-Hudson and Dyson-Hudson 1980; Galaty and Johnson 1990). Maasai social and mobility strategies and the ways in which they are intertwined with the centrality of livestock management are key factors for understanding Maasai patterns of settlement occupation.

Two central principals structuring Maasai society are the organization of labor required for conducting the varied tasks of livestock keeping at the household level and the management of risks from environmental unpredictability. One of the key approaches to managing risk is through social relations of mutual aid based on kin ties (clans, sections, and moieties) and grouping of men by age sets (Jacobs 1975; Sperling and Galaty 1990; Grandin 1991). Maasai society is patriarchal and polygamous and herds are typically owned and managed by men and their extended household that may include a number of wives, their children, and dependant relatives (Jacobs 1975). The need for cooperation with kin or age-set partners for herding can also influence joint residence patterns in Maasai settlements, which are often comprised of a number of co-residing households (Jacobs 1975; Grandin et al. 1991).

Maasai subsistence is ideally derived from the products of livestock including meat, milk, and blood, but also includes non-pastoral foods such as grain or honey that in the past would have been acquired from neighboring hunter-gatherer or agricultural groups and today is purchased from commercial markets (Sperling and Galaty 1990). A taboo prohibiting the consumption of game meat is seen to reflect Maasai ideological commitment to a pastoral economy and subsistence, however (Jacobs 1975). In spite of increased access to external markets, livestock and especially cattle continue to represent for the Maasai a major source of wealth, individual prestige, and value symbolism (Galaty 1980; Grandin 1991; Ryan et al. 2000).

African pastoral societies in more arid and less politically stable regions respond to a wide variety of environmental, social, and political stresses including droughts and armed conflicts, by undertaking relatively large scale systematic or periodical movements (Stenning 1957; McCabe 1994; McCabe et al. 1999). By comparison, Maasai households of the productive central Rift Valley region of Kenya are considered to be fairly sedentary (e.g., Bower 1984). Their annual cycle of migration is relatively small-scale in its geographical extent and follows a highly regular pattern mainly involving a shift between fixed wet- and dry-season settlement areas (Jacobs 1975; Western and Dunne 1979). Households maintain relatively established settlements with long lasting construction in areas in proximity to permanent sources of water whereas more ephemerally constructed camps with short-term use are positioned within areas of seasonal grazing reserves farther away from the permanent water sources (Jacobs 1975; Western and Dunne 1979; Grandin et al. 1991). Depending in large part on available labor for the tasks of herding, seasonal shifts with the herds to temporary camps may involve young men only, other members of the household, or entire households. Severe droughts that occur in East Africa periodically can bring about more extensive movement away from long-term settlement areas and migration with the herds and entire households to better-watered regions at higher elevations where pasture is available (Western 1975).

In a detailed study of Maasai patterns of settlement use in the Amboseli area (Figure 4.1) Western and Dunne (1979) identified a range of environmental factors affecting decisions regarding settlement location and length of use and linked them to the relatively high occupational stability of Maasai settlements. The authors showed that the optimization of access to water and pasture is a primary consideration in settlement location but that secondary environmental considerations related to the welfare of people and livestock also play an important role. In their study, settlement locations were associated with gentle topographic gradients, proximity to hilltops where the soil is well drained, and vegetation of low canopy and proportion of cover, all of which are conditions that contribute to minimizing stresses to livestock. Specific stresses that they cite include physical exertion, health risks such as fleas, and the danger of predation. Western and Dunne (1979) argued that in an environment where seasonality and rainfall are relatively predictable and ideal locations for settlement are in short supply, greater occupational stability may be expected and that in the long run this is advantageous in terms of the amount of labor diverted to the construction of new settlements. They observed that in their study area settlement use-life was typically no longer than 7-10 years due to eventual excessive accumulation of livestock dung within the settlement enclosures, which posed health risks. The average use-life of settlements was 3.7 years (Western and Dunne 1979). Moreover, they suggested based on analysis of aerial photographs covering a period of two decades that locations of abandoned settlements are reoccupied within 20-25 years. Although ideal ecological locations for settlements may be used continually, the sites of long-abandoned settlements themselves are not reused and multiple such sites are highly visible in the study area (pers. obs.; see also Worden 2007: 35).

Research on Maasai patterns of land and settlement use over the past several decades within the wider region of the Amboseli Plains and adjacent areas has also revealed considerable change over time and a general trend towards increased sedentarization (Grandin 1987; Grandin et al. 1991). Sedentarization in Maasai areas in southern Kenya has been linked to land tenure reform by the state since the 1960s, which has emphasized privatization. Local efforts to establish and fortify land security in the face of long-term erosion of Maasai territories have also played a role in reducing mobility. Responses have included the parceling of land out to individual private owners, reduction in the number of households cohabiting settlements, individualization of herd management, and an overall increase in settlement longevity (Grandin 1987; Grandin et al. 1991).

The effects of such transformations in land tenure and associated impacts on land use have been unevenly distributed across the various Maasai areas, however. In relatively dry areas such as the study locality of Eselenkei, communal use of land, broad relations of cooperation, and spatially extensive access to grazing grounds continue to be important (Worden 2007: 25; see also BurnSilver et al. 2003). Worden's (2007) survey of occupied and abandoned settlements in the area of Eselenkei locality has shown that in recent decades, permanent settlement has spread to include areas formerly used on an ephemeral basis only during wet seasons. He also demonstrated that settlement has become more spatially aggregated to form distinct settlement clusters, and that the rate of settlement abandonment has decreased appreciably (Worden 2007: 35). Moreover, the average length of settlement use in this area now – >7 years (Worden 2007: 36) – is nearly twice as that recorded in the region by Western and Dunne (1979) during the 1970's. These processes are related in large part to the development of additional permanent sources of water such as bore holes within previous wet-season dispersal areas. Additional infrastructure that can influence decisions regarding settlement use and reduced mobility among contemporary Maasai pastoralists includes schools, shops, churches, and clinics, which are sparsely distributed in the study area. Although the mobility of settlements has decreased, the mobility of people and herds continues to be relatively flexible and spatially extensive in the Eselenkei study area due to adherence to communal use of land.

As ecological and engineered environments Maasai settlements are characterized by spatially focused human activity related to the fundamental need to house livestock within the settlements at night for protection from predators (Western and Dunne 1979). Such activities include the construction of dung and branch houses, which can last up to a decade or more and utilization of surrounding vegetation for construction, settlement maintenance, and firewood. The settlements also function as livestock enclosures and accumulate considerable quantities of dung (Western and Dunne 1979). Grazing by livestock also depresses vegetation growth in and around Maasai settlements. Additional characteristics of Maasai settlements that can be expected to affect ecological interactions include the relatively small and constant size of the human population, the proportion of large *versus* small stock in livestock herds, and the presence of small numbers of cats and dogs. People living in settlements in the study area also deposited little or no organic trash and did not grow crops. This differentiates study-area settlements from those in more sedentary contexts, which as a result of increased trash accumulation and grain storage provide sources of food for commensal species. On the other hand, livestock dung contains abundant seeds and insects, which are important in the diets of many species of micromammals. I consider these characteristics to be aspects of engineering and as proximate factors that underlie the overall effect of the creation and maintenance of Maasai settlements. This study addresses the overall ecological effect of Maasai settlements by comparing the settlements to outside habitats and examining ecological processes along a gradient of increasing level of human occupation.

In spite of recent reductions in mobility and the increasing longevity of settlements, however, the number of people living in the settlements continues to vary seasonally with a shift towards increased logistical mobility (sensu Binford 1980). As a result, it can be expected, following Western and Dunne (1979) on the one hand, that vegetation reduction will increase with increasing settlement longevity (Western and Dunne 1979). Reid and Ellis (1995) and Muchiru et al. (2009) have demonstrated, however, that the accumulation of livestock dung also has a significant and positive impact on vegetation by concentrating seeds, enhancing nutrient contents, and facilitating germination. This impact may mainly be realized, however, after final abandonment of a settlement through the creation of islands of dense vegetation, which also draw intensive use by large herbivores (Muchiru et al. 2008, 2009).

To date, there are no data that I am aware of on the impact of Maasai settlements on communities of micromammalian species. Contemporary rodent communities in East African savannas vary significantly, however, in the composition and relative abundances of species due to differences in rainfall, vegetation, and the degree of human habitat disturbance (Delany and Roberts 1978; Delany and Happold 1979: 133-135; Delany 1986). Rodent abundance and population density is negatively affected, in general, by grazing and trampling of vegetation by wild and domestic animals and by human use of fire (Keesing 1998; Salvatori et al. 2001). Habitat modification in pastoral settlements is expected to differ from wider landscape patterns due to much greater intensity of vegetation depletion, increased dung accumulation, and human activity (Muchiru et al. 2008, 2009). So far, cosmopolitan commensal species including house mice and rats have been recorded in a number of regions of East Africa, but seem to be restricted to urban and agricultural areas (Kingdon 1974a: 578-581, 604).

4.3. Applicability of the Study to the Archaeology of Pastoralism in East Africa

A number of broad similarities can be identified between contemporary and prehistoric pastoral societies of East Africa including the general physical and environmental setting as well as mobile herd-based economic pastoralist systems that have been adapted to these conditions (Ambrose 1984; Marshall 1990a, b; Kusimba and Kusimba 2005). It has also been argued, based in large part on evidence from linguistic studies, that present day and Neolithic pastoralists of East Africa may have belonged to the same broad language groups (Ambrose 1982; Smith 1992: 178-179; Ehret 2002). Cushitic (Ethiopian) and Nilotic (Sudanic) populations are thought to have begun migrating into the region early on in a number of separate events. Historic and archaeological studies show, however, that there has also been considerable change through time in the ethnic composition, geographic configuration of economic activities, and settlement patterns of East African pastoralists (Lamprey and Waller 1990; Sutton 1990: 33-56; Kusimba and Kusimba 2005). This has included the introduction of farming and iron by Bantu speaking populations from West Africa during the East African Iron Age beginning after c. 1,250 bp. More recently, colonial rule since the end of the nineteenth century and independent governance since the 1960's have affected local pastoralists in different ways (see Sperling and Galaty 1990).

It is important to emphasize that in the context of the present study the main focus is not expressly on capitalizing on the similarities expected between contemporary and prehistoric East African pastoralists but rather on the variability in levels of settlement occupation that can be observed within a defined existing system. I am interested in exploiting that variability to examine the effect of settlement occupation on the ecology of local micromammalian communities. Exploring such ecological interrelationships among biotic communities and a specific aspect of human behavior in the observable present, namely settlement occupation, should constitute a relevant analogy for interpretation of archaeological micromammalian remains where we may expect similar ecological and human behavioral contexts and a similar determining structure. This focus on human/animal relations and their ecological underpinnings should, therefore, correspond to the logic of relational analogies as explicated by Wylie (1982, 1985).

It is also important to emphasize that given the long record of humanity in East Africa encompassing millions of years of hunter-gatherers and millennia of food producers the study does not purport to unveil circumstances of incipient commensalization. Archaeological and ecological studies have revealed evidence for range expansion of native and introduced commensal species in Africa (Davis and Fagan 1962; Fagan 1969; Kingdon 1974a: 587-588, 621; Plug et al. 1979; Voigt and von den Driesch 1984) but this is not the focus of this research. Instead my goal is to focus on the ecological signal of seasonal settlements of Maasai herders and on variability in the ecological impact of settlements in order to collect empirical data of relevance to our understanding of the linkage between the process of human site occupation and commensalism of micromammalian species.

Moreover, as a result of the variability in duration of occupation and the length of time that people in the study are spending in settlements from year to year and contrasts between this pattern and more sedentary contexts with year-round and long-term occupation and large and growing human populations, it may be expected that the study will have broad implications for the ability of archaeologists to develop specific predictions for inferring levels of site occupation and degree of mobility from micromammalian remains in both seasonal and sedentary contexts.

CHAPTER 5

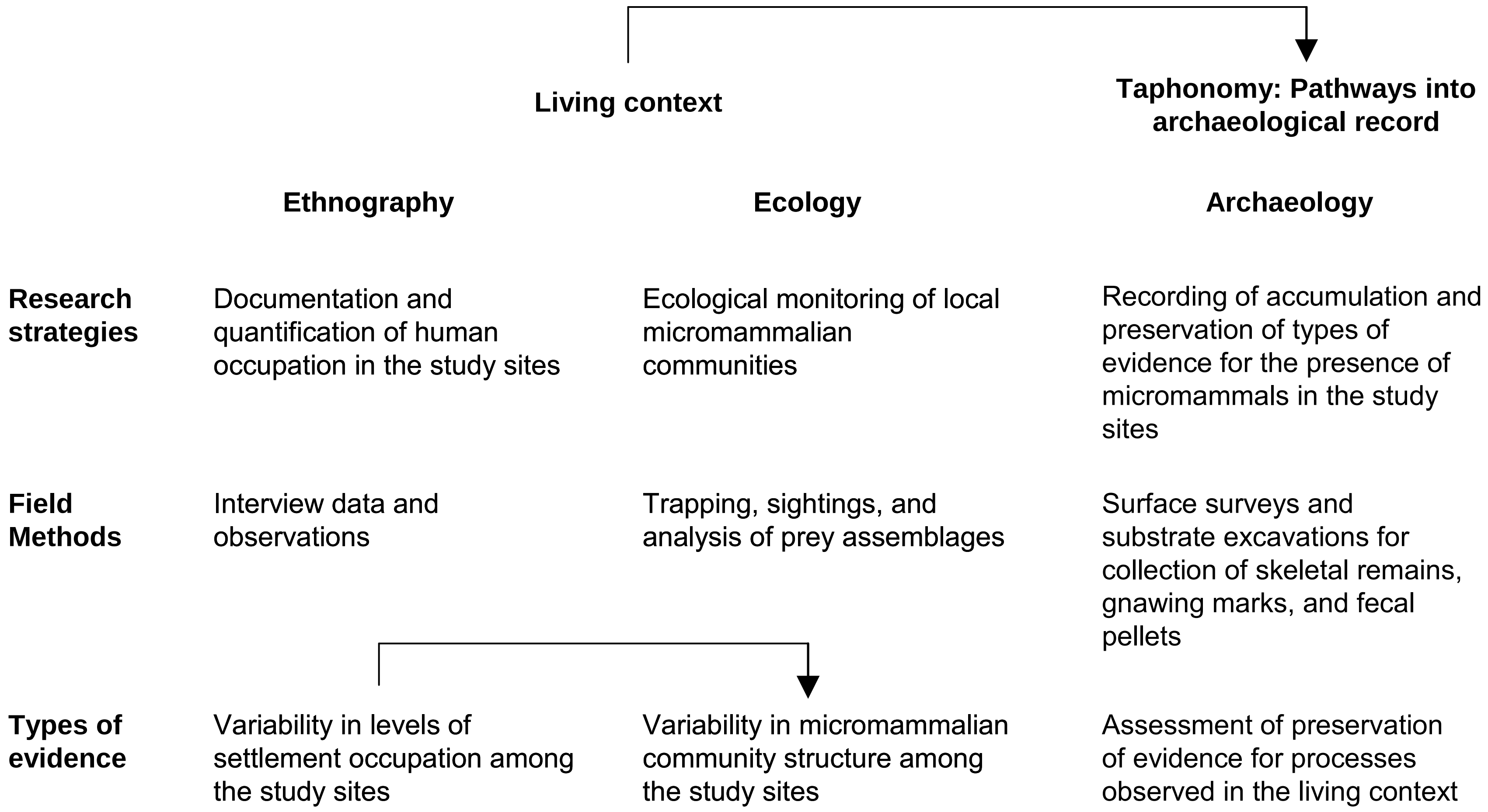
RESEARCH DESIGN AND METHODS

5.1 The Study Design

This study was designed to evaluate the prediction made by Tchernov's (1984, 1991a) model on the impact of increasing levels of human settlement occupation on the structure of local small animal communities. Data collection and analysis were based on a combination of ethnographic, ecological, and archaeological field techniques. The logic of methods used for collection of the various types of data in the living context as well as taphonomic aspects of the research question are schematically depicted in Figure 5.1 and addressed in detail below. I conducted the study between January and November of 2006.

In order to examine the hypothesized relationship between increasing levels of human settlement occupation on the structure of local animal communities I selected a sample of settlements with varying levels of occupation and conducted ecological monitoring of the micromammalian communities in each of the settlements. I deployed two monitoring arrays for micromammals in each of the study settlements, one inside the settlement and another in a control site that was located outside of the settlement and at some distance from it (following Courtney and Fenton 1976).

Figure 5.1. Diagram of the analytical structure of the study. Arrows indicate expected effects among the contexts and types of evidence.

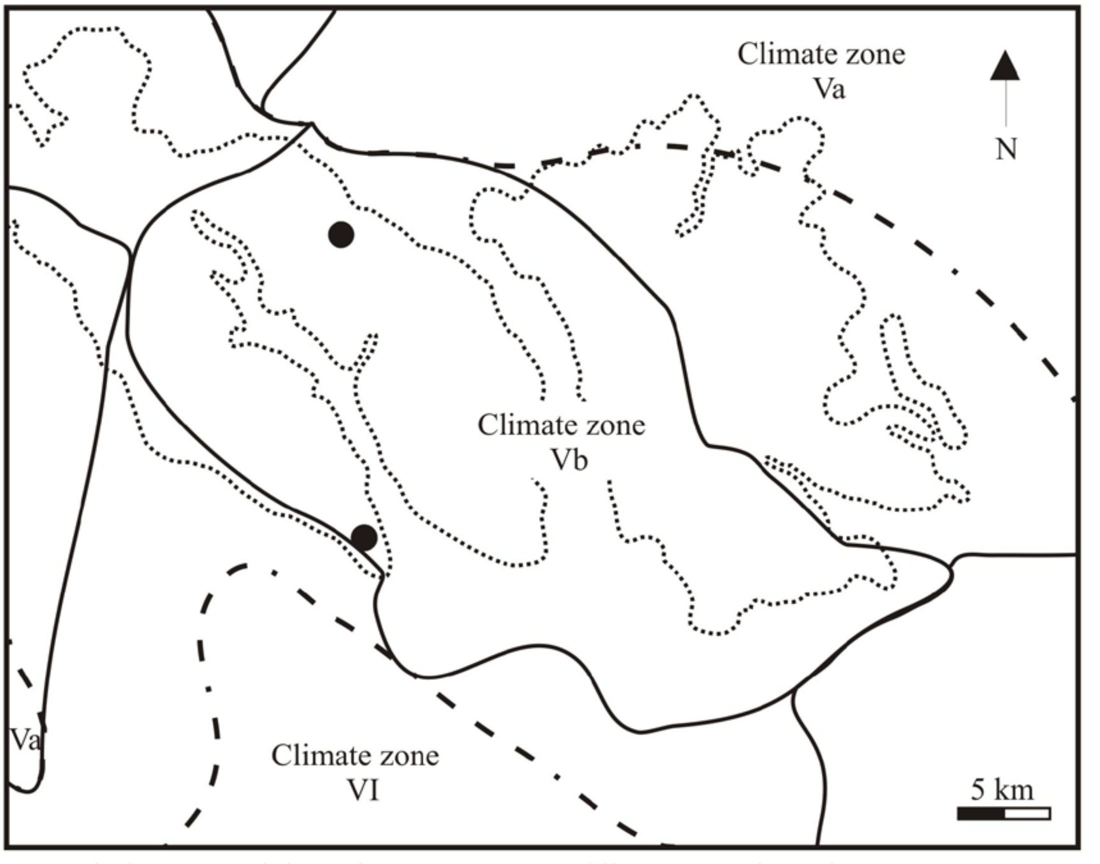


	Living context		**Taphonomy: Pathways into archaeological record**
	Ethnography	**Ecology**	**Archaeology**
Research strategies	Documentation and quantification of human occupation in the study sites	Ecological monitoring of local micromammalian communities	Recording of accumulation and preservation of types of evidence for the presence of micromammals in the study sites
Field Methods	Interview data and observations	Trapping, sightings, and analysis of prey assemblages	Surface surveys and substrate excavations for collection of skeletal remains, gnawing marks, and fecal pellets
Types of evidence	Variability in levels of settlement occupation among the study sites	Variability in micromammalian community structure among the study sites	Assessment of preservation of evidence for processes observed in the living context

5.2 The Study Settlements and Sample Selection

The study was conducted in a series of six Maasai settlements; all located within the administrative and territorial unit of a single Maasai group ranch (Figure 5.2). The goal of the sampling procedure was to identify a series of settlements that would encompass a maximum amount of variability in levels of human occupation and minimum amount of variability in terms of the general biotic and physical environment. Aided by detailed information on various settlement characteristics that was collected by J. Worden in the study area during 1999-2000 through a comprehensive regional settlement survey (pers. comm. 2005; see also Worden 2007: 26) I visited each of the settlement neighborhoods in the study area prior to the commencement of the study. As a result, I selected a sample of six settlements that represented a gradient of increasing levels of occupation. These settlements could be used to investigate the effect of level of human occupation on the ecology of local micromammalian communities while also allowing as much control as possible for other sources of variability that might affect the main research factors. For example, the fact that two of the study settlements remained unoccupied throughout the study period was an unplanned aspect of the study that could be statistically controlled for within the study design. The criteria that I used in selecting the study settlements included the duration of occupation or settlement age, the type of settlement in terms of the intensity of seasonal occupation (i.e., including long-term *emparnat* and short-term *enkaron* settlement types), and comparability in the environmental setting of the settlements. Maasai ecological preferences for locating settlements in similar environmental settings that are beneficial to the welfare of people and livestock (Western and Dunne 1979) contributed to selection of environmentally comparable study sites. An unplanned aspect of the study was the fact that two of the study settlements remained unoccupied for extended periods during and in the 1-2 years preceding the period of research. The influence of this factor on ecological patterns was examined and accounted for in analysis of the data.

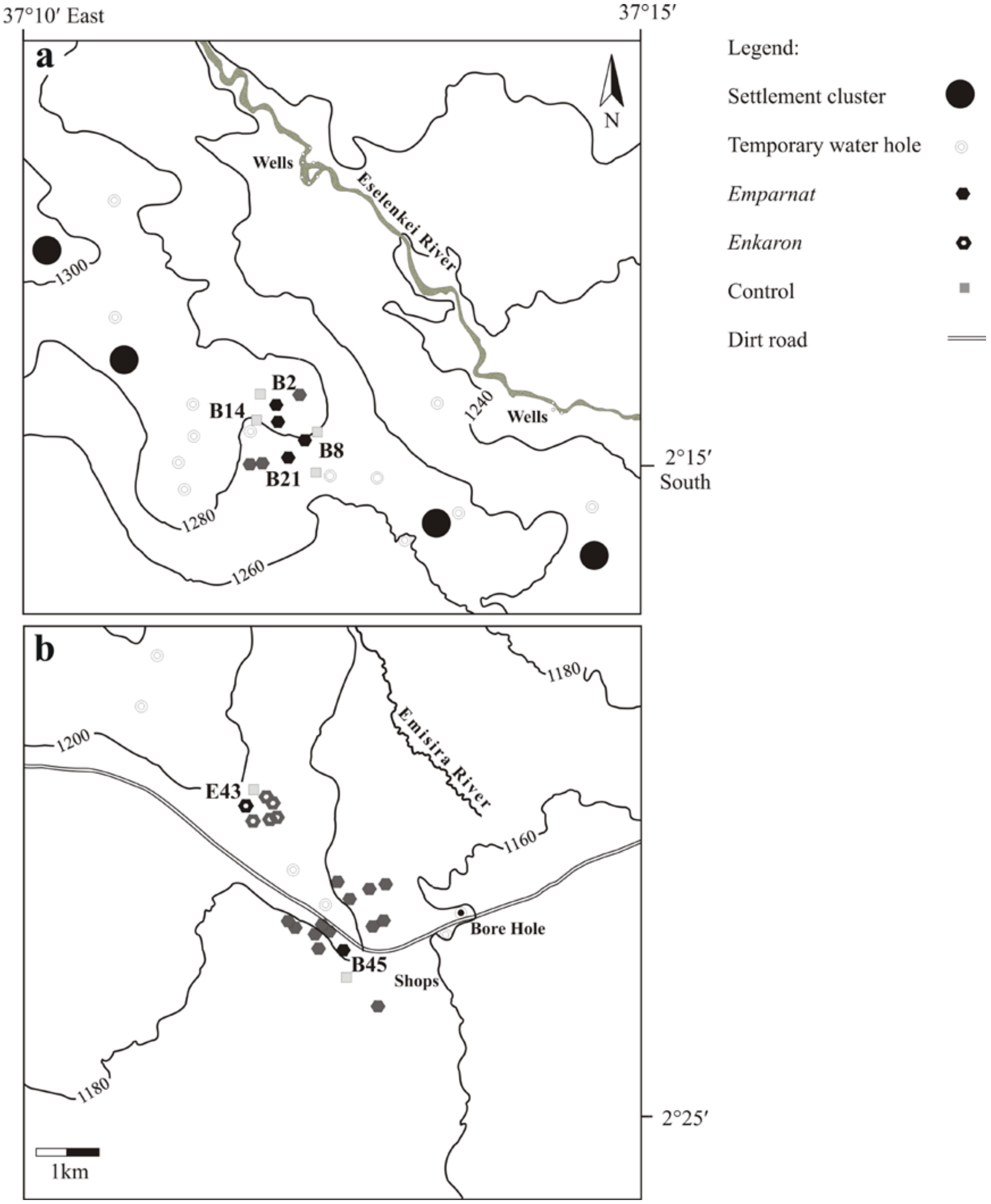
Figure 5.2. Map of the study area showing group ranch boundaries (study group ranch in center), climate zone boundaries (Va: mean annual rainfall 625-750 mm; Vb: 475-625 mm; VI: < 475 mm), and distribution of bushland/bushed grassland vegetation dominated by *Acacia* (*A. ancistroclada* and *A. mellifera*) and *Commiphora* (*C. schimperi*) trees in association with *Chloris roxburghiana* and *Sporobolus angustifolia* grasses overlaying a soil substrate of sandy clay loam. Climate and vegetation/soil data from Touber et al. (1978a, b).



The study focused on two areas of settlement within the group ranch. The first is situated in the northern part of the group ranch and contains five neighborhoods of *emparnat* long-term wet-season settlements that are arranged linearly along the course of Eselenkei River and 2-5 km south of the river (Figure 5.2). J. Worden's data revealed a wide distribution in settlement ages in this area ranging from a few years of occupation to over 20 years (Worden, pers. comm. 2005). The second settlement area was situated at the southern boundary of the group ranch and contains the oldest of the extant settlements in the region. The distance between the northern and southern settlement areas is approximately 16 km but both lie within a single continuous ecological zone and have similar climate, soil, and vegetation conditions based on soil and vegetation reconnaissance maps of the Kenya Soil Survey (Touber et al. 1978a, b; see Figure 5.2).

The spatial distribution of the six study settlements is shown in Figure 5.3. Five of the six settlements in the study sample are *emparnat* settlements (designated by the letter B). I selected four of these settlements from one of the neighborhoods that demonstrated the greatest diversity in settlement age in the northern part of the study area (Figure 5.3a). These four *emparnat* settlements were chosen to represent a wide range of ages and to establish a sample with roughly proportional spacing of ages as follows: 2, 8, 14, and 21 years. An additional and considerably older *emparnat* settlement (B45) was selected in the southern part of the study area (Figure 5.3b). This settlement is over 40 years old and extends the age range of the study sample to closely match the actual age range of Maasai settlements in the region according to J. Worden's recent survey (pers. comm. 2005; see also Worden 2007: 26). A key factor that has affected length of occupation and greater intensities of use of settlements in this neighborhood is the presence of more modern infrastructure including a bore hole and resultant small concentration of buildings including shops, a boarding school, church, and clinic.

Figure 5.3. Distribution of the study settlements (darkened hexagons; B designates *imparnati* and E *enkaron* settlements) and associated control sites in the northern (a) and southern (b) study neighborhoods in relation to adjacent settlements, settlement clusters, and important local resources. Drawn using GPS data collected during the study.



The last of the study settlements is an *enkaron* short-term dry-season settlement (E43) that is situated adjacent to the southern study neighborhood (Figure 5.3b). This settlement is also over 40 years old but has been occupied during only a relatively small proportion of each year as compared to the *emparnat* settlements. It was included in the study in order to provide a contrast to the similarly aged but more intensely occupied *emparnat* of B45 and to account for the systematic difference in level of occupation between Maasai settlements that are occupied on a long- and short-term seasonal basis.

5.3 Ethnographic Data on Settlement History, Use, and Occupation Patterns

The goal of the ethnographic component of the study was to document as accurately as possible the varying levels of human occupation in the six study settlements based on observation and interview data. Life-histories of pastoral settlements can be especially complex and reflect the influences of seasonal mobility, political and climatic events, and the social history of families that can result in multiple building and diminishing phases (Herbich and Dietler 1993). My focus in this study is on the effect of mobility on the temporal pattern of settlement occupation over time. I used the duration of the study to collect in-depth information on patterns of occupation in the study neighborhoods and detailed life-histories of the study settlements. These data provided the basis for quantifying the level of human occupation in the study settlements and for constructing a numerical scale that could be used for testing statistically the significance of the ecological effect of increasing levels of occupation. In this part of the study I draw on theoretical and methodological approaches to the description and quantification of settlement occupation that are available in the ethnographic and archaeological literature on mobility and sedentism. My aim here is to determine the appropriate level of precision of the measurement and defining as explicitly as possible what is being measured given the complexity of settlement use and occupation (see Rafferty 1985; Kelly 1992).

As a result of my review of the ethnoarchaeological and archaeological literature on mobility I identified and documented the following two dimensions of Maasai settlement occupation:

1) Occupation duration or settlement age – the length of settlement use as expressed by the number of years since the erection of the settlement.

2) Intensity of seasonal occupation – the proportion of each year that the settlement is typically occupied by all or the majority of its inhabitants as opposed to being completely or partly unoccupied for purposes of seasonal grazing-related residential movements.

It should be emphasized that whereas the occupation duration of any settlement could be determined in years in a straightforward manner, the intensity of seasonal occupation over time could only be determined by allocating settlements to general categories of proportion of the year occupied, such as a quarter, a half, or the whole year. This is due to the variability in intensity of seasonal occupation from year to year and my dependence on people's memories. I illustrate this process in the following example. The *enkaron* settlement of E43 is typically used for a relatively short period during the height of the long dry season each year (i.e., roughly August to October). As a result, I allocated this settlement to a category of low intensity of seasonal occupation, in this case one quarter of a year. In contrast, the *emparnat* settlement B45, which was also situated in the southern study neighborhood, had the most consistent occupation throughout each year and was allocated to a category of high intensity of seasonal occupation, in this case a whole year. Considering two dimensions, those of duration and intensity accommodates different sources of variability in levels of occupation and provides the basis for a flexible analytical approach to the quantification of settlement occupation. These sources of variation in occupation levels include the clear-cut distinction between long-term *emparnat* and more seasonal *enkaron* settlements and differences among *emparnat* settlements in the length of time during the year that main residences are occupied by different herd owners. This latter aspect of variability in the seasonal intensity of *emparnat* occupation is related to differences in strategies of herding and mobility among herders.

I collected data on the two dimensions of settlement occupation through a combination of observations of patterns of occupation in the study settlements during the year-long study and detailed interviews with local residents regarding preceding annual cycles of settlement occupation, partial occupation, and lack of occupation. Participant observation was an important methodological approach and formed a major part of the daily routine during the study period. To reach settlements on a daily basis I camped adjacent to settlements and during each session in the year-long study lived for four weeks at a time in the northern study neighborhood and two in the southern study neighborhood. I obtained permission for this research from group ranch officials that included the chairman, secretary, and treasurer of Eselenkei group ranch in 2005 -2006. I also established relationships with residents of the study settlements by spending much of my time at their settlements and bringing as often as I could basic supplies such as tea leaves and maize flour, which were needed by women on a daily basis. Close familiarity and interaction with settlement residents allowed me to conduct observations and interviews and to receive their cooperation for placing traps within their homes. Although trapping of rodents especially inside houses could be construed as a source of disturbance for daily lives I was welcomed by residents. Only on a single occasion during the entire study was there an unauthorized removal of one of the traps from a settlement trapping grid and this trap was soon located and reinstated by the group ranch chairman. In contrast to attitudes of farmers in agricultural regions that I visited in Kenya, Maasai that I talked to about rodents did not express aversion to rodents or request that they be destroyed.

I conducted interviews with knowledgeable elders who lived in the neighborhoods of the study settlements. I interviewed at least three elders from each of the two study neighborhoods. Two research assistants, who lived in the study region and speak fluent Maa, Swahili, and English assisted me with the interviews which we conducted at settlements – typically taking tea with elders outside their house or sitting under one of the shade trees outside settlements where elders often discuss matters at public meetings. Although women rarely participated in interviews on mobility and settlement occupation in the few instances when wives of elders were present during interviews they emphasized that decisions on matters of herding and mobility are made by men. Men are also considered the herd and settlement owners in Maasai society. I also observed that women were often less accessible than elder men for extended interviews due to their involvement in daily tasks such as food preparation inside the house, maintenance of houses, administering to calves and kids which remain at the settlement during the day, or transportation of water from wells and boreholes for household needs with donkeys. Nonetheless, some information on settlement history and use was obtained from women through conversations on management of donkeys and issues of water supply that influence decisions regarding mobility and settlement occupation (see Marshall and Weissbrod in press).

During interviews I spoke English and some Swahili but not Maa. Two different types of interviews were conducted (see Bernard 2005: Ch.9). The first type was based on unstructured conversations about settlement and mobility strategies used by the different households of the six study settlements. During these interviews I also addressed issues relating to social, economic, structural, and historic characteristics of the settlements. Because the extent of seasonal occupation of settlements of the northern study neighborhood seemed to vary considerably I also conducted lengthy semi-structured interviews on the detailed life-histories of the four *emparnat* study settlements of this neighborhood. In these in-depth interviews I asked elders to recount, season by season, whether settlements were occupied or partly or completely unoccupied due to residential movements or migrations going back as much as 15 years from the time of the study. The interviews were guided by the Maasai seasonal calendar (Table 5.1). In order to establish chronological correspondence among the accounts of different interviewees and with Christian calendar years, reference was consistently made during the interviews to commonly known and dated local events, such as age-set ceremonies and other types of events which are often named for especially distinct climatic or political events that occurred during the period. I used the detailed data on settlement life-histories to determine the intensity of seasonal occupation in each of the study settlements as 'proportions of the year typically occupied' according to four categories: 0.25, 0.5, 0.75, and 1 year which represents a scale of increasing levels of intensity of seasonal occupation.

Table 5.1. Seasons of the Maasai calendar in relation to the annual climatic cycle and months of the Christian calendar.

Maasai seasonal calndar	Abbreviation used in text	Seasonal climatic cycle	Christian annual calndar
Olodolo	Olo	Short dry season	December-February
Ingakwa	Ing	Long rainy season	March-May
Olameyu	Ola	Long dry season	June-August
Ntungus	Ntu	Height of the long dry season	September
Ilkisirat	Ilk	Short raint season	October-November

5.4 Ecological Monitoring of the Micromammalian Communities

I monitored the micromammalian communities in each of the study settlements through a standard ecological field technique for studying small rodents and shrews called capture-mark-release (CMR) or mark-recapture trapping (Barnett and Dutton 1995: 6-8; Krebs 1999: 19-20). Ecologists routinely employ such live-trapping techniques for investigating biological diversity in terrestrial non-volant communities of small animals. This includes studies in a range of different human modified environments, among them various settlement settings (e.g., Misonne 1963; Courtney and Fenton 1976; Dickman 1987; Chernousova 1996; Cameron 1997; Keesing 1998; Caro 2002). I can cite only two examples of such ecological studies that have considered the anthropological implications of human-induced effects on micromammalian communities, however. Nabhan et al. (1982) examined human-environmental interactions among the Native American Papago by surveying biotic communities including small rodents in both an active agricultural community and a National Monument that had formerly been a mature farming community but was converted to an unoccupied, unmanaged state. In this study of the small rodents, the investigators deployed grids of traps in each of the areas and compared them on the basis of diversity measures that were derived from frequencies of captures of the different species. In the second example, Dean (pers. comm. 2005; see also Dean 2005) examined the environmental impact of early agricultural settlements of the Archaic and Preclassic periods of southern Arizona (1200 B.C.-A.D. 200) through trapping of living small rodents and counts of burrows on archaeological sites and in off-site areas. She compared the two types of trapping sites based on measures of abundance and species composition.

A simple orthogonal grid of traps is a basic design for CMR trapping. The frequencies of captures and the proportion of animals recaptured provide the data for computing the abundance and population size of different species in the trapping area and measures of the diversity of species in the community (Barnett and Dutton 1995: 1-3; Krebs 1999: 19-20). Measures of biological diversity include species richness, which is the number of species, and indices of heterogeneity or community diversity such as the Shannon-Wiener Function that also account for the degree of evenness in representation of different species (Krebs 1999: 412). One of the concerns in designing a trapping experiment involves the adequacy of the design for obtaining unbiased estimates of the composition of species that are present in the sampled habitat and their abundances.

The CMR trapping program presents a widely applied solution to this problem. More accurate estimates are obtained by including more than a single sampling event, marking of individual animals that are captured, and recapture of individuals (Krebs 1999: 19). The reliability of such estimates depends, however, on two important assumptions. The first is that the size of the populations of animals in the study area is constant during the trapping period with negligible effects of births, deaths, emigration, or immigration (i.e., closed populations; Krebs 1999: 20). This assumption typically holds through relatively short periods of sampling and studies of small rodent populations typically involve sessions of 4-8 days (e.g., Cameron 1997; Keesing 1998; Canova and Fasola 2000; Salvatori et al. 2001; Caro 2002). A more problematic assumption is that the likelihood of being captured is distributed equally across all individuals in the population of each of the species in the study area as well as across different species (Krebs 1999: 32). It has been demonstrated, for example, that dispersing sub-adults or lactating females can have varying propensities to enter traps due in part to differences in the level of mobility and territorial behavior (Barnett and Dutton 1995: 22-23, and references therein). Such variability can also account for differences in trapability among species (see also Drickamer 1995).

One approach to addressing some of the concerns involved in unequal trapability is to apply a constant trapping effort across all sites that are included in the study (Krebs 1999: 33). This approach is particularly compatible with the goals of this study and should enhance comparability and reliable detection of trends among the study sites. Random selection of study sites is another approach to dealing with the problem of unequal trapability; but is not applicable here given the strict criteria established for site selection as described above (see also below on selection of control sites). Replication is an additional aspect of the design of the trapping program that is expected to improve precision of the estimates of abundance and other ecological measures. Greater confidence in the estimates and in their relationship with the research factors can be achieved by repeating the trapping experiment in each study site a number of times thereby ruling out possible influences of chance events with unevenly distributed effects (Krebs 1999: 344).

Suitable control sites were selected in areas adjacent to the study settlements according to a number of considerations. First, I identified a zone in the vicinity of each of the study settlements that led away from any of the neighboring settlements and would reduce the likelihood of confounding effects from settlements with different levels of occupation (see Figure 5.3). Second, in this zone I located an area that had the densest vegetation cover based on visual inspection. These areas were in most cases located in fenced or formerly fenced reserves that residents maintained near the settlement for grazing of calves during the dry season (sing. *olopololi*) (Mol 1996; see also Grandin et al. 1991) and in some cases were also adjacent to seasonal drainage channels where vegetation is typically more dense. Third, I situated the control sites at a distance of at least 250 m away from the settlements in order to maximize the potential for contrast in environmental characteristics between settlement and control sites. Previous research suggests that the impact of Maasai settlements on the density of surrounding tree vegetation drops off beyond a distance of 225 m away from settlements (Western and Dunne 1979). Because this distance may be considered relatively small from the point of view of distribution of micromammalian communities and migratory habits of some species I also compared trapping results to data from analysis of micromammalian prey remains in owl pellets and mongoose scats collected from the vicinity of settlements in the study area. These prey data can be taken to represent more comprehensive spatial sampling of the environment surrounding settlements. Due to the above considerations it was not possible to randomly select sites for the controls.

It is important to emphasize that control sites were chosen to represent off-settlement background levels in community parameters of local micromammals. These sites were not selected to represent 'pristine' conditions and it is assumed that they are influenced to some extent by grazing and other human activities that may be related to occupation in adjacent settlements. In three cases during the study period control sites were relocated to a similar part of the same habitat following at least two trapping sessions with no captures in the original location.

In each of the trapping sites, including six settlements and six control sites, I laid out a uniform grid design of 25 (5 × 5) large folding aluminum Sherman live-traps (3x3.5x9"). Trap grids were deployed in each of the trapping sites for a period of 5-7 days at a time and this was repeated three times, at different seasons, totaling four trapping sessions. The first trapping session was conducted during the dry season of

January-February 2006, which was also towards the end of a severe two-year long drought. At that time all settlements in the sample except B45 (see Figure 5.3b) were unoccupied following migration of people and livestock closer to areas of permanent water or to regions of higher elevation where grazing was still available. The second session was conducted after the rainy season of March-April during which considerable rainfall was experienced. People and livestock had returned to most of the study settlements following commencement of the rains and prior to the beginning of the second session. Two of the settlements – B8 and E43 – remained unoccupied throughout the study period. The third session was conducted in July-August around the height of the dry season. The fourth session in September-October overlapped with resumed dry-season migration although all of the settlements were still fully or partly occupied.

I planned the trapping procedures and grid architecture according to general recommendations in Barnett and Dutton (1995). Traps in the control sites were arranged in a standard grid form with 5-10 m spacing between traps (see Barnett and Dutton 1995: 10, and references therein). This was impossible in the settlements due to regular human and livestock traffic and hence traps were placed inside houses and enclosure fences maintaining 5-10 m spacing where possible and approximating a grid form. Drawings of the study settlements in Figures 5.4 and 5.5 show the location of traps. The figures also show that trap grids extend over all or a significant proportion of each of the areas of the study settlements. Table 5.2 provides the numbers of traps that were placed in different contexts of the settlements – circumference fence, internal enclosure fences, and houses. During each trapping session, I marked each captured animal with a unique identifier using temporary sharpie markers that persisted during each session but not from session to session (see

Barnett and Dutton 1995: 31-32). Traps were kept open during both day and night in most sessions and inspected twice daily — early in the morning and in the afternoon –– in order to identify nocturnal and diurnal activity patterns. In a few instances traps were closed during the day due to disturbance by diurnal animals such as dwarf mongoose (*Helogale parvula*). Bait used included a mixture of fried coconut and peanut butter and was replenished twice daily. I also recorded the following information for each captured animal (see Barnett and Dutton 1995: 27): taxa to the genus level (following criteria detailed in Kingdon 1997: 193-214), trap number and context, trapping term (nocturnal or diurnal), mark, weight, body and tail length, length of hind foot, sex (following Kunz et al. 1996: Fig. 55), and observations on state of maturity and reproductive status. Additional information was recorded on cases of trap deaths and various disturbances of the traps. Taxonomic identification was confined to the genus rather than species level because identification of archaeological micromammalian remains that is based on skeletal characteristics often allow only genus level resolution or above.

Figure 5.4. Drawings of study settlements in the southern study neighborhood showing the location of traps.

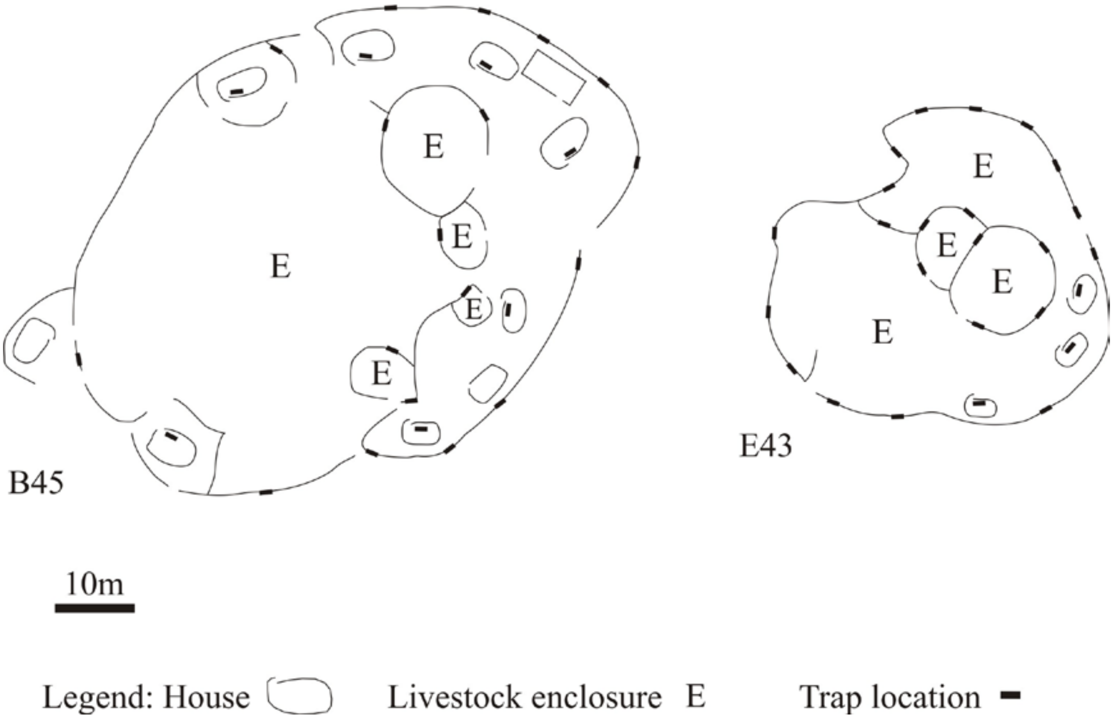


Figure 5.5. Drawings of study settlements in the northern study neighborhood showing the location of traps.

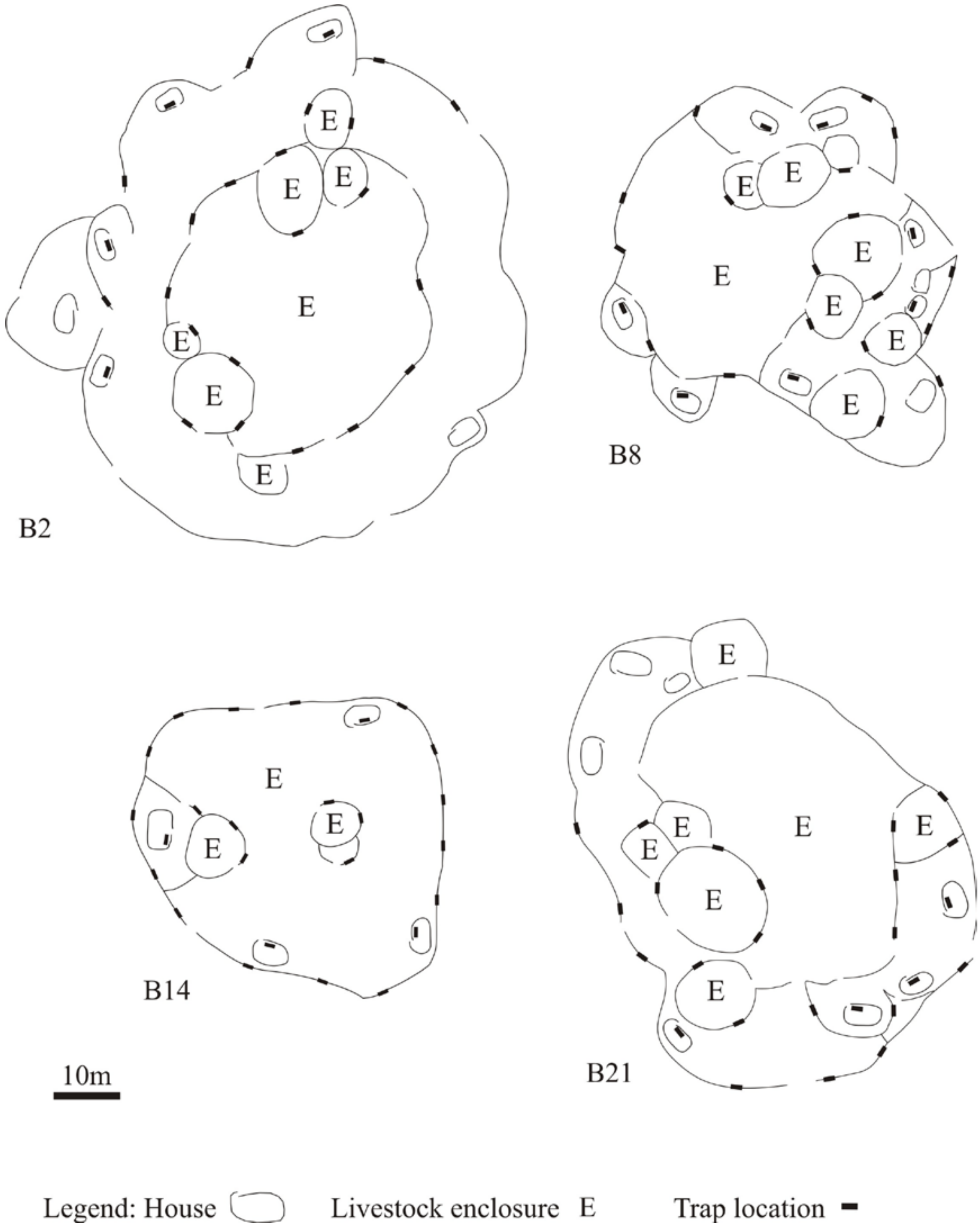


Table 5.2. Numbers of traps in the different structural contexts of the study settlements.

	Study settlements					
Structural contexts	B2	B8	B14	B21	B45	E43
Circumferance fence	5	10	15	9	12	14
Enclosure fences	16	8	6	12	6	8
Houses	4	7	4	4	7	3
Total	25	25	25	25	25	25

5.41 Population and Activity Patterns of Micromammals

Obtaining precise estimates of the population size (Krebs 1999: 17) of specific micromammalian species in the study sites is an important criterion for assessing the impact of settlements (e.g., Courtney and Fenton 1976). Interspecific interactions such as commensalism affect community composition and the abundances of species and therefore are routinely evaluated based on the net effect (positive, negative, or neutral) of one species (e.g., humans) on the population size of another (e.g., micromammals) (Morin 1999: 21-22). I used the Schumacher and Eschmeyer method of population estimation for capture-mark-release studies (Krebs 1999: 38-39) to obtain population sizes for the most abundant taxon in the study in each of the study sites and to compare population sizes between settlement and control sites. The reliability of estimators of population size such as the Schumacher and Eschmeyer method relies on a number of assumptions. These include a constant population size during the sampling period, random sampling, and equal trappability among individuals and species. Some of these concerns are addressed above in the discussion on CMR trapping techniques. In this study systematic rather than random sampling was applied and this approach will provide data for reliable estimation of population size when individual animals are uniformly distributed in the sampled area, whether marked or unmarked. I expect the assumption of uniform mixing to hold in the study sites because of the relatively small size and confined nature of the habitats and the fact that trap grids were deployed to cover a considerable proportion of these habitats.

Additional data from the trapping study that was used to assess commensalism in the study settlements includes other population characteristics of various species such as representation of different age groups, reproductive status, and extent of movement within the habitat (an index of population density) as well as activity patterns (diurnal *versus* nocturnal). Such characteristics have been reported for commensal populations of micromammals in other contexts and can be compared to the conditions in commensal habitats versus non-commensal habitats. This includes greater rates of reproduction and higher population densities (e.g., Courtney and Fenton 1976).

5.42 Ecological Indices of Micromammalian Community Structure

An important aspect of Tchernov's (1984, 1991a) commensalism model was the prediction that biological diversity will decrease in highly sedentary settlements as the population size of one or a few species (i.e., human commensals) increases and many other species are partly or completely excluded. In contrast to population characteristics which pertain to individual species, biological diversity is by definition a property of biological communities which include multiple species. The measurement of biological diversity of micromammalian communities in Maasai settlements and adjacent control sites is, therefore, an important aspect of this study. Ecologists measure biological diversity within specific habitats by taking into account the abundance of different species, numbers of species (richness), and the heterogeneity in distribution of abundances among the various species in a given community (community diversity). The study of ecological processes in biological communities is founded on the premise that the structure of such communities is a function of interactions among member species and between species and important processes in their environment including those driven by human activities (Morin 1999: 3-8). Community structure in ecological terms reflects aspects of the functioning of the community within a specific habitat type and encompasses the composition of species, their habitat requirements, and behavioral characteristics that define species' niches or ecological roles.

Ecological indices of community structure allow the comparison of habitats in terms of their resident biological communities which is the goal of the present study. Because this study focuses mainly on variability in the community structure of micromammals across the study sites, it relies for the most part on a relative measure of species abundances (cf. Krebs 1999: 17) based on numbers of individuals per each taxon that are captured in traps. This approach is further supported by the fact that as an artifact of the study design the spatial extent of trap grids and the effort invested in trapping (nos. of trapping terms, days, and sessions) are roughly equal across the study sites.

I employed the Shannon-Wiener index (H') with base e logarithm which is one of the most widely used methods for computing community diversity in ecology (Krebs 1999: 444-445). This index takes into account both the number of species in the sampled community and the abundances of the individual species. High values of the Shannon-Wiener index indicate that in a given biological community abundances are more equally distributed among the different species in contrast to dominance by one or a few species which would produce a low value of the index. Although use of the Shannon-Wiener index is generally considered more reliable in cases where random samples are drawn from a large community and may be biased in cases where there is considerable variability in numbers of species across sites, in this study low variability could be expected in numbers of species across sites. In order to improve reliability I also applied the comparative approach and repeated sampling.

In addition, I conducted comparisons among communities from the study sites and between these and data on species configuration in prey assemblages of owls and mongoose from the study area using an index of community similarity. Measures of biological diversity provide a description of biological communities that is independent of the specific species that make up the communities. Measures of community similarity can be used to asses the similarity among communities by comparing both the composition of species and their respective abundances. In the context of Tchernov's (1984, 1991a) commensalism model and the design of this study decreasing similarity between settlements and outside habitats and among settlements along a gradient of increasing level of human occupation should imply increasing habitat transformation. I used Morisita's index of similarity, which is little biased by sample size and is generally recommended as one of the more reliable of the similarity indices (Krebs 1999: 390-391). Values of this index range between zero for no similarity and one for complete similarity.

5.43 Vegetation Monitoring

Ecological studies have repeatedly demonstrated significant relationships between variability in various vegetation characteristics at the habitat and microhabitat level and biological diversity and community composition of small animals such as rodents and shrews (e.g., Cameron 1997; Monadjem 1997; Keesing 1998; Canova and Fasola 2000; Scott and Dunstone 2000). Research of this nature seeking to explain patterns in community diversity of small animals typically examines a wide range of characteristics of the vegetation and other environmental variables in an attempt to account for habitat heterogeneity as fully as possible. In the present study, however, I selected the study sites with the explicit aim of minimizing (i.e., controlling for) habitat heterogeneity except for that which is related to differences between settlement and control sites and among the settlements in relation to level of occupation. Moreover, there are differences in microhabitat structure between settlement and control sites that may hamper attempts to compare the two site types using detailed quantitative descriptions of vegetation characteristics. For example, vegetation inside settlements is almost entirely restricted to the narrow strip within branch fences of the livestock enclosures and is undoubtedly affected to a considerable extent by deposits of livestock dung (see Muchiru et al. 2008), which is often thick and extends over much of the area of most settlements.

In light of these constraints, I focused on recording basic information on the richness and diversity of the different plants in the study sites. With the assistance of Raphael Mayiani and Joseph Lekanayia who are intimately familiar with the variety of local plants, I used Maasai folk classification to identify plant species. Translation to scientific names was based on a number of sources including Dale and Greenway (1961) and Mol (1996) and in part on the knowledge of my Maasai research assistants. In order to collect data on plant species in the settlements and controls, we took inventories of the species of perennial vegetation — trees and shrubs —from plots of 3 m radius around each of the 25 traps in trap grids. It should be noted that whereas these plots were circular in the control sites, in the settlements, where vegetation growth as well as trap placement was restricted to the area within the branch enclosure fences, plots were linear extending 3 m on either side of the trap. In addition, due to their scarcity trees in settlement counts were completely enumerated.

In all other cases, I computed the ubiquity of each species of plant in the study sites by tallying the number of trap plots in which each species occurred. The data on vegetation was collected during the beginning of the study in January-February of 2006. Seasonal differences in vegetation were not taken into account because of the focus on perennial vegetation.

5.5 Collection of Evidence on Taphonomic Pathways of Micromammals in Maasai Settlements

Consideration of taphonomic pathways and potential for preservation of evidence of relationships that are examined in the living context is a necessary component of ethnoarchaeological research (see David and Kramer 2001: 2). In this study, examining the effect of level of human occupation in seasonal Maasai settlements on the structure of local micromammalian communities, the taphonomic issue is whether evidence on the structure of micromammalian communities in Maasai settlements is incorporated into the archaeological record. Although it has been suggested that the remains of small animals living inside human settlements are expected to accumulate there (i.e., autochthonous or *in situ* accumulation; see Tchernov 1984: 96; Evans 1978: 35; Reitz and Wing 2008: 119) this has not been demonstrated ethnoarchaeologically for micromammals. As a result, during the course of the study I conducted surface surveys and excavation of the substrate of current and long-abandoned Maasai settlements. I searched systematically for three types of evidence for the presence of micromammals in settlements: 1) micromammalian skeletal material, 2) gnaw marks on livestock bones regularly discarded on the surface of settlements, and 3) micromammalian fecal pellets.

I surveyed the surface assemblages of livestock skeletal remains in all six of the study settlements for diagnostic marks made by gnawing micromammals (see Thornton and Fee 2001). Surveys covered the entire area of the settlements and surrounding band approximately 20 m wide. During surveys, I picked up all visible skeletal specimens, then inspected for gnaw marks, and subsequently replaced them. In order to investigate the accumulation of micromammalian skeletal material and fecal pellets in Maasai settlements I excavated a collapsed house in a settlement that had been abandoned for five years at the time of the study. This settlement was situated within the study area approximately 8 km due east of the northern study neighborhood. The goals of the excavation were to uncover a sufficient portion of the original house floor to provide an understanding of its internal organization, to collect sediment samples for fine-screening (through one mm mesh), and to analyze micromammalian skeletal and fecal contents. Sediment samples were dry-screened in the field through a series of screens of diminishing mesh size (five, three, and one mm) and the collected residue bagged for laboratory sorting.

In addition, I collected various micromammalian biological materials from the study area in order to shed further light on taphonomic processes in the settlements. This included the collection of remains of micromammalian prey from owl pellets and mongoose scats from a number of localities in the vicinity of the study neighborhoods and < 2 km distance from settlements. Owl pellets were collected from under perches in trees and mongoose scats from scat middens. Given that avian and mammalian predators are important taphonomic agents and collectors of micromammalian remains in many environments (e.g., Reed 2003: 2-3), I used the prey remains as an additional baseline with which to interpret the trapping results (see also Happold and Happold 1986; Granjon et al. 2002; Torre et al. 2004; Granjon and Traoré 2007 on comparisons of trapping and owl data). This comparison allows me to address two questions with taphonomic implications: 1) how do micromammalian communities in Maasai settlements compare with prey communities representing the wider environment of the study neighborhoods? and 2) do assemblages of micromammalian prey remains from the vicinity of Maasai settlements record the impact of settlements on micromammalian communities? These questions are especially important from a taphonomic perspective because the remains of micromammals in some archaeological sites derive from accumulation by various predators (e.g., Weissbrod et al. 2005). Pellets and scats were dissected in their dry state in the field and taxonomic identification of cranial material including all *in situ* and isolated molar teeth was conducted in the comparative collection of the Mammal Division of the Field Museum of Natural History, Chicago. Determination of taxonomic frequencies in the prey assemblages was based on the minimum numbers of individuals (MNI) necessary to account for observed numbers of molar teeth, taking into account the anatomical position of teeth in upper or lower jaws, left or right jaws, and within each jaw (i.e., M1-M3).

I also collected micromammalian fecal pellets from traps to serve as comparative material for identification of fecal samples that were retrieved from the excavation of the Maasai house. I collected a number of samples of intact fecal pellets for nearly all of the species that were captured. Fecal pellets were photographed on a graph paper background and a number of measurements were taken from the photographs through an image analyzing computer program (ImageJ, version 1.38x). Intact micromammalian fecal pellets are generally of elliptical shape and measurements taken include the minor and major axes of each specimen as well as the area and circumference.

5.6 Analysis Procedures

In this section I present an overview of the statistical techniques that I used in data analysis. This includes techniques that were used for quantitative description of the ecological data and for examination of the relationship between ecological and human occupation variables. In particular, I provide the background to a number of specialized statistical techniques that were required due to the configuration of sampling and characteristics of the data that were collected. The statistical background presented here addresses the principals in application of the techniques, but does not provide the mathematical underpinnings for those techniques. The two main aspects of the analysis are the comparison between settlement and control sites and examination of the trend among the sites in conjunction with increasing levels of human occupation in the settlements. These aspects represent the building blocks of the research design and correspond to the main research hypotheses. Statistical analysis was performed with SPSS software package version 16.0 (SPSS Inc.) unless stated otherwise.

The analysis is based primarily on parametric statistical techniques such as analysis of variance, regression, and correlation. These techniques depend on a number of important assumptions about the distribution of values of the parameter in question in the population from which the data was sampled. I address concerns of linearity, normality, and homoscedastcity in the data through the following analytical strategies: 1) selection of statistical designs that are appropriate for the structure of the data as described below, 2) transformation of variables, and 3) post-hoc evaluation of test results. Transformation of certain variables by obtaining the logarithm of the values, for example, can in some situations improve the homogeneity in variance among data points (homoscedastcity) and the linearity in the relationship among the variables or groups of cases (Cohen et al. 2003: 221-227). Such transformation can also improve the normality in distribution of the values of the variables when sampling was not random (Cohen et al. 2003: 247). Various statistical techniques are also associated with specific diagnostic tests that allow evaluation of the results and of whether the analysis complies with the basic assumptions of statistical inference.

5.61 Repeated Measures Analysis of Variance

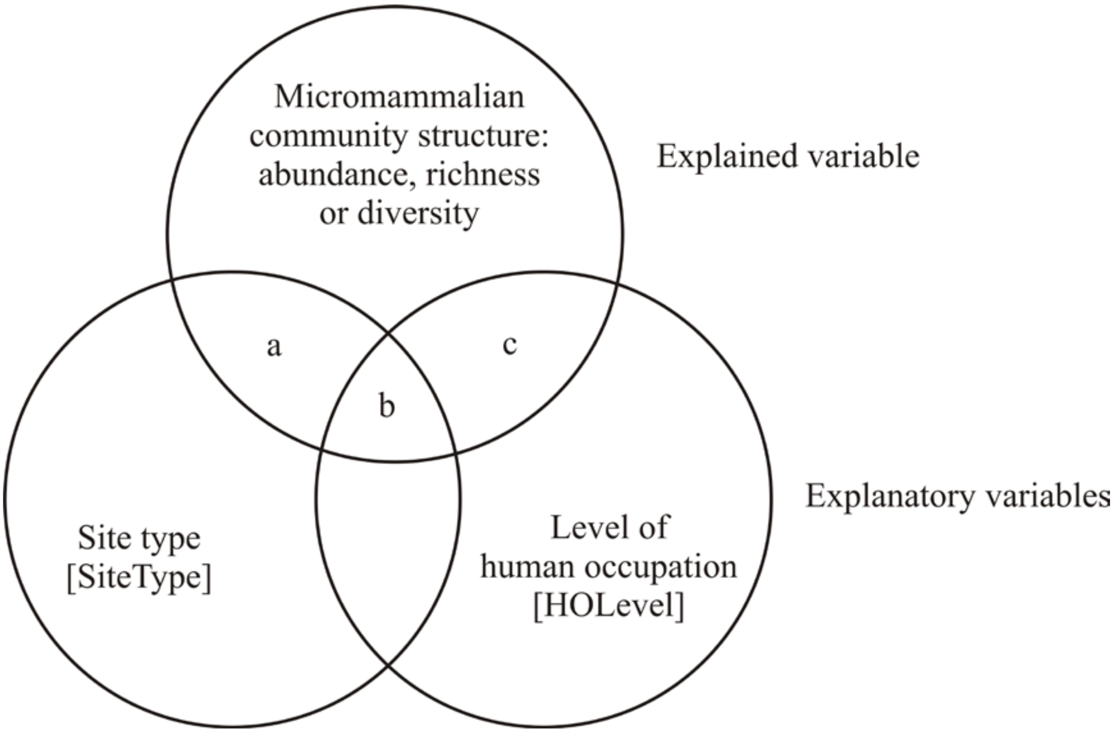
In this study, repeated measurements were conducted on a fixed set of experimental units. The repeated measurements are the four trapping sessions and the experimental units are the six pairs of settlement and control study sites. This design is defined as pseudo-replication wherein the repeated measurements are not independent of each other (Krebs 1999: 341). Replication, in general, contributes to the precision of the measurement but cases of pseudo-replication violate the basic assumption of independence of the measurements which underlies widely used statistical tests such as the *t*-test and standard analysis of variance (ANOVA). When also taking into consideration the repeated measurements repeated measures analysis of variance is the appropriate statistical test for comparing the means of various types of ecological data in the settlement and control site samples. This statistical design is more properly termed a factorial repeated measures ANOVA given that it simultaneously assesses the effects of more than a single factor, which in the present study include: 1) the effect of settlements *versus* controls and 2) the effect of temporal differences among the trapping sessions. In this design, the comparison between the settlements and controls is represented by the between-subjects factor whereas the variability within each site is represented by the within-subjects factor. The analysis tests the statistical significance of both of these effects as well as of the interaction between them. Significant interaction between the two factors when examined for abundance data from the trapping study, for example, would imply that levels of micromammalian abundance in the settlements or controls depends on time of the year.

The repeated measures option in SPSS software provides results that include a univariate test of significance with probability levels in addition to an evaluation of whether the results uphold two important assumptions of the analysis – high correlation among the repeated measures (sphericity) and equality of group variances (homoscedastcity) (see Zar 1999: 259). This evaluation is based on a multivariate analysis of variance (MANOVA) test and associated Wilks' Lambda criteria of significance.

5.62 Multiple Regression/Correlation Analysis (MRC)

MRC analysis extends the principals of simple regression and correlation analysis to cases in which more than a single explanatory (independent) variable is expected to affect the explained (dependent) variable. This versatile statistical technique possesses the useful capacity to represent complex relationships by accommodating combinations of diverse types of explanatory variables, which are measured on both quantitative and qualitative scales (Cohen et al. 2003: 1). In this study the main factor to be explained is variability in the structure of micromammalian communities among the study sites. This factor may be represented by either one of the three ecological attributes of micromammalian community structure: abundance, richness, or community diversity. As an artifact of the research design, two factors are expected to account jointly for a significant proportion of this variability: 1) differences between settlements and controls (Abb. SiteType) and 2) variability among the settlements along a gradient of increasing level of human occupation (Abb. HOLevel).

Figure 5.6. Venn diagram illustrating the idealized relationship between the three main research variables in terms of a multiple regression correlation model.



The Venn diagram in Figure 5.6 depicts the idealized relationship between the three main research variables. Following Cohen et al's (2003: 38) illustrative use of such diagrams, the area enclosed by each of the circles represents the total variance of each of the variables. The variance may be considered as standardized to 1 and therefore each variable is represented by a circle of uniform size. The area of overlap among the circles represents the linear relationships among the variables. Although the two explanatory research factors should ideally represent mutually exclusive aspects of the variation in the explained factor, variables that are based on real-life data are often intercorrelated and partly redundant in terms of the proportion of variation they account for in the explained variable. Cohen et al. (2003: 7) introduce the concept of the unique relationship that holds between each explanatory variable and the explained variable when the relationship with additional variables is also taken into account (see areas marked 'a' and 'c' in Figure 5.6).

The unique contributions to explained variability that can be estimated through MRC analysis are of particular interest in the context of a natural experiment in which we wish to isolate as well possible the effect of specific explanatory variables while controlling for the effects of other explanatory variables as well as of additional incidental sources of variation. In addition, MRC analysis also provides an estimate of the overall effect size which is the proportion of variation in the explained variable that is accounted for by all explanatory variables combined. In Figure 5.6, the overall effect size is the sum of areas 'a', 'b', and 'c'. Unique effects are denoted sr^2 and the overall effect size R^2. Given that the data was collected in four separate sessions in different seasons and periods of the year a factor of seasonality was also represented in the analysis but in a somewhat different manner than other research factors. In the same way that a single categorical variable coded with 1's and 0's could represent the differences between two sessions, three such categorical variables are required to represent the entire range of variability among the four trapping sessions in MRC analysis (see Cohen et al. 2003: 302-303).

In order to derive the cumulative contribution of such a seasonality factor to explained variability the three variables representing this factor can be entered into the analysis as a set and the increment added to explained variability by this set (IR^2) can thereby be determined. The increment added to explained variability by a set of variables is a combination of the unique effects of each of the separate variables. Lastly, it is important to emphasize that data analysis through MRC provides only indications of underlying causality rather than proof of absolute causality (Cohen et al. 2003: 3-4). MRC analysis as presented here is appropriate for detecting significant associations between research factors but not absolute causality given that additional systematic differences may exist between cases or groups of cases in the study that could not be controlled for in the setting of a natural experiment.

5.63 Chi-squared Analysis

The chi-squared test is another technique for assessing the association between research variables which is appropriate for dealing with variables wherein cases are grouped into or ranked according to discrete categories rather than measured on a continuous scale (Shennan 1997: 104). This statistical technique evaluates whether an association exists between two categorical variables but does not provide a measure of the magnitude or direction of the association, as in regression and correlation analysis. I used the Pearson chi-squared (χ^2) test for cross-tabulated data in comparing abundances of different species (i.e. no. captured) among the different structural contexts of the study settlements (circumference fence, enclosure fences, and houses) in relation to varying levels of human occupation. Here abundances are tabulated according to both taxonomic category (i.e., genus) and one of each of the study settlements that represent the varying levels of occupation. This produces a table that is typically referred to as a contingency table wherein the study settlements are presented in columns and the species in rows.

The Pearson χ^2 test is particularly useful for examining the association between species abundances and the study settlements in each of the separate structural contexts due to uneven distribution of sampling effort (i.e., no. of traps) across contexts and across settlements for each of the contexts (see Figures 5.4 and

5.5 and Table 5.2). This problem has been referred to as biased representation (see Haber 2008) and is accommodated by the Pearson χ^2 test, which can simultaneously weigh the absolute (observed) abundance of a species in each context in relation to both the overall abundance of that species in any of the settlements, as well as in all the settlements combined (expected abundance). Following Haber (2008: 224) it can be stated that considerable variation among the settlements in the distribution of the weighted abundances for any of the three contexts can be expected if there is a significant association between species abundances and particular settlements or levels of occupation. In other words, such patterned variation would imply dependence between these two variables and would lead to a significant statistic of the Pearson χ^2 test.

5.64 Discriminant Analysis

In order to identify to taxon fecal pellets that were collected from deposits of the excavated Maasai house discriminant analysis was employed in the analysis of data on shape characteristics of micromammalian fecal pellets. Discriminant analysis is an appropriate technique for this purpose because it presupposes an existing classification or separation among groups, in the present case the separation among micromammalian taxa based on fecal pellet shape. It also provides an assessment of the extent that such separation is valid based on available empirical data (i.e., measurements of fecal pellets of known taxa collected from traps). In addition, discriminant analysis examines the allocation to such established groups of specimens from unknown groups (i.e., fecal pellet specimens from the collapsed house) (see Shennan 1997: 220). Because standard discriminant analysis can accommodate only up to two different groups and in the present case there are seven such groups represented by the different species a form of discriminant analysis — canonical variate analysis (CVA) — was employed, which can accommodate such a design.

5.65 Levels of Measurement of the Research Variables

It is important to explicitly determine the level of measurement of variables that are subjected to statistical analysis because the use of certain types of variables such as those which are measured on categorical or rank scales restrict the range of mathematical operations and statistical techniques that can be applied (Shennan 1997: 8-12). In this study, variables such as the distinction between settlement and control sites (SiteType), between *emparnat* and *enkaron* settlements, or between the different structural contexts of the settlements are clearly measured on a categorical scale. Other research variables such as the ecological measures of abundance, richness, and community diversity, or the level of human occupation as measured in years or proportions of the year relate to continuous scales and can be considered scale or ratio variables. This is because the position of cases along the scale on which they are measured can be defined in terms of some standard unit of measurement such as years, months, or numbers of species and the scales have an absolute and non-arbitrary zero point (see Shennan 1997: 10).

CHAPTER 6

THE QUANTIFICATION OF SETTLEMENT OCCUPATION

6.1 Introduction

In the first part of the chapter I present ethnographic information on the study settlements that I use as the basis for preliminary categorization of the six settlements according to varying levels of human occupation. In the latter part of the chapter I present more detailed data on occupation patterns from interviews on the specific life-histories of the study settlements that provide an important additional layer of information that I use to establish a quantitative index of the level of settlement occupation.

6.2 Settlement History, Use, and Occupation Patterns in the Two Study Neighborhoods

6.21 Settlement Layout in the Study Neighborhoods

Schematic maps of the study neighborhoods (Figures 6.1, 6.2) show the location of the six study settlements, five long-term wet-season *imparnati* and one dry-season short-term *enkaron*, in relation to the overall settlement layout of the neighborhoods. Situated adjacent to the *emparnat* and *enkaron* study settlements in each of the three neighborhoods are other settlements of the same types but of varying ages, as well as other types of settlements and sites of long-abandoned settlements. In addition to the *emparnat* and *enkaron* settlements, which are in the majority in their respective neighborhoods, there are also a number of adjunct relatively small-scale and ephemerally constructed settlements that have been used at times by herders from other areas. Maa language terms for these types of settlements such as *olmuate* or *roncho* (Mol 1996: 360 and 348, respectively) indicate the ephemeral mode of their use for short-term cattle herding movements that can occur outside the regular seasonal shift between *emparnat* and *enkaron* settlements.

Sites of long abandoned settlements termed *emurua* in Maa (pl. *imurua*; Mol 1996: 266), a word generally referring to the settled nature of the place, are marked by rotund patches of grayish sediment from degraded piles of livestock dung and indicate a general continuity in occupation in these areas. Such patches also occur in conjunction with a number of the study settlements as indicated on the maps (Figures 6.1, 6.2) and represent former portions of these settlements that were fenced off during phases of structural reorganization. Settlement reorganization has occurred in three of the study settlements following abandonment or settling in of households at the settlement and testifies to the typically dynamic and complex nature of settlement occupation histories. Table 6.1 provides additional details on the social, structural, and economic characteristic of the study settlements.

Figure 6.1. Schematic map of the southern study neighborhood: *emparnat* (a) and *enkaron* (b) clusters. Numbers next to settlements indicate their ages in years and study settlements are darkened (settlement ages are as of 2006). Drawn using GPS data collected during the study. Age data on study settlements collected through observations and interviews. Age data on *emparnat* settlements abutting the 45 year old study settlement in the southern neighborhood and older than 5 years is taken from J. Worden (pers. comm., 2006). Frames represent an area of approximately 2 × 2 km each.

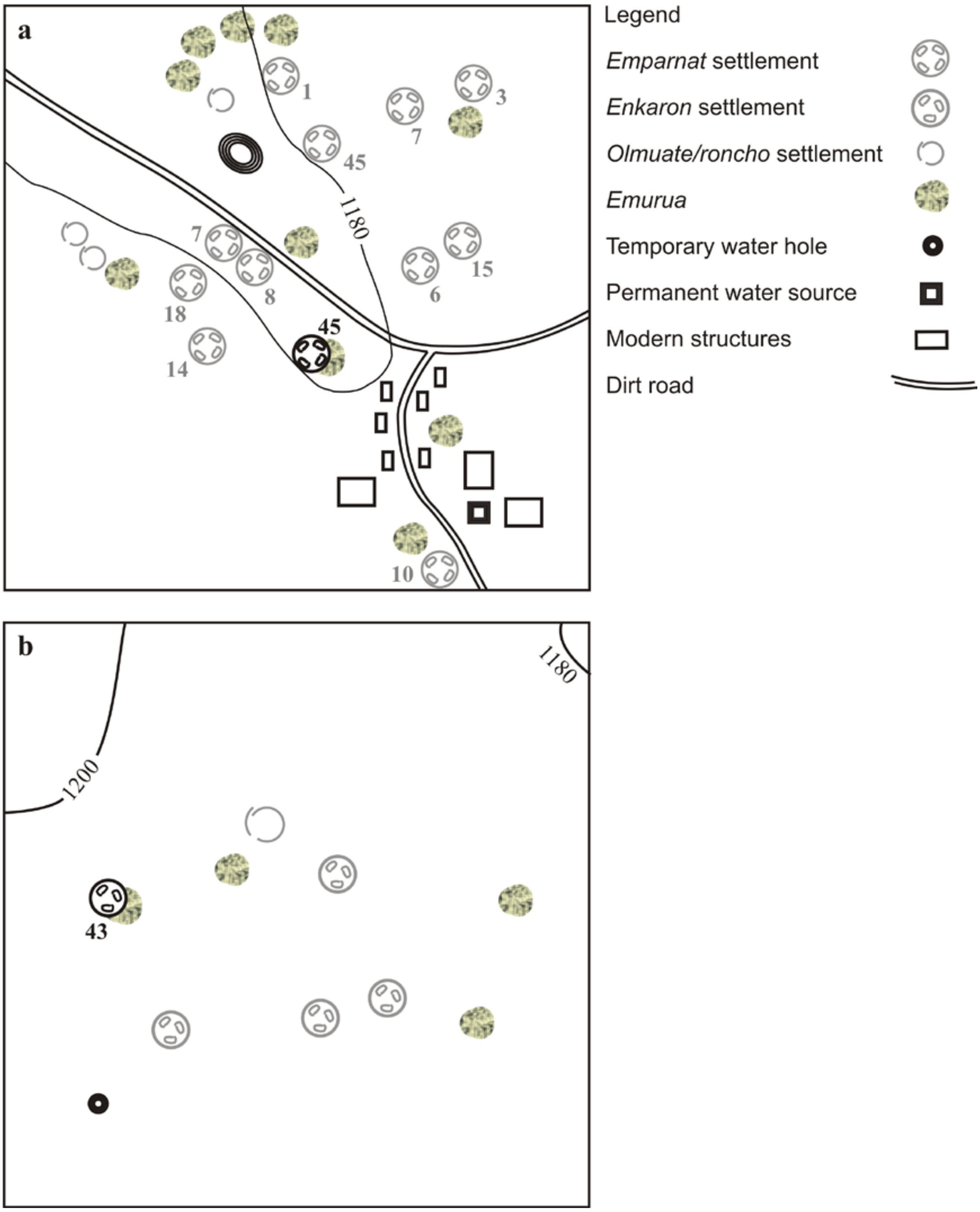


Figure 6.2. Schematic map of the northern study neighborhood. Numbers next to settlements indicate their ages in years and study settlements are darkened (settlement ages are as of 2006). Drawn using GPS data collected during the study. Frame represents an area of approximately 2 × 2 km.

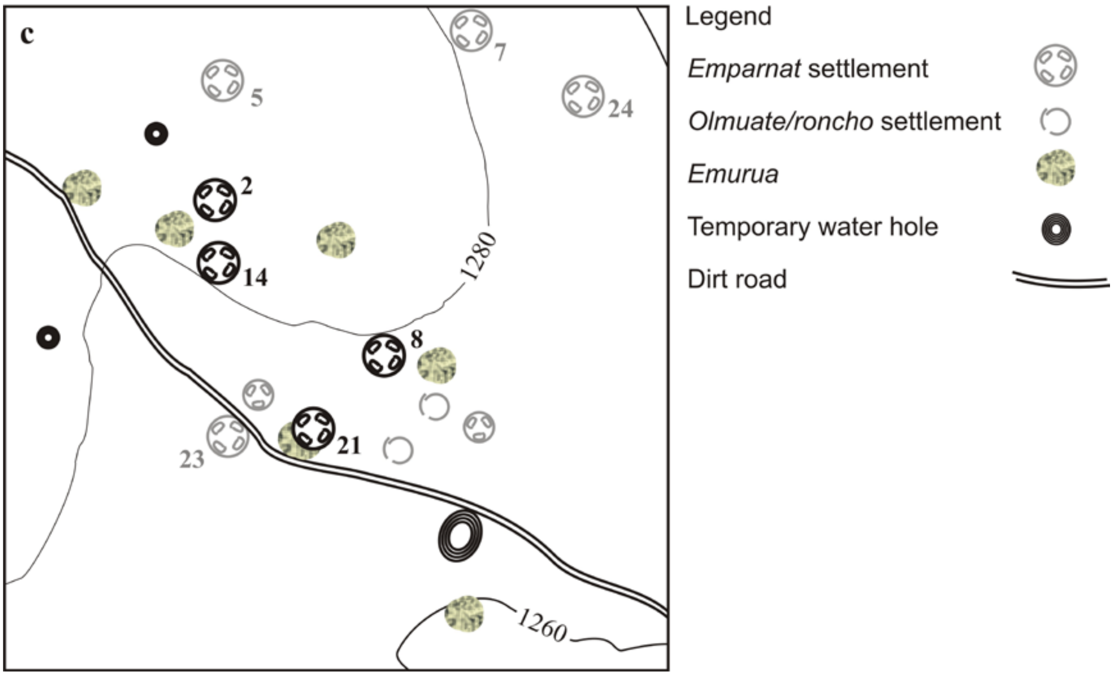


Table 6.1. Social, structural, and economic characteristics of the six study settlements[a].

Settlement	No. Households	No. Houses	Diameter (m)	Adult population size and composition				Livestock holdings: Cattle, sheep/goats & donkeys (est.)
				Population size	Men	Women	Young adults	
B2	3	6	80	10	3	4	3	200
B8[b]	1	9	60	15	4	11	-	500
B14	1	4	50	3	1	2	0	50
B21	1	6	70	13	4	6	3	500
E43[c]	2	3	40	-	-	-	-	-
B45	1	9	70	13	6	4	3	500

[a] Values presented in the table refer to numbers generally observed in the settlements during the study period.

[b] Figures of population and livestock holdings for *emparnat* settlement B8 were collected through discussions with people of the settlement in their current settlement location. This settlement had not been used for the six months prior to the study and was not occupied during the period of research.

[c] Figures of population and livestock holdings not provided for *enkaron* settlement E43 because it has not been in use by its owners for the past two years.

6.22 History of Settlement Occupation in the Study Neighborhoods

6.221 The Southern Neighborhood: *Emparnat* and *Enkeron* Clusters

The oldest of the current settlements in the study area including the oldest of the study settlements – B45 – are located in the southern study neighborhood. The beginning of continuous settlement at this location coincided with the drilling of a bore hole and establishment of a store for basic supplies in the 1950's. A short time after that the area was also set up as a center of distribution of relief food during the major drought of 1960/1961, which is locally dubbed Olari Lenguruma (Year of the Flour). Three of the *imurua* that are situated among the current settlements of the southern neighborhood (Figure 6.1a) represent the earliest settlements established at that time. These were soon replaced by a second wave of settlement construction. Settlement B45 was erected in the southern study neighborhood during this second wave. A number of settlements were also erected during this early period in an area nearby at a distance of c. 2 km to the northwest of the southern study neighborhood (Figure 6.1b). This area was later designated for short-term *enkaron* settlements.

The settlement dynamic in this area during intervening decades has generally involved increasing density and decreased mobility of settlements. A number of different aspects of this process can be noted. First, the local development of the *emparnat-enkaron* system during the early 1980's involved official designation of the current *emparnat* and *enkaron* neighborhoods for wet- and dry-season settlement, respectively (see also Worden 2007: 40). Second, as a result of this change in the system of seasonal mobility, *emparnat* settlement was gradually pushed back from the area in between the current *emparnat* and *enkaron* neighborhoods. Three of the *imurua* flanking the southern *emparant* neighborhood to the west were abandoned during this phase in the 1980's and some of their former inhabitants now reside in the current settlements of this neighborhood (Figure 6.1a). Third, these processes were accompanied by a gradual and ongoing transition from multi-household settlements to ones consisting of a single or a few households. The occurrence of a number of relatively young settlements in this neighborhood and continued erection of new settlements without abandonment of old ones are in part a reflection of this increasing individualization in herd management. In fact, two of the settlements situated on the western margin of the neighborhood are new *imparnati* at the stage of construction, and recently have also been used as *roncho*. Another illustration of this process of individualization in settlement use is provided by the history of settlement B45. This settlement was reported to have originally been founded by more than a dozen different households, whereas today only one of these households remains there. A large abandoned section of the settlement that was fenced off in the early 1990's and currently has the appearance of the degraded dung sediment of *imurua* testifies to the long and complex history of this settlement (Figure 6.3).

Figure 6.3. The oldest of the study settlement, B45, flanked by a fenced-out section (*emurua*) conspicuous by the white color of the sediment in the black and white photograph and surrounded by an extensive bare zone due to the long-term and continuous occupation of the settlement.

Settlement B45, the oldest of the study settlements, represents an extreme along the recent trend towards the reduction in the mobility of people and settlements in the study region. This settlement was occupied by a single extended household totaling 13 adult residents at the time of the study. This household was made up of an elderly matriarch and her mother and a number of her adult offspring including five brothers and their sister. The settlement included nine houses during the study period and was of relatively large size (70 m diameter). The family possessed extensive herds of several hundred head of cattle, sheep, and goats and a large number of donkeys (N=17). The wealth, relatively large size of the household, and close cooperation among the siblings provided substantial labor resources for the residents of settlement B45.

Interview data indicates that relatively continuous occupation of the southern neighborhood replaced an earlier pattern of short-term occupation that prior to the development of the local bore hole, was confined to the wet season when rain water was available in temporary pools (see Figure 6.1a). This is supported by regional settlement data recently collected by J. Worden (2007: 20, 31-32), which shows the spread of settlement into formerly wet-season grazing areas with the development of permanent sources of water during the later half of the previous century. A number of *imurua* surrounding the main temporary water hole of the southern neighborhood (Figure 6.1a) were reported to belong to this earlier phase of more ephemeral occupation of the area. In addition to the greater availability of water other prominent factors that can be related to reduced mobility in the southern neighborhood include the establishment of a boarding school, health center, church, and a number of shops that are concentrated in an area adjacent to the pastoral *emparnat* settlements of the neighborhood (Figure 6.1a and Figure 6.4). During the height of the drought of 2005/2006 and the beginning of the study period settlement B45 and other settlements of the southern neighborhood remained occupied by some of their inhabitants, mainly women, children, and the elderly, whereas the northern settlements that are situated more than 3 km away from the closest permanent source of water and about 2.5 km away from the local school remained entirely unoccupied. Continuous occupation of settlement B45 was reported as being the norm in the past as well.

Figure 6.4. Tin, brick, and concrete structures of the shopping and community service center adjacent to the settlements of the southern study neighborhood.

According to one of the local elders, a man whom I interviewed about patterns of settlement use and mobility strategies in the southern study neighborhood, some of the herd owners of this neighborhood choose to remain with the herds in the area even during years of severe droughts while others migrate long-distance to better grazing grounds. These people see greater risk in migrating with cattle herds to different ecological and animal disease zones than in remaining and incurring losses due to harsh conditions of the drought. The benefits of remaining in proximity to resources such as a permanent water source, schools, and medical services are also an important consideration affecting such mobility decisions. Availability of such resources seems to affect local movements with the herds during the dry season as well. A mobility strategy that is practiced by some of the herd owners of the southern neighborhood during the dry season but which has not been observed in the northern neighborhood is the dividing of the household in a pattern of logistical mobility. In these cases some remain at the *emparant* settlement, while young men and some wives undertake separate residential shifts with the small and large livestock herds for grazing purposes. In some cases households may divide into as many as three different groups.

Further indicators of the relative sedentariness, increasing individualization, and high intensity of seasonal occupation of the inhabitants of settlement B45 include a number of structural and environmental characteristics that are absent from all other study settlements. These include the presence of a rectangular dung and branch structure used as a store house, the realignment of house entrances to fit the installment of doors and the locking of those doors, and the conspicuous abundance of trash items such as plastic bags, which are carried down wind from the adjacent shopping center and accumulate within the branch fences of the settlement. In addition, the settlement is surrounded by a particularly large zone, *c.* 200 m in radius, which has become almost entirely devoid of vegetation (Figure 6.3). It should be noted, however, that other important characteristics of the neighborhood such as general settlement and residential house structure, cooperative herd management, and seasonal herding mobility follow long-established local traditions of the pastoral Maasai (see Jacobs 1975; Western and Dunne 1979).

The history of occupation of the single short-term *enkaron* settlement among the study settlements appears to be nearly as long as the occupation of settlement B45 where its current owners reside. A testimony to this is a relatively large abandoned and fenced off section of the settlement consisting of well-degraded dung sediment. Owners of the *enkaron* settlement E43 discontinued their use of this settlement for short-term dry-season migration two years prior to the commencement of the study. The houses and enclosure fences still remained intact during the study period and have provided temporary shelter for herders migrating through the area from the time it ceased to be used by the original owners. *Enkaron* E43 belonged to the residents of settlement B45 who used to share it with a woman from another settlement. The *enkaron* consisted of three small houses with an internal plan simplified in comparison with houses in *emparnat* settlements.

The *enkaron* study settlement differs from the more established *emparnat* settlements by its smaller size (40 m diameter) and less elaborate construction of houses and fences. This *enkaron* is part of a cluster of *enkaron* settlements (Figure 6.1b) belonging to the southern neighborhood and located approximately 2 km northwest of the *emparnat* settlements. It has been used regularly by residents of the southern neighborhood for short-term dry-season herding movements for a number of decades up until 2004. At that time a different area about 1.5 km farther away from the *emparnat* neighborhood was designated by the community for *enkaron* settlement of the southern neighborhood.

The three *imurua* located within and adjacent to the *enkaron* cluster (Figure 6.1b) represent settlements that were occupied during the 1960's and 1970's prior to the establishment of the *emparnat-enkaron* dry-season dispersal system and when occupation in this area may have extended over a somewhat greater proportion of each year. Households that occupied the former settlements of these *imurua* eventually relocated to the adjacent *emparnat* neighborhood or to other neighborhoods in the region. As a result, in the process of consolidation of the *empranat-enkaron* system occupation of this location was restricted to the height of the dry season. Most of the current settlements in the *enkaron* cluster date from the 1990's although the exact timing that each of them was erected was not documented in the current study. Information from interviews and my own observations during the study period indicate that despite the discontinued use of this *enkaron* cluster by its owners, the *enkaron* study settlement has continued to be used by herders from other areas but on an ephemeral and irregular basis. This has corresponded to the mode of occupation of *olmuate* or *roncho* settlements and has been associated with longer distance herding movements of herders during previous dry-seasons and the severe drought of 2005/2006.

6.222 The Northern *Emparnat* Neighborhood

The northern neighborhood originated at a much later time in comparison to the southern study neighborhood and exhibits somewhat higher rates of residential mobility. At the same time, the development of the northern neighborhood provides further illustration of the increase in spatial circumscription of settlement in the region in recent decades. The beginning of this neighborhood dates to the early 1980's and coincided with the adjudication of Eselenkei group ranch, the official allocation of group ranch areas for *emparnat* and *enkaron* settlement and dry-season grazing reserves, and the pushing back of settlement from the area extending between the present day southern and northern neighborhoods to the north closer to where permanent sources of water are situated in the Eselenkei River. Other settlement clusters were established during the same period to the east and west of the northern study neighborhood thereby enabling access to water sources to the north and dry-season grazing reserve extending to the south of these neighborhoods. Information from interviews with local residents and observations during the study period indicate that the position of the northern neighborhood is favorable in terms of access to adjacent grazing grounds but that its greater distance from other important resources such as permanent water sources, schools, and shops has led to higher rates of residential mobility especially during prolonged dry periods.

The two oldest of the current *emparnat* settlements of the northern neighborhood (Figure 6.2) were erected in conjunction with the initiation of the *emparant-enkaron* dry-season dispersal system. The majority of households of the neighborhood relocated at that time from a single settlement that was situated within the area of the present day dry season grazing reserve. Over the succeeding two decades settlement in the neighborhood spread in a northwesterly direction as additional settlements were erected usually by single households that split-off from the two oldest founder settlements. The *imurua* adjacent to the current settlements of the northern neighborhood (Figure 6.2) do not seem to have been part of the development of the current *emparant* settlement at this locale. According to elders of the neighborhood the three northern *imurua* adjacent to the current settlements date to a much earlier period possibly during the 1950's or 1960's when the age-set of these elders known as the Iseuri was in the stage of young adults or 'warriors' (see Maasai age-set chronology provided by Mol 1996: 12). These older *imurua* are today visible only as patches of tree clearings and lack the distinctive grayish sediment from degraded dung that typically mark the location of abandoned settlements. Two additional more recent *imurua* that are situated on the eastern edge of the neighborhood (Figure 6.2) have been occupied during the later 1980's and early 1990's for a number of short episodes between a few months to a year by households that have since migrated away from the neighborhood. In addition, the *emparnat* settlements of the northern neighborhood are also associated with four temporary *roncho* and *olmuate* settlements (Figure 6.2) that have been used based on ties with local residents by herders from other areas for short-term cattle movements.

The oldest of the four study settlements, B21, has had a complex history of occupation, abandonment, and restructuring as attested to by the currently fenced off *emurua* section of the settlement (Figure 6.2). As in the case of settlement B45, settlement B21 was also occupied by a single extended household at the time of the study and included four brothers and their wives, two of the brothers having two wives each. The settlement included six houses during the study period and was also of relatively large size (70 m diameter). The family possessed extensive herds of several hundred head of cattle, sheep, and goats and a large number of donkeys (N=14). The household of settlement B21 had substantial labor resources including a motorized vehicle, which would have contributed to flexibility in making decisions regarding mobility and settlement use.

Emparnat settlement B21 was first established shortly after the severe drought of 1984/1985 locally dubbed as Olari Enkare Nanyukie (Year of the Red Water) and replaced a former short-term *roncho* at the same location that was used during a single preceding season. Currently settlement B21 is occupied by a single extended family household that originally split-off from one of the founder settlements of the neighborhood and took over settlement B21 in the mid 1990's following abandonment by the previous owners. The current inhabitants of B21 testified to continuity in use of the dung and branch houses of the settlement during that transition. I expect that a significant hiatus in occupation of the settlement or in use of the houses would have led to disintegration of houses because they require constant maintenance.

The present owners of the settlement have followed a pattern of seasonal shifting between *emparnat* occupation during each wet season and beginning of the dry season and *enkaron* occupation during the height of the dry season. During some years they have also tended to divide the household and the resources needed for daily survival such as labor and milking cattle. As a result, they have also maintained partial occupation of the *emparnat* settlement during dry-seasons. In the height of the long dry season of August-October of 2006, for example, two of the six women of the household remained at the *emparnat* with school going children and a number of gestating and lactating cattle and sheep/goats with offspring. Periods of lack of occupation of settlement B21 have occurred in years of more severe droughts, such as in the later part of 2005 and beginning of 2006.

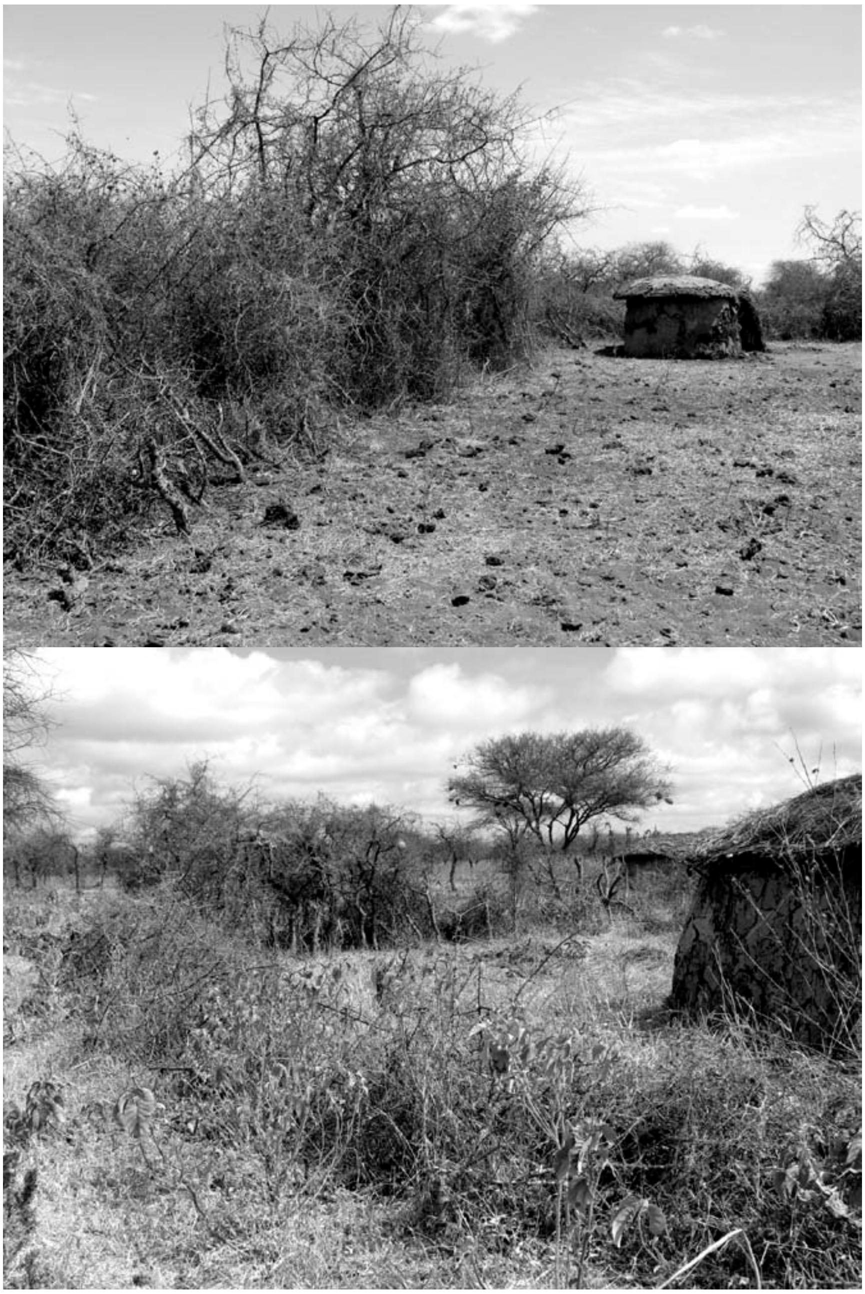
The resources available to the owners of settlement B21 may be important factors allowing seasonal splitting up of the household and movement farther away from the permanent sources of water, as well as movement of the household as a whole unit during some years. These resources include significant human labor necessary to carry out the daily tasks of livestock keeping, close-knit cooperation in herd management among members of the extended family household, and relatively high number of donkeys for daily water collection (see Table 6.1). An additional key resource in the possession of the owners of settlement B21 is a motorized vehicle which is the only vehicle in the northern neighborhood and one of only a few of those that are present in the study area as a whole. Based on the frequency with which settlement B21 has remained unoccupied or partly occupied the level of occupation of the owners may be assigned to a category of intermediate intensity of seasonal occupation in comparison to a lower intensity of occupation in *enkaron* settlements and higher intensity of occupation in the oldest of the study settlements, B45.

The second oldest of the study settlements of the northern neighborhood, B14, seems to have experienced greater continuity in occupation than settlement B21. A single household consisting of one aged man and his two wives occupied settlement B14 at the time of the study. The settlement included 4 houses of which only two were consistently used during the study period. The settlement was of relatively small size (50 m diameter). The family possessed a small herd of a few dozens of sheep and goat, no cattle, and only a single donkey. Some of their herd has been lost during the severe drought of 2005/2006. As only few resources were available to the household of settlement B21 and no young adults which typically assume some of the responsibilities of herd management with the aging of the head of the household they relied heavily on neighboring clan associates such as the owners of settlement B8 for assistance in moving herds.

Settlement B14 was erected at the beginning of the 1990's by the current owner after he split-off from the same founder settlement as several other of the current settlement owners of the northern neighborhood. In previous years, the owners of the settlement have tended to either divide the household between the *emparnat* and *enkaron* settlements during the dry season or to rely on a clan member in the neighboring settlement of B8 to shift their cattle to dry-season grazing grounds. In this way the inhabitants of settlement B14 were able to remain as a unit at the *emparnat* throughout some of the annual seasonal cycles. Certain structural elements of the settlement, which were not found in adjacent settlements and rarely seen in the study area as a whole may be considered indicators of relative sedentariness (see also Worden 2007: 27). These include a grass roof on one of the four houses of the settlement (Figure 6.5) and a particularly sturdy and developed circumference fence made up of live trees and shrubs (Figure 6.6). The small livestock holdings of the owners of settlement B14 and only one donkey available to them for daily collection of water (see Table 6.1) may be another reason for their relative sedentariness (see also Marshall and Weissbrod in press). The fact that the head of the household is of advanced age and that his adult sons — an important source of labor — are not living at the settlement also affects the mobility of this household. Moreover, during the severe drought of 2005/2006 the occupants of settlement B14 left the neighborhood at a relatively late stage than other neighboring households and returned to their settlement approximately one month before any of the other households in the neighborhood. The intensity of seasonal occupation over time in settlement B14 may be greater than that of the neighboring settlement of B21, but still lower than at settlement B45 — where partial occupation appears to have been the rule even during the most severe periods of drought.

Figure 6.5. Grass-roof house in study settlement B14 (above) compared to typical dung-roof houses in study settlement B21 (below) in the northern study neighborhood.

Figure 6.6. Tall live-fence surrounding study settlement B14 (above) compared to low-lying dead branch fence in study settlement B8 (below) in the northern study neighborhood.



In the two youngest of the study settlements, B2 and B8, the owners have tended like other neighboring herd owners to undertake seasonal shifts between the *emparant* and *enkaron* settlements of the northern neighborhood. They have also, however, followed a more elaborate strategy of seasonal residential mobility and settlement use. Although settlement B8 was not occupied during the study period I was able to talk to the former residents on a number of occasions at their new location in another group ranch to the south of Eselenkei. In these meetings I learned that settlement B8 housed a single extended household composed of an aged man, his wives, and a number of adult sons with wives totaling to 15 adults. The settlement included 9 houses and was of moderate size (60 m diameter). The family possessed large livestock holdings consisting of hundreds of cattle, sheep, and goats, and a large number of donkeys (N=20). The household of settlement B8 had substantial labor resources at their disposal and were also able to assist clan associates in movement of their herds.

In contrast to the other *emparnat* study settlements that had one household each, settlement B2 was occupied by three different households consisting of an elder head of household and wives and for one of the owners his sister and mother. The settlement consisted of six houses, some of which were still being constructed at the time of the study, and had an especially large size (80 m diameter) in comparison with other study settlements as well as with most settlements that I observed in the region. The household of settlement B2 possessed herds of moderate size consisting of perhaps two hundred head of cattle, sheep, and goats and five donkeys. This household depended for labor in herd management on three young adult males and the female co-residing kin of one of the owners.

The owners of settlements B2 and B8 have each maintained two *emparnat* settlements, one in the northern neighborhood and another located closer to the permanent sources of water at the Eselenkei riverbed. During the height of the dry season of each annual cycle and following the movement of cattle herds to *enkaron* settlements with young men and in some cases women as well, other women, children and old people have retreated with small livestock to the settlements situated closer to the permanent sources of water. Seasonal reoccupation of the *emparnat* settlements of the northern neighborhood is triggered by the rejuvenation of pasture within the grazing reserve following the onset of the rains of each wet season each year.

Different factors seem to influence the settlement and mobility strategies of the owners of settlements B2 and B8. The resources available to the owners of settlement B8 that affect mobility include labor, close-knit cooperation, and donkeys (see Table 6.1; for additional details on donkeys and Maasai settlement use see also Marshall and Weissbrod in press). Nonetheless, the advanced age of the head of the household may have influenced his decision to leave settlement B8 during the height of each dry season and retreat with some of the women and school-going children to a settlement situated closer to water, schools, and shops. The network of social ties of the owners of settlement B8 may be an additional important factor influencing their settlement and mobility strategies. This household migrated to the northern study neighborhood only in the last decade and its members may be considered the only 'outsiders' among the current households of the neighborhood. Nearly all of the others have roots in the two founder settlements that were established in the early 1980's. Since relocating to the northern study neighborhood the owners of settlement B8 have undertaken longer distance dry-season movements than most other settlement owners. Instead of using the *enkaron* cluster belonging to the northern neighborhood they have continued to use a more distant *enkaron* cluster belonging to an adjacent neighborhood where they share clan affiliation with a larger proportion of the resident households.

A different strategy is followed by the residents of settlement B2. Three separate and more contracted households make up the settlement population. They have stronger social and family ties within the northern neighborhood, but also posses relatively limited resources such as labor, within-household cooperative potential, and donkeys (see Table 6.1). The owners of settlement B2 erected one of their two current *emparnat* settlements at a location closer to the permanent sources of water and only recently erected a second *emparnat* in the northern neighborhood. Maintaining this second *emparnat* allows them during each dry season to shift closer to the grazing reserves as the dry season progresses and reduce the length of daily cattle grazing orbits. At the height of the dry season, the cattle herds are moved to the *enkaron* settlement and further into the grazing reserves. At this time households of settlement B2 retreat with the herds of small livestock from their *emparnat* in the northern neighborhood to their second *emparnat* that is situated closer to water. These divergent strategies regarding mobility and settlement use of the residents of settlements B2 and B8 result in a relatively high frequency with which the settlements are unoccupied and low intensity of seasonal occupation of the two settlements. Along the scale of intensity of seasonal occupation represented by the *emparnat* study settlements, settlements B2 and B8 may be assigned to a category of relatively low intensity. This corresponds more closely to the rate of intermittent occupation of settlement B21, than to that of more intensively occupied settlements such as B14 and B45 or the less intensively occupied *enkaron* settlement of E43.

6.23 Stochastic Aspects of Settlement Occupation in the Study Neighborhoods

Less predictable factors than systematic seasonal mobility and the long-term flexible mobility strategies of individual settlement owners have further complicated patterns of occupation through time in the study settlements. Abandonment of settlements is an inevitable and influential phase in the life-history of Maasai settlements but its timing is difficult to predict (see also Cameron and Tomka 1993 and papers therein). This is especially true within the study area where Maasai families have had considerably decreased settlement mobility over the past three decades (see Worden 2007: 35-36). Two of the study settlements, *emparnat* B8 and *enkaron* E43, were deserted by their owners prior to the beginning of the study and although they remained structurally intact during the study period, some evidence for initial disintegration of houses and enclosure fences could be observed. The owners of settlement B8 left their settlement together with neighboring settlement owners during the severe drought of 2005/2006, but did not return during the study period. It appears that for the time being they have relocated to a different group ranch where they have more established clan ties and are registered members of the group ranch. It is unclear whether settlement B8 will become an *emurua* or will be resettled by its original owners or by others. The *enkaron* E43 was deserted in 2004 together with all neighboring *enkaron* settlements, following a community decision to relocate the *enkaron* cluster of the southern study neighborhood and thereby to improve access to pasture in the increasingly congested grazing reserve. Despite desertion by the owners, enkaron E43 has been used at least twice since 2004 for short-term stays by other herd owners moving cattle herds long-distance during the drought period.

Other *emparnat* study settlements in the northern neighborhood were also occupied by herders from other neighborhoods at different times during the study period when these settlements were unoccupied by their owners. At the height of the severe drought in the beginning of 2006 following an out-of-season localized rain event and grass flush in the area in February at a period when settlements in the northern neighborhood were not occupied by their owners other herders with sheep and goats temporarily moved into settlements B2 and B21. In addition, the owners of settlement B14 left prior to the height of the following long dry season in July of 2006 reportedly due to an insufficient number of donkeys for daily water collection (see also Marshall and Weissbrod in press). This necessitated their move closer to the permanent sources of water at the Eselenkei riverbed. This move may be considered stochastic given the previous long-term pattern of relatively high intensity of seasonal occupation by the owners of settlement B14. Nonetheless, soon after this the settlement became temporarily occupied by other herders moving cattle closer to the grazing reserve adjacent to the northern study neighborhood. These movements occurred more than a month before the community-wide seasonal shift to the *enkaron* settlements within the grazing reserve. They may be explained on the one hand by the relatively distant position of the northern neighborhood from the permanent sources of water and on the other by its favorable location vis-à-vis the grazing reserve.

6.3 Towards Quantitative Description of Occupation Level in the Study Settlements

I use background information on the settlements, presented in the previous section, and the more detailed data on patterns of occupation and lack of occupation through time in the four study settlements of the northern neighborhood to construct a quantitative measure of the level of human occupation in the six study settlements (Tables 6.2-3 and Figure 6.7; see also Table 6.4 for chronological details on events and age-sets referred to in the data tables). In this section I analyze the information on varying levels of occupation of the study settlements according to two separate analytical components – occupation duration and intensity of seasonal occupation. Occupation duration also referred to as settlement age in the present study, simply corresponds to the number of years since the erection of the settlement. I define intensity of seasonal occupation as the number of seasons during each year that the settlement is typically occupied by the majority of its inhabitants, as opposed to being completely or partly unoccupied due to seasonal grazing related residential movements. The intensity of seasonal occupation can be used to distinguish between *enkaron* settlements that are occupied typically for short periods during the height of the long dry season and in years with low precipitation during the short dry season as well (c. 0.25 of the year), and *emparnat* settlements that are occupied on a more continuous basis during remaining seasons of the year (0.5-0.75 of the year).

Table 6.2. Observation on patterns of seasonal occupation in the four study settlements of the northern neighborhood during the study period (for details on chronological markers see Table 6.4).

Season	Settlement occupation patterns	Rainfall and other local events
Ntu-06	Owners of study settlements B2 and B21 as well as 'outsiders' occupying settlement B14 move their cattle herds to *enkaron* settlements. Household of settlement B21 divides between *emparnat* and *enkaron,* most of the people and cattle and sheep/goat herds move to *enkaron* while 2 of the 6 women remain at *emparant* with school-going childeren and a number of gestating and lactating cattle and sheep/goats with offspring. Owners of settlement B2 leave their emparnat at the northern neighborhood sending the cattle herds to *enkaron* with *ilmurran* and two of the women while the rest of the households retreat with the sheep and goats to an *emparant* closer to the permanent sources of water. end of study period in the northern study neighborhood.	A community decision from September 1st to allow movement from *emparant* to *enkaron* settlements inside the dry-season grazing reserves.
Ola-06	Some of the owners of settlement B2 return to the settlement in early May. with sheep and goat herds and *ilmurran* return in July with *the* cattle herds. Owners of settlement B14 leave the settlement in July moving closer to the permanent sources of water due to lack of donkeys for daily water collection. Cattle herd from another neighborhood situated farther from the grazing reserves brought by *ilmurran* and a young wife to settlement B14 in mid July to reduce daily cattle grazing orbits before movement to dry-season *enkaron* settlements. Cattle herd from another neighborhood brought by *ilmurran* to one of the temporary *roncho* settlements of the northern neighborhood.	
Ing-06	Owners of some of the other settlements of the northern study neighborhood return to their settlements.	Significant rainfall.
Olo-06	Owners of northern neighborhood settlements leave at beginning of the study period. Following a significant but localized out-of-season rain event in the area of the northern neighborhood in January 18th herders from other neighborhoods with sheep and goats settle temporarily in study settlements B2 and B21. Owner of settlement B14 returns to the settlement in later January. Owners of settlement B21 return to the settlement in mid February.	Height of a severe drought in 2005/2006.

Table 6.3. Oral history data from interviews on past patterns of seasonal occupation in the four study settlements of the northern neighborhood.

Season	Settlement occupation patterns	Rainfall and other local events
Ilk-05	Owners of settlement B14 leave.	A single rain event and no grass rejuvenation. Continuation of the severe drought.
Ntu-05		Shaving ceremony of the *ilmurran* (Eunoto) of Ilkiponi age-set.
Ola-05	Owners of settlements B2, B8, and B21 leave for early movement to *enkaron* settlements in July-August. Owners of settlements B2 and B8 move cattle herds to enkaron settlements and retreat with sheep/goats to *emparnat* settlements closer to the permanent sources of water. Owners of settlement B14 send the cattle to *enkaron* with the herds of settlement B8 and remain with sheep/goats.	
Ing-05	Owners of settlements B8 and B21 return to the settlements in March. *Ilmurran* of settlement B2 occupy the settlement with cattle while all others remain at their emparnat closer to the permanent sources of water.	Limited rain and continuation of the severe drought.
Olo-05	Owners of settlement B14 present with sheep/goats.	
Ilk-04	Owners of settlement B14 present with sheep/goats.	Limited rain.
Ntu-04	Owners of B2, B8, and B21 leave for early movement to *enkaron* settlements in August. Owners of settlements B2 and B8 move cattle herds to *enkaron* settlements and retreat with sheep/goats to *emparnat* settlements closer to the permanent sources of water.	
Ola-04	Settlement B2 is erected and its owners reside there in temporary houses.	
Ing-04	Owners of settlements B8 and B21 return to the settlements.	Average rain.
Olo-04	Owners of settlements B8 and B21 leave. Owners of settlement B14 present with sheep/goats.	Scatered rains.

Table 6.3. Cont.

Season	Settlement occupation patterns	Rainfall and other local events
Ilk-03	Owners of settlement B14 present with sheep/goats.	
Ntu-03	Owners of settlements B8 and B21 leave.	
Ola-03	Owners of settlement B21 move cattle to *enkaron* settlement but remain at the *emparnat* settlement with sheep/goats.	
Ing-03	Cattle herds are returned to the *emparnat* settlements.	Heavy rainfall with flooding extends to June. Ceremony of graduation to elderhood of Ilkidotu age-set.
Olo-03	Owners of settlements B8, B14 and B21 move cattle to *enkaron* settlements but remain at the *emparnat* settlements with sheep/goats. Owners of settlement B14 present with sheep/goats.	
Ilk-02	Cattle herds are returned to the emparnat settlements.	Sufficient rain.
Ntu-02		
Ola-02	Owners of settlements B8, B14 and B21 move cattle to *enkaron* settlement but remain at the *emparnat* settlement with sheep/goats. A number of herd owners from other neighborhoods moved their cattle herds to the enkaron settlements of the northern study neighborhood.	Ceremony of termination of circumcision of Ilkiponi age-set.
Ing-02		Sufficient rain.
Olo-02		
Ilk-01	Cattle herds are returned to the emparnat settlements.	
Ntu-01		
Ola-01	Owners of settlements B8, B14 and B21 move cattle to *enkaron* settlement but remain at the *emparnat* settlement with sheep/goats.	First election of current group ranch chairman to office.
Ing-01	Cattle herds are returned to the emparnat settlements.	
Olo-01	Owners of settlements B8, B14 and B21 move cattle to enkaron settlement but remain at the emparnat settlement with sheep/goats.	

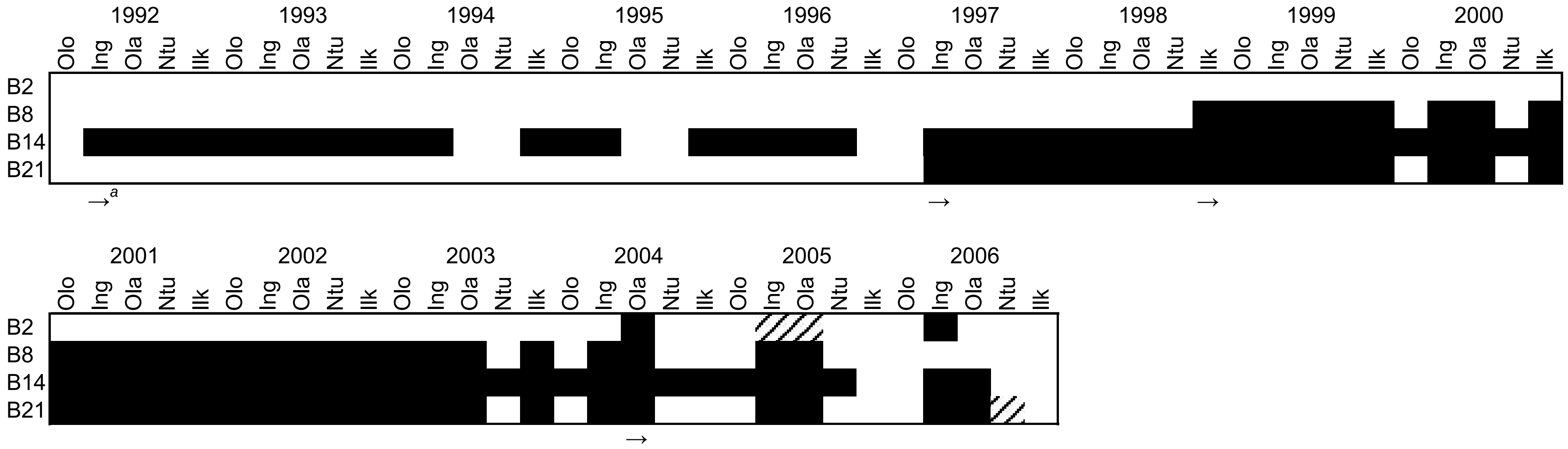
Table 6.3. Cont.

Season	Settlement occupation patterns	Rainfall and other local events
Ilk-00	Owners of settlements B8 and B21 return to the settlements.	Limited rain and extreme cold conditions.
Ntu-00		
Ola-00	Owners of settlements B8 and B21 leave to enkaron settlements. Owner of settlement B14 remains at the *emparnat* settlement with sheep/goats.	
Ing-00	Owners of settlements B8 and B21 return to the settlements in Mar.	Moderate rainfall but extending longer than usual.
Olo-00	Owners of settlements B8 and B21 move to areas receiving localized rainfall. Owner of settlement B14 remains with sheep/goats.	Rainfall extendes from the previous short wet season.
Ilk-99	Cattle herds are returned to the *emparnat* settlements.	Significant rainfall.
Ntu-99		
Ola-99	Herd owners move cattle to *enkaron* settlements but remain in the *emparant* settlements.	
Ing-99		Significant rainfall.
Olo-99		Abundant forage.
Ilk-98	Owners of settlement B8 erect their settlement.	
Ntu-98		
Ola-98		Outbreak of striped mice (zebra mice; *Lemniscomys* sp.) in the settlements.
Ing-98		Heavy El-Niño rainfall.
Olo-98		Short break in rainfall.
Ilk-97	Cattle herds are returned to the *emparnat* settlements.	Begnning of heavy El-Niño rainfall.
Ntu-97		
Ola-97	Herd owners move cattle to *enkaron* settlements but remain in the *emparant* settlements.	
Ing-97	Owner of settlement B14 returns to the settlement. The current owners of settlement B21 settle into the settlement.	Heavy rainfall.
Olo-97		

Table 6.3. Cont.

Season	Settlement occupation patterns	Rainfall and other local events
Ilk-96	Owner of settlement B14 leaves the settlement together with other herd owners of the neighborhood.	Localized rainfall.
Ntu-96		
Ola-96	Herd owners move cattle to *enkaron* settlements but remain in *emparant* settlements. Previous owners of settlement B21 migrate away from northern study neighborhood.	
Ing-96	Cattle herd of owner of settlement B14 returned to the settlement.	Significant rainfall.
Olo-96	Herd owner of settlement B14 moves cattle to enkaron settlement but remains with sheep/goats while other herd owners of the neighborhood leave.	Ceremony of graduation to taking milk of Ilkidotu age-set. Year of the star (Olari Lolakira).
Ilk-95	Herd owner of settlement B14 returns to the settlement.	Limited rainfall.
Ntu-95		
Ola-95	Owner of settlement B14 moves to *enkaron* settlement.	
Ing-95		Limited rainfall.
Olo-95		
Ilk-94	Herd owner of settlement B14 returns to the settlement.	Moderate rainfall.
Ntu-94		
Ola-94	Owner of settlement B14 moves to *enkaron* settlement.	
Ing-94		Significant rainfall.
Olo-94	Cattle of herd owner of settlement B14 returned to settlement.	
Ilk-93		Significant rainfall.
Ntu-93		
Ola-93	Herd owner of settlement B14 moves cattle to *enkaron* settlement but remains with sheep/goats.	
Ing-93		Heavy rainfall.
Olo-93		
Ilk-92		Heavy rainfall and abundant forage. The Kenyan genral elections.
Ntu-92		
Ola-92		
Ing-92	Settlement B14 is erected.	
Olo-92		

Figure 6.7. Chart of intermittent occupation patterns through time in the four study settlements of the northern neighborhood showing seasons of occupation (black), partial occupation (hatched), and lack of occupation (blank).



[a] Arrows indicate beginning of record for each of the settlements.

Table 6.4. Chronological markers and age-sets in Maasai society in the study area[a].

Age-set (pl.)	**Age at time of study (2006)**	**Dates as young men or worriers (*ilmurran*)**
Ilnyankusi	66-79	1942-1959
Iseuri	55-65	1957-1975
Ilkeshimu/Ilkitoip	40-54	1973-1985
Ilkidotu	28-42	1983-1996
Ilkiponi	18-29	>1996

Event	**Translation**	**Description**	**Timing**
Olari Lenguruma	Year of the Flour	Severe drought	1960/1961
Olari Enkare Nanyukie	Year of the Red Water	Severe drought	1984/1985
Olari Lolakira	Year of the Star	Astronomical event	1996

[a] Information in table based in part on my data and in part follows Mol 1996: 12, Rodriguez 2006: 59.

Quantitative assessment of the intensity of seasonal occupation in the study settlements is a relatively complicated procedure when compared to the simple derivation of values representing the duration of occupation or settlement age in years. This task necessitates considerably greater detail on life-histories of the study settlements in terms of former annual cycles of settlement occupation and lack of occupation. Moreover, the information on varying levels of intensity of seasonal occupation can be considered in terms of two different scales of analysis corresponding first to systematic seasonal mobility between *emparnat* and *enkaron* settlements and second to individual household level variation in the intensity of seasonal occupation among the different owners of the settlements. The first scale is a dichotomous categorical one distinguishing between two discrete categories, *emparant* settlements with more extensive seasonal occupation and *enkaron* settlements with relatively short-term seasonal occupation. The second scale is a more continuous one or more properly a scaled variable that identifies a range of varying levels of intensity of seasonal occupation among owners of the different *emparnat* settlements and assigns the *enkaron* settlement to the lower end of that range. Moreover, settlement B45, the oldest of the study settlements, can be assigned to the higher end of the range along this scale based on its extensive age and relative sedentariness.

The background information on the four *emparant* study settlements in the northern neighborhood indicates that they occupy intermediate and possibly varying positions on the scale characterizing the six study settlements. The owners of settlement B14 show a relatively high intensity of seasonal occupation in comparison to owners of neighboring settlements but a lower level of occupation than the owners of settlement B45 in the southern neighborhood. This last settlement is also the only one among the study settlements that remained occupied throughout the severe drought of 2005/2006. In the northern study neighborhood, owners of settlements B2, B8, and B21 show lower rates of intensity of seasonal occupation than the owners of the neighboring settlement B14 but also follow differing mobility strategies within the system of regular shifts between *emparant* and *enkaron* settlements. The differences in the level of occupation that were detected among the four study settlements of the northern neighborhood can be further assessed through consideration of the life-histories of the settlements detailing patterns of occupation, partial occupation, and lack of occupation through time. This information is provided in Tables 6.2 and 6.3, which present observations on settlement use during the study period and accounts of past settlement use based on interviews. Figure 6.7 provides a graphic representation of the detailed information in the tables. It is important to note the fact that information on partial occupation for any of the four study settlements was mainly retrieved for the observable portion of the period in question and the recent past covered by the interviews. The resolution of interview information on long-term patterns of settlement occupation is reduced as one goes back in time and relies on more long-term memory.

The information on past cycles of settlement occupation and lack of occupation that is presented in Table 6.3 and Figure 6.7 generally supports my assessment of the relative sedentariness of the owners of settlement B14, as compared to the owners of neighboring study settlements. Over time this settlement has seen significant continuity in occupation that extended throughout some of the dry seasons during which neighbors left their settlements. Table 6.3 and Figure 6.7 do not indicate further differentiation in intensity of seasonal occupation among the owners of settlements B2, B8, and B21, despite their varying mobility strategies (see detailed descriptions presented in previous section). Two intermediate categories may therefore be constructed along the scale of intensity of seasonal occupation. These include occupation intensity in settlement B14 that corresponds to a relatively high position on the scale and occupation intensity in settlements B2, B8, and B21 that corresponds to a lower position. Additional support for this scaling is provided through elders in interviews ranking the settlement owners of the northern study neighborhood according to the intensity with which they occupy their settlements on a seasonal basis. When asked to rank their own level of seasonal occupation and those of their neighboring settlement owners, all interviewees ranked settlement B14 at the higher end of the range of intensity of seasonal occupation and assigned a lower position on the scale for settlements B2, B8, and B21.

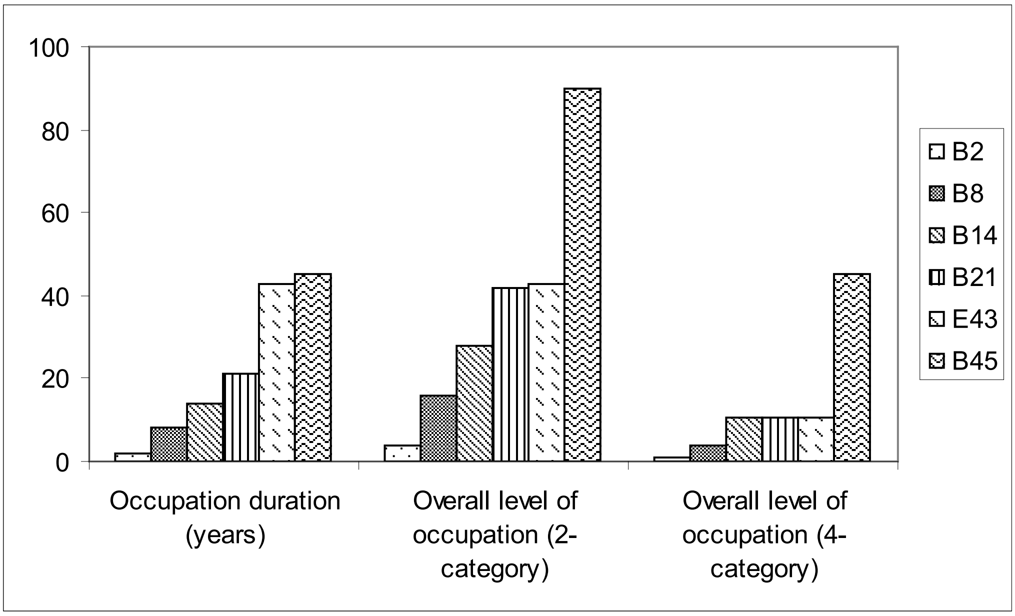
Overall, the information on varying levels of intensity of seasonal occupation in the study settlements indicates that the six settlements fall into either two categories or four positions on the scale of intensity of seasonal occupation, depending on the scale of analysis. A more detailed continuous variable of intensity could not be achieved in this study because of the complexity that was found to characterize patterns of occupation in the study settlements and the limited resolution that is provided by historic data on settlement occupation through time. In a contracted two-category scale, the study settlements receive a value of either one (*enkaron*) or two (*emparnat*). In an extended four-category scale, the settlements are scored according to the scheme presented in Table 6.5. The *enkaron* settlement, E43, which is the least intensely occupied of the study settlements, receives a value of .25 representing its typically short-term seasonal occupation that extends through only a few months of each year. At the other end of the scale, settlement B45, the most intensely occupied of the study settlements, receives a value of one representing year-round occupation. In the northern study neighborhood, settlement B14, which shows relatively high intensity of seasonal occupation and the group of settlements B2, B8, and B21, which exhibit lower levels of intensity, correspond to the two intermediate categories representing .75 and .5 of the year, respectively. Representing the categories of intensity of seasonal occupation as fractions of the year is more appropriate in the context of a study of seasonal patterns of settlement use than assigning the arbitrary numbers 1-4. Using fractions or a scale of 1-4 should have negligible mathematical significance for statistical analysis.

Table 6.5. Primary and derived quantitative measures of levels of occupation in the study settlements based on oral-history information collected through interviews.

	Intensity of seasonal occupation		Occupation duration (years)	Overall level of occupation (2-category)	Overall level of occupation (4-category)
	2-category scale	4-category scale			
B2	2	.5	2	4	1
B8	2	.5	8	16	4
B14	2	.75	14	28	10.5
B21	2	.5	21	42	10.5
E43	1	.25	43	43	10.75
B45	2	1	45	90	45

In addition to variability among the study settlements, which is related to the intensity of seasonal occupation, there is considerable variability related to duration of occupation or settlement age. A measure combining both the duration of occupation and intensity of seasonal occupation provides a more realistic estimation of the overall level of occupation in the study settlements than either duration or intensity can provide separately. Table 6.5 and Figure 6.8 show that multiplying settlement occupation duration by scores of either the two-category or four-category scales of intensity of seasonal occupation provides a noticeably lower overall level of occupation of the *enkraon* settlement E43 than for settlement B45, which has a nearly equivalent duration of occupation but significantly greater intensity of seasonal occupation. In addition, overall levels of occupation based on the two-category intensity scale retain more of the variation attributable to occupation duration among the study settlements than levels of occupation based on the four-category intensity scale (Figure 6.8).

Figure 6.8. Distribution of primary (settlement age) and derived (overall) levels of occupation across the study settlements.



It is important to note that the two derived scales of overall level of occupation lack an interpretable unit of measurement such as years or portion of the year. In that sense, values along the two scales are not reducible to the primary components of duration or intensity. Rather, the scales were constructed to represent as accurately as possible the variation in overall level of occupation across the study settlements. I will use the two scales to gauge the ecological impact on local micromammalian communities of increasing level of human occupation in the study settlements.

CHAPTER 7

VARIABILITY IN MICROMAMMALIAN COMMUNITIES IN THE STUDY SETTLEMENTS

7.1 Introduction

In this chapter I examine three lines of ecological evidence: 1) the structure and composition of micromammalian communities in the study sites, 2) underlying population characteristics that provide clues on how different species interact with settlement environments, and 3) the quantitative relationship between ecological and human occupation parameters. In the first part of this chapter I apply a descriptive approach for addressing micromammalian community and population characteristics. In the last section of this chapter I analyze the ecological effect of Maasai settlements through a formal hypothesis testing approach based on multiple regression/correlation statistics. In this analysis I take into account the effects of the main research factors including the effect of settlements *versus* that of the control sites and of the overall level of human occupation of the settlements. I also account for potential effects of additional factors such as seasonal variability throughout the study period and extended lack of human occupation in two of the study settlements (B8 and E43).

The micromammalian trapping program was conducted in twelve study sites including six settlement and control pairs and during four separate sessions between January and October of 2006. Table 7.1 shows that trapping effort was nearly equally distributed among settlements and controls and amounted to a total of 7,350 trap days (Σ no. traps × no. days of trapping). This trapping effort produced captures of 352 small rodents and shrews and 428 recaptures of these individuals (see detailed trapping records in Appendix 1). The overall capture success achieved in the study (total no. of captures/no. trap days) is approximately 11%. Micromammals captured in the twelve trapping sites belong to nine different genera that are listed in Table 7.2. Additional data on micromammals from sightings and analysis of owl pellets and mongoose scats (Table 7.2) provides a more complete census of the taxa that may be expected locally and indicates that the trapping program obtained 75% of the twelve genera occurring in the study area (see Chapter 8 for more detailed comparisons of trapping and prey data). Moreover, species from eight of the nine genera that were recorded through trapping occurred in the settlements. Zebra mice (*Lemniscomys* sp.) were captured only in the controls whereas Taterillus gerbils (*Taterillus* sp.) were captured only in the settlements.

Table 7.1. Distribution of trapping effort (Σ no. traps × no. trap days) across the study sites.

	Trapping sessions in 2006				
Sites	I Jan-Feb	II May-Jun	III Jul-Aug	IV Sep-Oct	Total
Settlements					
B2	150	175	175	175	675
B8	125	175	125	125	550
B14	125	175	175	175	650
B21	150	175	175	175	675
E43	125	125	125	125	500
B45	125	175	175	175	650
Total	800	1000	950	950	3700
Controls					
C2	125	175	175	175	650
C8	125	175	125	125	550
C14	125	175	175	175	650
C21	125	175	175	175	650
C43	125	125	125	125	500
C45	125	175	175	175	650
Total	750	1000	950	950	3650

Table 7.2. Micromammalian species records in the study area based on trapping, sightings, and analysis of prey remains in owl pellets and mongoose scats.

	Trapping		Sightings	Pellets & scats[a]
Genus: common name (scientific name)	Controls	Settlements		
Spiny mouse (*Acomys* sp.)	+	+	+	+
Multimammate rat (*Mastomys* sp.)	+	+	+	
Zebra mouse (*Lemniscomys* spp.)	+		+	
Elephant shrew (*Elephantulus* sp.)	+	+	+	+
Naked-soled gerbil (*Tatera* sp.)	+	+	+	+
White-toothed shrew (*Crocidura* sp.)	+	+	+	+
Teterillus gerbil (*Teterillus* sp.)		+	+	+
Common gerbil (*Gerbillus* sp.)	+	+	+	+
Narrow-footed woodland mouse (*Grammomys* sp.)	+	+		+
Climbing mouse (*Dendromus* sp.)				+
African dormouse (*Graphiurus* sp.)			+	
Common mouse (*Mus* sp.)				+

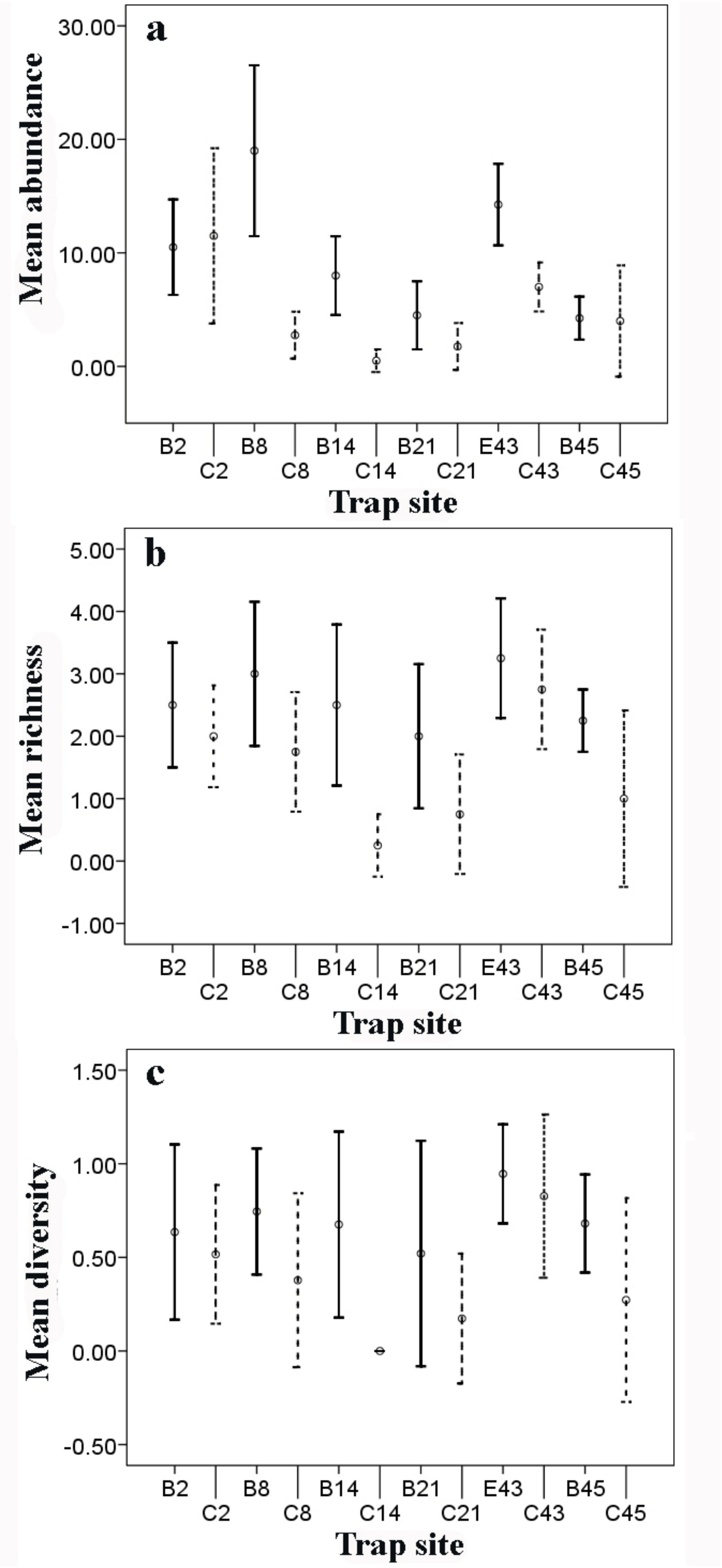
[a] Additional more detailed data on prey assemblages provided in Chapter 8.

One possible explanation for the high similarity in species composition between the settlements and controls is the relative proximity of control sites to the settlements (225-400 m). Results of the trapping study indicated, however, that there was little exchange in micromammalian individuals between adjacent settlement and control sites. During the trapping period there were only two instances when an animal captured in either a settlement or control site had a mark from the adjacent site. Moreover, variability in composition and frequencies of species among both the settlement and control sites was considerable. This variability is addressed in the analyses below.

7.2 Patterns in Micromammalian Community Structure: Abundance, Richness, and Community Diversity

The charts in Figure 7.1a-c present average values of micromammalian abundance (no. of captures), richness (no. of species), and community diversity (Shannon-Wiener index) in the twelve study sites (i.e., all sessions were pooled). The values of the three indices are generally higher in the settlements. The only exception is settlement B2, which has lower abundance than in the adjacent control. It is noteworthy that the average abundance in settlement B2 and its control site are similar and relatively high. In settlement B45 average abundance is the lowest among the study settlements and only slightly higher than in the adjacent control. Average abundance, richness, and community diversity peak in settlements B8 and E43, which remained unoccupied or had only ephemeral human occupation throughout the study period.

Figure 7.1. Mean values ± standard errors of micromammalian abundance (no. of individuals) (a), richness (no. of species) (b), and community diversity (Shannon-Wiener index) (c) arranged by settlement-control (B-C) pairs.



I used a factorial repeated measures analysis of variance (ANOVA) to examine whether the differences in means between the settlements and controls are statistically significant. This design simultaneously compares the two groups of settlement and control sites (between-subjects factor) while taking into account variability among the four trapping sessions that represent repeated measures (within-subjects factor termed seasonality). The results of the analysis are presented in Table 7.3. The multivariate statistic (Wilks' Lambda) tests against violations of two of the important underlying assumptions of repeated measures ANOVA: high correlation among the repeated measures and equality of group variances. These tests are significant only for richness and diversity. In these cases the differences in mean richness and diversity between the settlements and controls (between-subjects) are also significant. Therefore, mean micromammalian richness and diversity in the settlements are greater than in the controls by 1.167 species and .339 units of diversity, respectively. The mean difference of 5.5 additional individuals in the settlements as compared to the controls is not significant. The non-significant difference in abundance between the settlements and controls may be due to the relatively high numbers of individuals that were captured in the control of settlement B2 and relatively low numbers in settlement B45. These results do not indicate marked commensalism and decrease in biological diversity in the settlements and contrast with patterns predicted in Tchernov's (1984, 1991a) commensalism model for highly sedentary settlement environments (see additional analyses below).

Table 7.3. Repeated measures analysis of variance statistics for the mean differences in micromammalian abundance, richness, and diversity between settlements and controls[a].

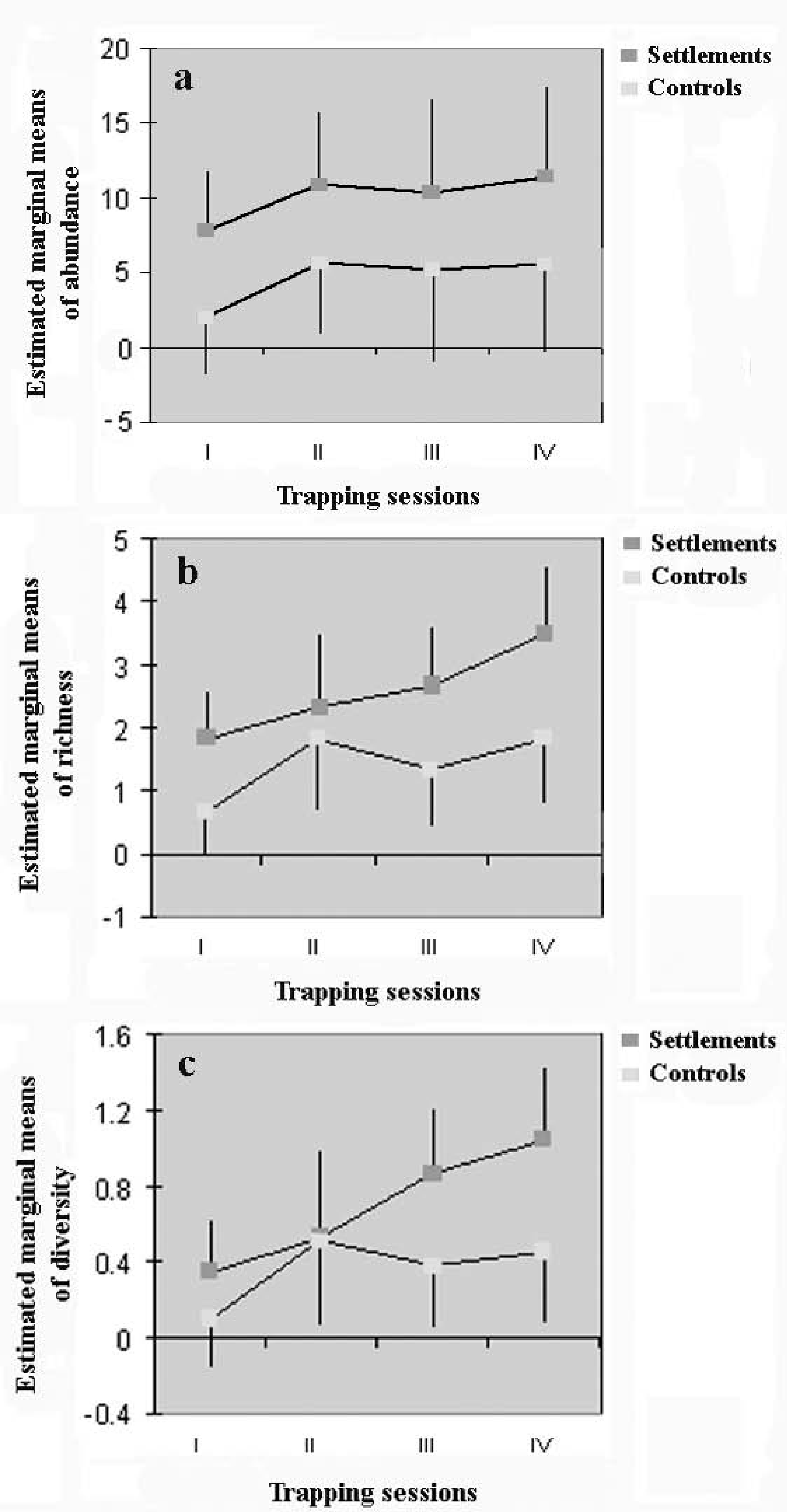
		Community indices		
Statistics	Statistic	Abundance	Richness	Diversity
Multivariate test (Wilks' Lambda)	*F*	1.246	7.936	7.722
	p	.356	**.009**	**.010**
Between-subjects	*F*	3.649	7.717	6.71
	p	.085	**.020**	**.027**
Within-subjects	*F*	1.813	5.545	3.29
	p	.166	.059	.100
Seasonality × Site type interaction	*F*	.025	.727	.512
	p	.995	.414	.490
Mean difference		5.500	1.167	0.339
df	Constrast	1	1	1
	Error	10	10	10

[a] Significant results highlighted in bold.

The lack of significant interactions of seasonality × site type (Table 7.3) reflects the fact that the higher levels of micromammalian abundance, richness, and community diversity in the settlements are maintained throughout the four trapping sessions. A graphical representation of this is shown in Figure 7.2. Although the within-subjects seasonality factor was not significant in the analysis of variance important seasonal trends can be noted among the four trapping sessions in abundance, richness, and diversity. Figure 7.2 shows that levels of these indices uniformly increase between the first and second trapping sessions in both the settlements and controls. In the settlements, richness and diversity continue to increase throughout the study period whereas there is a concomitant leveling off in richness and diversity in the controls as well as in abundance in both the settlements and controls. The similar seasonal trends in abundance, richness, and diversity in the controls in contrast to the settlements indicates that in the settlements higher levels of abundance are maintained throughout the study period through continued addition of individuals (recruitment) from new species rather than through intrinsic increase in population sizes, which would impact abundance.

Although it is conceivable that more animals entered traps during the later sessions because of habituation to and scent-marking of traps (see Drickamer 1995) such effects are not likely to have had marked impact on trapping rates in this case. The marked increases in abundance, richness, and diversity between the first and second trapping sessions can be related to the intervening wet-season. Moreover, such marked increases in abundance between the first and second sessions were detected only in four of the individual settlements: B8, B14, E43, and B45. In settlements B2 and B21, however, abundances decrease at the same time. This may be related to the fact that these two settlements became reoccupied by people and livestock just prior to the second session and this could have depressed recruitment rates at a time when the other four study settlements experienced a greater degree of occupational stability. These patterns indicate that both seasonality and intermittent human occupation may have influenced micromammalian communities in the study settlements. It can also be noted that, in settlements E43 and B45, relatively few new species were recruited during the second session, whereas numbers of individuals in these settlements did increase somewhat at the same time.

Figure 7.2. Seasonal variability in micromammalian abundance (a), richness (b), and community diversity (c) in the settlements and controls based on estimated mean values from repeated measures analysis of variance. Means are fitted with 95% confidence intervals.



I also used Spearman's rank correlation (*r*) to examine the influence of level of human occupation and lack of occupation on micromammalian abundance, richness, and community diversity. The factor of lack of occupation is represented as a categorical variable distinguishing among the two study settlements with significant lack of occupation (code=2) and the rest (code=1). This factor is also referred to below as 'abandonment' for the sake of brevity. Table 7.4 presents the correlation coefficients and shows that most of the relationships with levels of occupation are negative. Note that the five scales of occupation level are structured so that low values represent low levels of occupation. This implies that increasing levels of human occupation are generally associated with a reduction in micromammalian abundance, richness, and community diversity in both the settlements and controls. It is difficult to determine the difference in magnitude of the effect of level of human occupation between the settlements and controls, however, given that some of the coefficients from the controls are lower than corresponding coefficients in the settlements but others are higher. None of these coefficients is significant, however. Positive and significant correlations exist between abandonment (i.e., lack of occupation) and abundance, richness, and diversity in the settlements. This indicates that higher levels of abandonment in settlements B8 and E43 are significantly associated with increased numbers of micromammalian individuals, numbers of species, and community heterogeneity. I will examine these relationships further below using the framework of multiple regression analysis, which can accommodate these diverse influences within a single model.

Table 7.4. Spearman's rank correlations between indices of micromammalian community structure and scales of level of human occupation in the study settlements (N=6 in all cases)[a].

Scale of human occupation level	Ecological indices					
	Abundance		Richness		Diversity	
	Settlements	Controls	Settlements	Controls	Settlements	Controls
Intensity 2-category	-0.393	-0.393	-0.664	-0.655	-0.655	-0.655
Intensity 4-category	-0.698	-0.395	-0.585	-0.698	-0.273	-0.698
Settlement age	-0.543	-0.086	-0.203	-0.086	0.314	-0.086
AgeInt2Cat	-0.543	-0.086	-0.203	-0.086	0.314	-0.086
AgeInt4Cat	-0.522	-0.116	-0.132	-0.116	0.377	-0.116
Abandonment	**0.828**	0.207	**0.840**	0.621	**0.828**	0.621

[a] Correlation coefficients highlighted in bold are significant at the α=.05 level.

7.3 Micromammalian Community Composition

The distribution of micromammalian species across the trapping sites is highly variable and for some of the species is also markedly patchy. Only one species, the spiny mouse (*Acomys* sp.) occurred in all of the settlement and control sites. Other species such as Teterillus and common gerbils (*Gerbillus* sp.) and the narrow-footed woodland mouse (*Grammomys* sp.) were captured in only one or two of the settlement or control sites. Species such as the narrow-footed woodland mouse were also abundant in some sites but sparse in others. Moreover, the distributions vary considerably between the settlements and controls. I examine the distribution of species across the trapping sites based on average numbers of individuals captured across the four trapping sessions and in each of the trapping sites (Table 7.5).

Tracing the occurrence and average abundance of species across the rows of Table 7.5 reveals a marked contrast in species distributions between the settlements and controls. It is evident that more species fill the columns of each of the settlement sites than the columns of most of the control sites and that in many cases average abundances in the settlements are greater than in the controls. The right hand column of Table 7.5 presents a qualitative description of species distributions based on the occurrences and average abundance data. According to these descriptors three of the species are ubiquitous in the settlements and all others are either localized or sporadic. In the controls only one of the species is ubiquitous and many are rare. Spiny mice, multimammate rats (*Mastomys* sp.), and elephant shrews (*Elephantulus* sp.) each occur in 4-6 of the settlement sites and in some of the sites reach relatively high average abundance ranging between 2.75 to 10.5 mean number of individuals per site. Common gerbils, narrow-footed woodland mice, and Taterillus gerbils occur in fewer of the settlement sites but in one of the sites reach relatively high average abundance. Naked-soled gerbils (*Tatera* sp.) and white-toothed shrews (*Crocidura* sp.) occur in 3-4 of the settlement sites in relatively low average abundance ranging mostly below 1.25 mean number of individuals per site.

The composition of micromammalian communities appears less stable across the control sites than the settlements. Only spiny mice occur in all of the control sites and no other species occurs in more than three sites. Five of the eight species occurring in the controls have maximum average abundance of 1 or less whereas in the settlements the average abundance of the same species is higher by as much as ×5 to ×9 as in the controls. These species include the multimammate rats, elephant and white-toothed shrews, common gerbils, and narrow-footed woodland mice. Only naked-soled gerbils have greater average abundance in the controls as compared to the settlements (*c.* ×3). This species occurs in a similar number of both settlement and control sites, N=4 and N=3, respectively. The zebra mouse is the only species that occurs in the control sites but not in the settlements and has maximum abundance no greater than 1 mean number of individuals.

Table 7.5. Average abundance ± standard errors and distribution of micromammalian species in the settlements and controls.

	Settlements						
Species	B2	B8	B14	B21	E43	B45	Distribution[a]
Spiny mouse	7.25 (1.97)	10.5 (1.55)	4.5 (0.65)	2 (0.71)	5 (0.82)	0.75 (0.48)	U
Multimammate rat	0.25 (0.25)	3.75 (3.42)	0.25 (0.25)	1 (0.71)	0.25 (0.25)	0.75 (0.48)	U
Zebra mouse							A
Elephant shrew	2 (0.82)	0.5 (0.29)	2.75 (1.25)	1.25 (0.75)			U
Naked-soled gerbil	0.25 (0.25)		0.25 (0.25)		0.75 (0.48)	0.5 (0.29)	S
White-toothed shrew	0.75 (0.75)			0.25 (0.25)	1.25 (0.95)		S
Teterillus gerbil		0.25 (0.25)				1.5 (1.5)	L
Common gerbil					7 (1.78)	0.75 (0.48)	L
Narrow-footed mouse		4 (1.47)	0.25 (0.25)				L
No. of species	5	5	5	4	5	5	
	Controls						
Spiny mouse	8.5 (2.96)	2 (0.58)	0.5 (0.5)	1.25 (0.75)	4.25 (1.49)	2.25 (1.44)	U
Multimammate rat		0.25 (0.25)					R
Zebra mouse				0.5 (0.5)	0.75 (0.48)	1 (1)	S
Elephant shrew	0.5 (0.5)				0.25 (0.25)		R
Naked-soled gerbil	2.5 (1.04)	0.25 (0.25)			1 (0.58)		L
White-toothed shrew		0.25 (0.25)					R
Teterillus gerbil							A
Common gerbil					0.75 (0.48)		R
Narrow-footed mouse						0.75 (0.75)	R
No. of species	3	4	1	2	5	3	

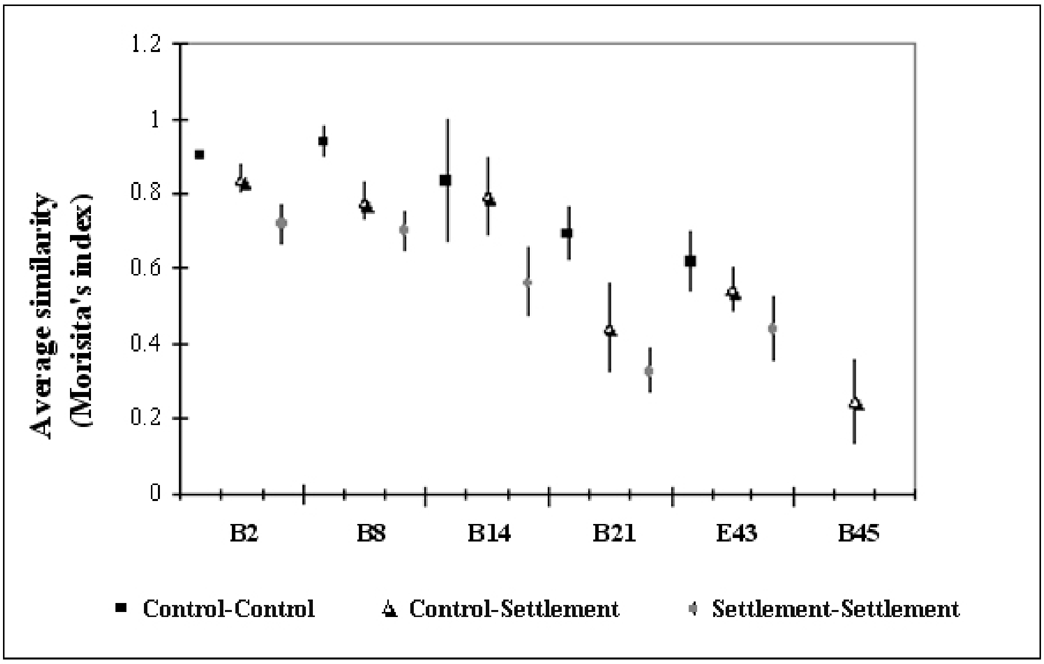
[a] **U**biqutous - occurs in high or low numbers in many sites
Localized - occurs in high or low numbers in a few sites
Sporadic - occurs in low numbers but in many sites
Rare - occurs in low numbers in one or a few sites
Absent

The data in Table 7.5 also provide an indication on how the composition of micromammalian communities varies with settlement age or was influenced by significant abandonment. Spiny mice are on average the most abundant species in the younger settlements B2-B21 as well as in all of the control sites. They are only the second most abundant species in settlements E43 and B45 where common and Taterillus gerbils, respectively, are more abundant than spiny mice. The average abundance of spiny mice is also highest in the two youngest settlements, B2 and B8 and in the control of settlement B2. Moreover, the unoccupied settlement, B8 has the highest average abundance of spiny mice among all trapping sites. Elephant shrews are the second most abundant species in settlements B2, B14, and B21 but are absent from settlements E43 and B45. This species also occurred in low numbers in the unoccupied settlement, B8 and in the controls of settlements B2 and E43. Multimammate rats occurred in all of the settlements but show particularly high numbers in settlement B8. Besides this settlement, the average abundance of multimammate rats is greatest in the older settlements B21 and B45. Only a single individual of this species was captured in any of the controls. Similarly, only a single white-toothed shrew individual was captured in the controls whereas this species was captured in moderate abundances in a number of the settlements. They occurred in both younger and older settlements.

Two of the species occur in particularly high numbers in the two unoccupied settlements but are rarely present in any of the other settlements or controls. Narrow-footed woodland mice are the second most abundant species in settlement B8 and common gerbils are the most abundant species in settlement E43. Naked-soled gerbils occur in both younger and older settlements but show greater abundances in the controls of both young and old settlements. It may also be significant that zebra mice occur in the controls of the older settlements, B21, E43, and B45.

Quantitative assessment of the degree of similarity or dissimilarity in micromammalian community composition between the settlements and controls and among the settlements is based on Morisita's index of community similarity (Krebs 1998: 390-391). I computed this index with the program for palaeontological statistics PAST, ver. 1.81 (Ryan et al. 1995) for each of the trapping sites per each trapping session (see Appendix 2 for matrix of similarities). I then averaged all of the similarity values that were obtained between pairs of each of the controls and adjacent settlements (control-settlement) and controls of the next oldest settlement (control-control) as well as between each of the settlements and the next oldest settlement (settlement-settlement). These average similarities are presented in Figure 7.3 and show that micromammalian communities in the controls uniformly have a greater degree of similarity with closest-neighbor controls (control-control) than with adjacent settlements (control-settlement). Similarities among the settlements are lower still. Furthermore, the degree of similarity between each control and its adjacent settlement appears to decline with age. Spearman's rank correlations between this decline in community similarity and the five scales of level of occupation are significant in the case of settlement age and for the derived four- and two-category scales of overall level of occupation (r=-.886, p=.019; r=-.886, p=.019, r=-.812, p=.050, respectively). These negative correlations indicate a decline in community similarity with increasing levels of occupation and suggest that increasing occupation levels have a significant affect on changes in the configuration of micromammalian communities. Low similarity among the settlements indicates that micromammalian species are to some extent not adapted to these environments and differences in species composition or abundances may result from competition. In addition, the finding that control sites are more similar to each other than to adjacent settlements indicates that they were situated at a sufficient distance from the settlements to provide a background signal.

Figure 7.3. Average community similarity with ± standard error bands based on Morisita's index comparing between: settlement-control pairs, each control and the control of the next oldest settlement, and each settlement and the next oldest settlement. Only control-settlement comparison is shown for settlement B45 because there are no older settlements or control sites.



7.4 Micromammalian Population Characteristics

7.41 Population Size

Spiny mice were the most ubiquitous species trapped during the study. They accounted for over 60% of all captures, occurred in all of the trapping sites, and were captured during the majority of trapping sessions in both settlements and controls. The relatively high numbers of spiny mouse captures and their wide distribution allow me to examine variability in population characteristics of spiny mice between settlements and controls and among the settlements and to asses the effect of settlements on the population size of a single species. Figure 7.4 presents numbers of spiny mouse individuals captured in each of the trapping sites in each of the trapping sessions and Figure 7.5 presents corresponding estimates of population size fitted with confidence intervals that are based on the Schumacher and Eschmeyer method of population estimation for capture-mark-release studies. The complete day-by-day records of captures and recaptures that I used for population estimation of spiny mice are presented in Appendix 3 in conjunction with corresponding charts of accumulation of individuals throughout each trapping session.

Figure 7.4. Abundances of *Acomys* sp. based on numbers of individuals captured in the settlements (a) and controls (b).

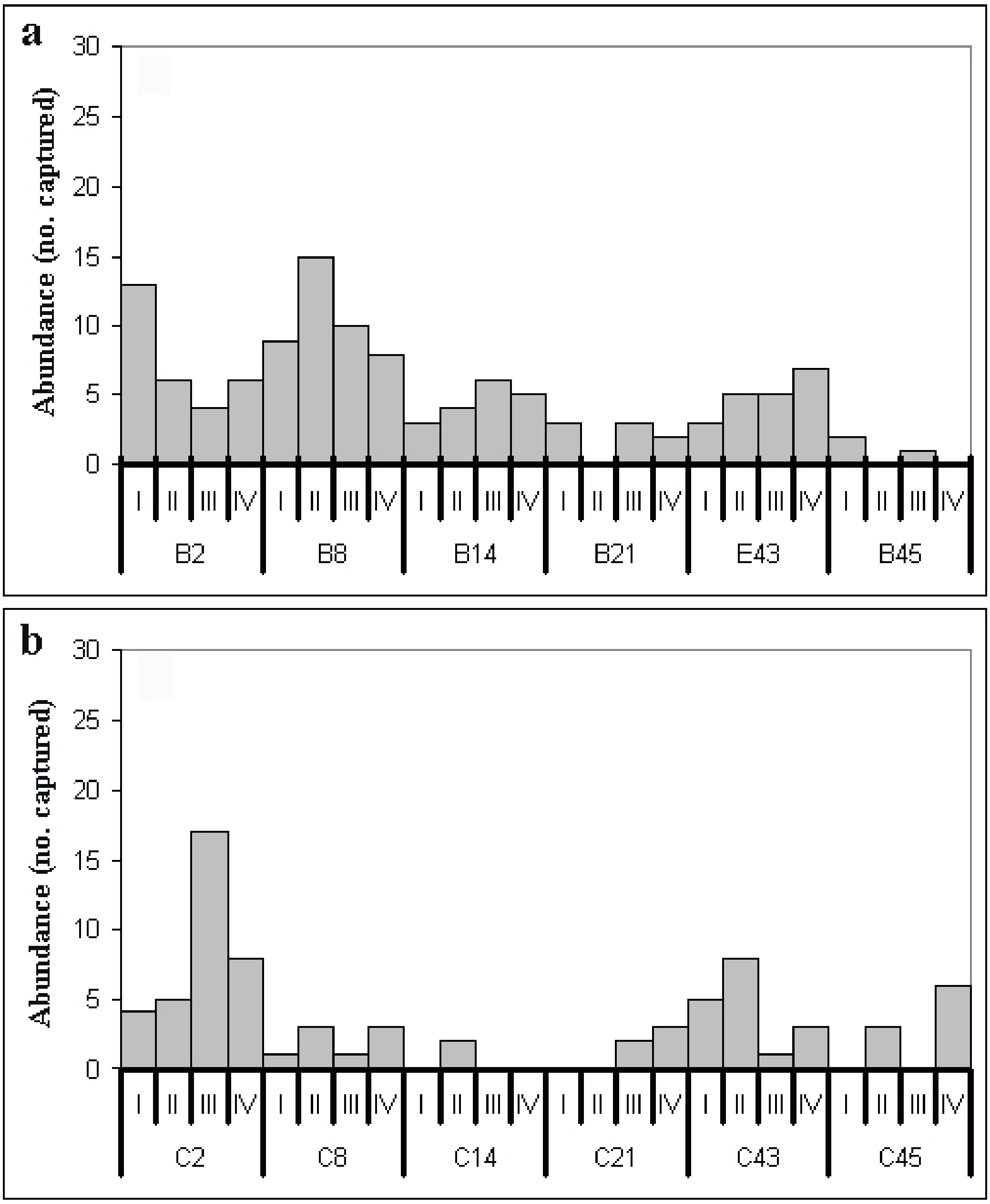
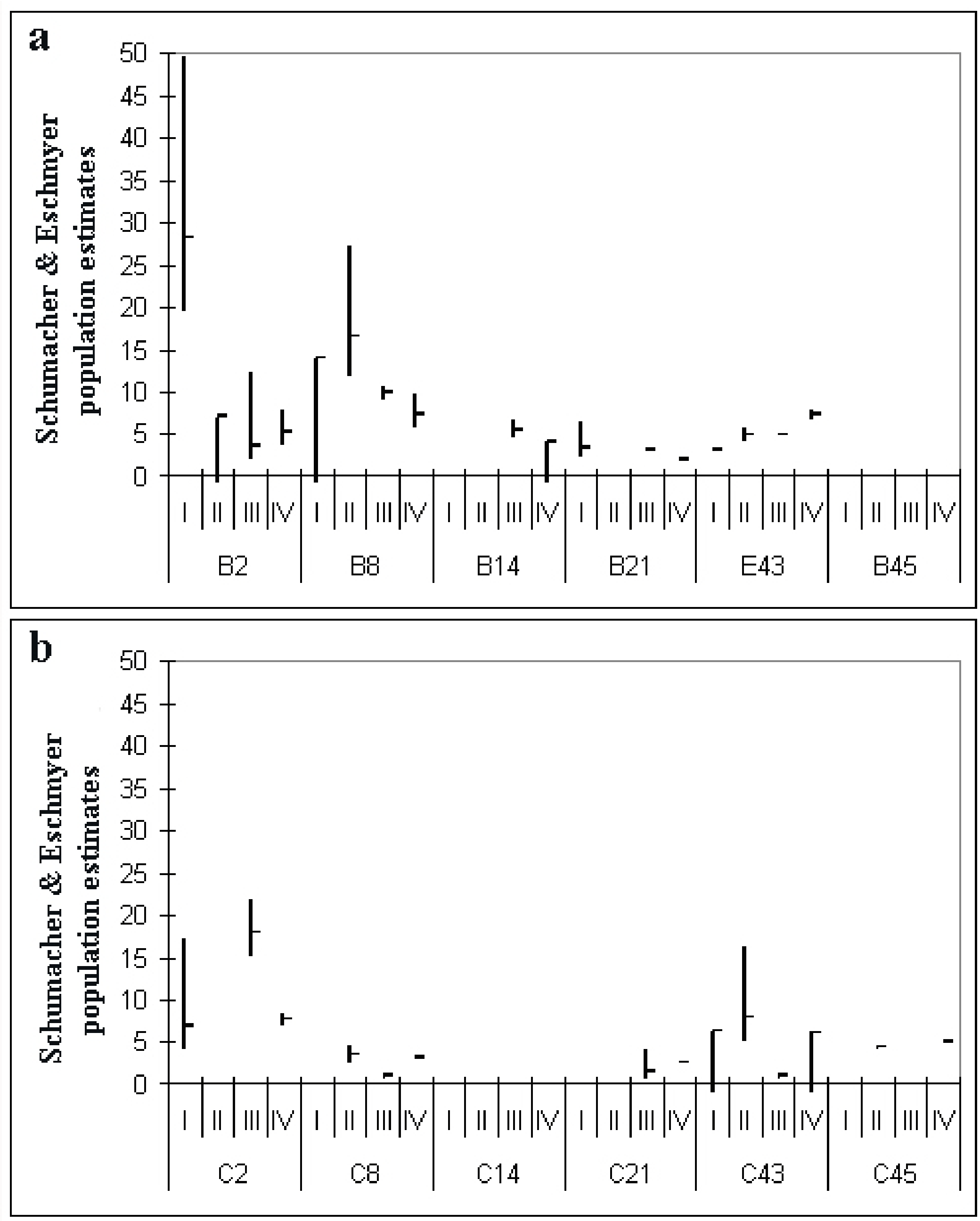


Figure 7.5. Population estimates of *Acomys* sp. with confidence intervals based on the Schumacher and Eschmeyer method for the settlements (a) and controls (b).



The abundances of spiny mice in the trapping sites calculated based on numbers of individuals captured are in most cases similar to those calculated on the basis of estimates of population size. These latter also take into account the rate of recapture of these individuals. The only exception to this can be detected in the first trapping session in settlement B2 where the estimate is markedly higher than actual numbers of individuals captured (compare Figures 7.4a and 7.5a). This relatively high estimate is due to the continuous increase in the rate of accumulation of newly trapped individuals during that session and relatively low number of recaptures of these individuals (see Appendix 3). This trapping dynamic indicates that there may have been significant immigration of individuals to the settlement at the time of trapping or gradual habituation of animals to the traps. Immigration would violate the assumption of constant population size underlying the Schumacher and Eschmeyer method of population estimation and therefore the estimate should be considered unreliable in this case. I also compared the abundance of spiny mice between the settlements and controls through factorial repeated measures ANOVA of the same design used above. The analysis showed that the differences in mean numbers of spiny mice between the settlements and controls are not significant (Wilks' Lambda: F=.177; p=.909).

As shown in Figures 7.4a and 7.5a a general decline can be detected in spiny mouse numbers and population size estimates in the settlements with increasing settlement age. This trend shows a markedly discontinuous pattern, however, mainly due to a peak in numbers in settlement B8 and to variability within sites among the four trapping sessions. An examination of the pattern of fluctuation in spiny mouse numbers from session to session in each of the trapping sites indicates greater consistency among the controls than among the settlements. In most of the controls spiny mouse numbers increase in the second and fourth trapping sessions in comparison to immediately preceding sessions (i.e., the first and third sessions, respectively). The only exception to this pattern is in the control of settlement B2, which shows continuous increase in numbers during the earlier three sessions, but this is followed by a decline during the fourth session. In the adjacent settlement the fluctuation in numbers reveals a near mirror image of the fluctuations in the control.

A peak in numbers during the first session in the settlement corresponds to a slump in the control and the reverse can be observed during the third session. I note, however, that a marked decrease in numbers in the settlement during the second session corresponds only to a slight increase in the control. Spiny mouse numbers in some of the other settlements appear to have remained more stable throughout the study period. A slight trend towards increasing numbers can be observed for settlements B14 and E43, which experienced a relatively high degree of stability of occupation or lack of occupation, respectively, throughout the study period. The numbers of spiny mice remain consistently low in settlements B21 and B45.

7.42 Population Structure

The few juvenile and sub-adult individuals and lactating females that I captured provide scant data on the population age structure and reproduction of spiny mice (Table 7.6). Ten immature spiny mice were nearly evenly distributed among five of the study settlements, excluding settlement B21. In contrast, almost all of the immature individuals that were recorded among the control sites were concentrated in the control of settlement B2. Between one and two lactating females were recorded in five of the settlements, excluding B45, and four lactating females were distributed among three of the controls. Lactating spiny mouse females were recorded throughout the duration of the study in all four sessions. Immature individuals of a number of other species were more common among the settlements (N=11) than among the controls (N=3). Most of the settlements, except B21, had small numbers of eiher immature elephant shrews, multimammate rats, narrow-footed woodland mice or the three species of gerbils. Three lactating elephant shrew females and two of the gerbil species were recorded among the settlements.

Table 7.6. Data on micromammalian population structure and rates of diurnal activity in the settlements and controls.

Site/ session		Juveniles		Subadults		Lactating females		Diurnal captures	
		Settlement	Control	Settlement	Control	Settlement	Control	Settlement	Control
B2	I		2	1				1	
	II		1	1					
	III	1			2	2	1	5	8
	IV				1			3	3
B8	I	1		1					
	II							6	
	III							6	
	IV	1		2		1		1	2
B14	I								
	II					1		4	
	III			1	1		1	12	
	IV			2				5	
B21	I					1			
	II								
	III							5	5
	IV					1		3	1
E43	I						1		
	II			1		2	1	3	
	III					1		6	
	IV			2				2	2
B45	I	2							
	II	2	1	1					8
	III								
	IV	1		1	1				1
Totals		8	4	13	5	9	4	62	30

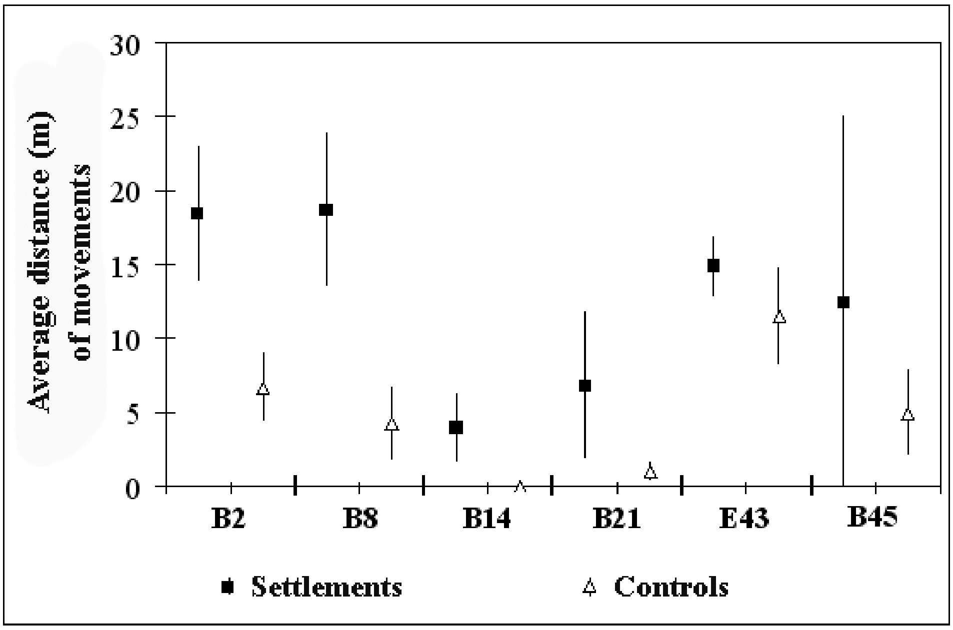
7.43 Activity Patterns

Evidence for differences in daily activity patterns of spiny mice among the trapping sites is based on records of diurnal captures of this generally nocturnal species. Table 7.6 shows that settlements had more than twice as many diurnal captures of spiny mice as the controls. Diurnal captures in the settlements concentrated mainly in settlements B8, B14, and E43, which had 8-13 cases each. Diurnal captures of spiny mice occurred in both occupied (B14) and unoccupied (B8 and E43) settlements. Two additional cases of diurnal activity were recorded in settlement B21 and none in settlements B2 and B45. In contrast, the majority of diurnal captures of spiny mice in the controls were recorded in the control of settlement B2 (*c*. 64%). Nearly all other cases of diurnal capture were of species with distinctly diurnal activity patterns. Elephant shrews account for 27 of the 29 non-spiny mouse cases of diurnal capture in the settlements and zebra mice for 14 of the 16 cases in the controls. Additional sporadic diurnal captures were of individuals of two of the gerbil species and white-toothed shrews.

7.44 Intensity of Habitat Use

In this section I examine differences in the intensity of habitat use among the trapping sites based on the extent and frequency of movements of individuals between successive recaptures. A total of 303 movements of spiny mouse individuals were recorded during the study with an average of 11.22 meters traveled per individual between successive locations of capture. This includes 101 occasions in which the individuals were captured consecutively in the same trap and coded as a movement with zero distance. Figure 7.6 presents averages of spiny mouse movements in the settlements and controls pooled from all trapping sessions for each of the study settlements. Average movement of spiny mice was greater in all of the study settlements than in adjacent controls although for E43 and B45 there is considerable overlap in standard errors between the settlement and control means. Settlement B45 produced only a single and relatively lengthy movement of spiny mice. The higher mean distances of movements in the settlements as compared to the controls may indicate larger home-ranges or lower population densities of micromammals. It is important to take into consideration, however, that as an indication of home-range size or population density the comparability of the intensity of movement between the settlements and controls may be hindered to some extent by fundamental differences in the habitat structure of the two habitat types. In the settlements, spatial use may be shaped in large part by the linear arrangement of fences and the highly patchy availability of vegetation and shelter, which is largely restricted to the fences. This is supported by observations on widespread micromammalian runways and fecal pellets inside branch fences of the settlements.

Figure 7.6. Average distance moved by *Acomys* sp. ± standard errors in the settlements and controls based on recapture data.



As a possible index of the effect of settlement structure on population density and spatial use Spearman's rank correlations among spiny mouse mean movement per site and the level of human occupation, abandonment, and settlement diameter were not significant. These correlations are consistently negative for the settlements indicating that the extent of movement of spiny mice declines somewhat with increasing level of occupation and settlement diameter.

7.5 Spatial Use of Settlement Habitats by Micromammalian Species

Spatial use of settlement habitats may be examined by comparing capture frequencies among the different structural contexts of the settlements: perimeter branch fence, internal livestock enclosure fences, and houses. I base these comparisons on the overall number of captures including recaptures in each of the three contexts. Figure 7.7 presents standardized species frequencies that were adjusted to the different numbers of traps that were set in each of the three contexts (i.e., varying trapping efforts). These relative frequencies show that the overall composition and distribution of species varies among the three contexts. Spiny mice were captured in relatively high frequencies in all parts of the settlements. They occur less frequently in the enclosures than in the perimeter fences and inside houses. Moreover, in perimeter fences, spiny mice were mainly associated with elephant shrews and common gerbils whereas inside houses they were mainly associated with multimammate rats and narrow-footed woodland mice. Species such as the different gerbils and elephant shrews occurred in relatively high frequencies in the perimeter fences but their frequencies decline considerably in internal enclosures and are nil in the houses. In contrast, multimammate rats appear to increase in frequency along the continuum of perimeter fences-to-enclosures-to-houses.

Figure 7.7. Species frequencies in the three structural contexts of the settlements: perimeter fence, enclosures, and houses. Frequencies are standardized to trapping effort. Species abbreviations are based on scientific names in Table 7.2.

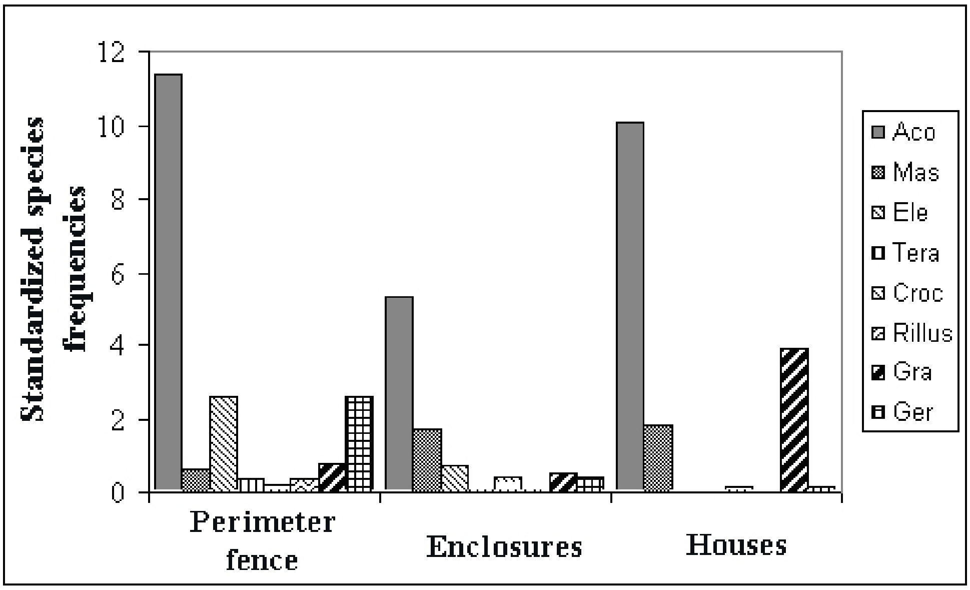


Figure 7.8 compares micromammalian richness and Shannon-Wiener diversity measures among the different structural contexts of the study settlements. Richness and diversity per context were computed based on data that was pooled from all trapping sessions in each of the settlements. Both richness and diversity are generally lower in the houses than in the perimeter fences and indicate that fences contribute more to overall diversity of the settlements. The only exception is settlement B8, which has greater diversity in the houses (Figure 7.8b). The numbers of species in the perimeter fences and houses fluctuate similarly among the settlements (Figure 7.8a). Differences among the settlements can also be observed in the enclosures, which have 4-5 species in most of the settlements and only a single species — spiny mice — and correspondingly zero diversity in settlements B14 and B45. Contrasting trends can be noted in diversity in the perimeter fences and houses (Figure 7.8b). Diversity appears to decline in the houses with settlement age while increasing in the perimeter fences. In the absence of a marked increase in richness in the older settlements this trend

implies that individuals are more equally distributed among the different species in the perimeter fences of these older settlements. Table 7.7 presents Spearman's rank correlations between richness and diversity in the different contexts and the scales of level of occupation. The increasing trend of diversity with settlement age in the perimeter fences is supported to some extent by a series of three positive and significant coefficients. Similarly, the decreasing trend of diversity with settlement age in the houses may be supported by two negative and significant coefficients. Multiple negative coefficients for the inner enclosures and houses for both richness and diversity indicate that these generally decrease with increasing levels of occupation. Only three of these coefficients are significant, however.

In regard to variability in spatial use of settlements it can be noted that only two species – spiny mice and multimammate rats – were recorded in houses that were occupied at the time of trapping. Multimammate rats were also the only species that was recorded inside houses in settlement B45.

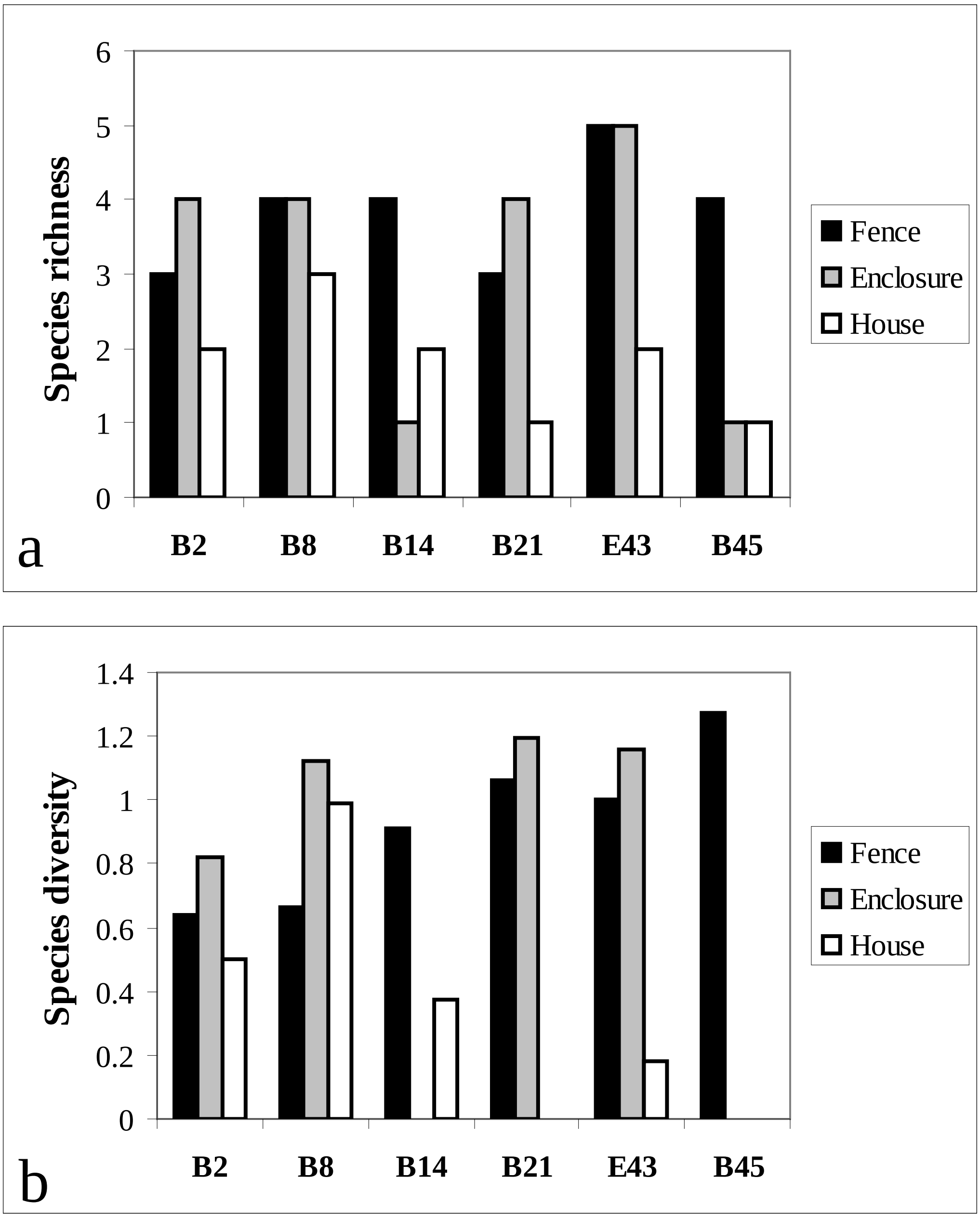
Table 7.7. Correlations between micromammalian richness and diversity in the three structural contexts of the settlements and the scales of level of human occupation (N=6 in all cases)[a, b].

Scale of human occupation level	Species richness			Community diversity		
	Fence	Enclosures	Houses	Fence	Enclosures	Houses
Intensity 2-category	-0.707	-0.707	-0.141	-0.131	-0.399	0.133
Intensity 4-category	-0.164	**-0.984**	-0.393	0.334	-0.801	-0.246
Settlement age	0.494	-0.123	-0.648	**0.943**	0.000	-0.841
AgeInt2Cat	0.494	-0.123	-0.648	**0.943**	0.000	-0.841
AgeInt4Cat	0.579	-0.204	-0.579	0.899	-0.132	-0.779

[a] Undelined correlation coefficients are significant at the α=.05 level.

[b] Correlation coefficients highlighted in bold are significant at the α=.01 level.

Figure 7.8. Micromammalian species richness (a) and community diversity (b) in the three structural contexts of the settlements: perimeter fence, enclosures, and houses.



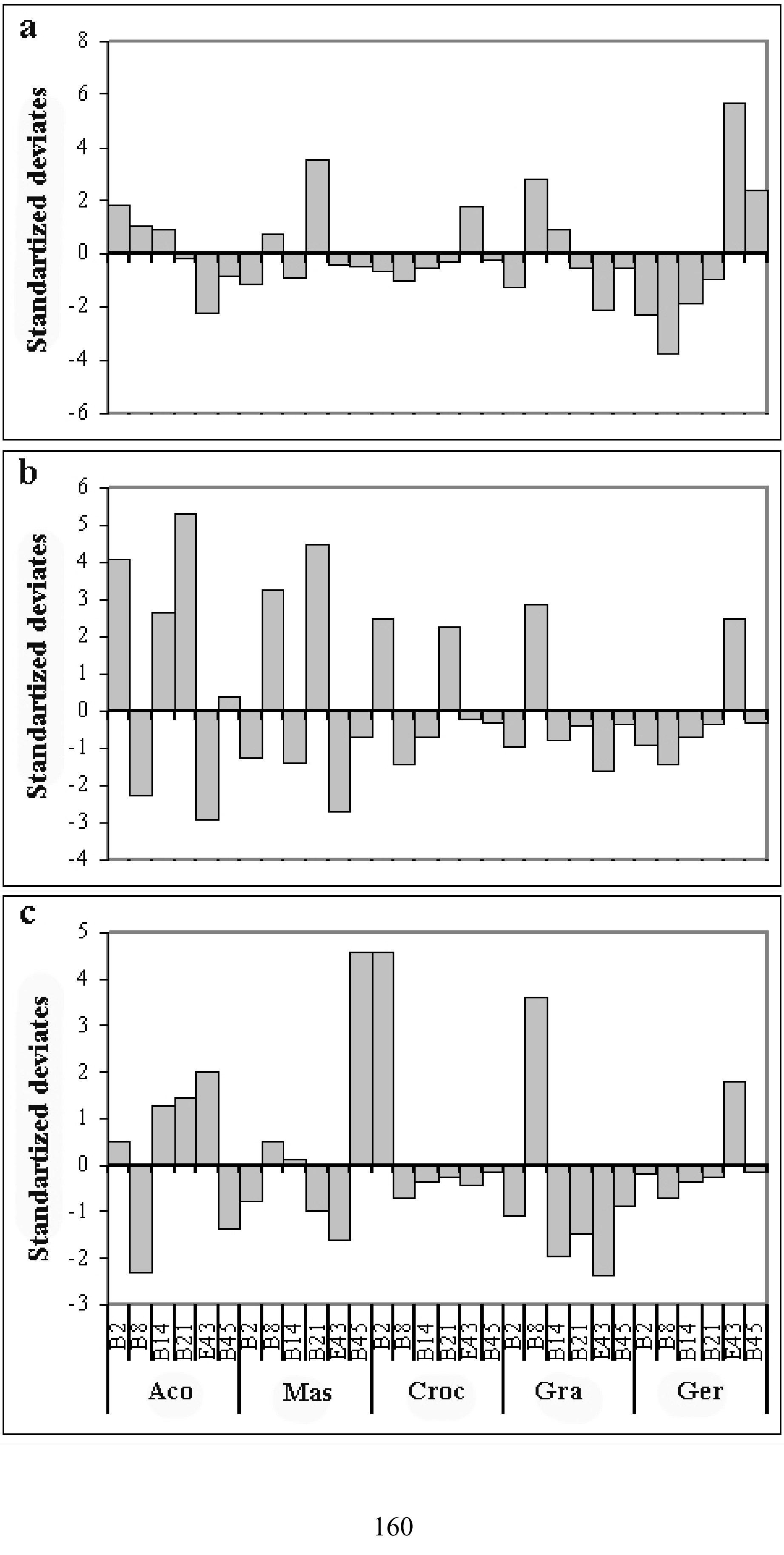
I used chi-squared analysis to compare capture frequencies of species in the three structural contexts in order to further examine ways in which species distribution in the different contexts varies among the settlements. Here, I also combined the numbers of captures and recaptures due to otherwise sparse data and because a consideration of recapture rates in the different contexts may provide a better indication of intensity of use. Chi-squared analysis can account for varying capture efforts among the three contexts by simultaneously weighing the absolute capture frequencies in relation to the overall numbers of captures in each settlement as well as in all settlements combined. This procedure produces the expected frequencies that may then be compared with the observed frequencies. These frequencies are presented in Table 7.8 from which separate species × settlement contingency tables for each of the contexts were used for the chi-squared analysis. Chi-squared analysis of the three resulting contingency tables shows significant dependence between species distributions and the different study settlements for each of the contexts ($\chi^2_{\mathrm{fence}}=361.213$; $df=47$; $p<.000$; $\chi^2_{\mathrm{enclosure}}=251.043$; $df=47$; $p<.001$; $\chi^2_{\mathrm{house}}=92.906$; $df=29$; $p<.001$).

Table 7.8. Contingency tables of observed and expected frequencies of micromammalian species in the three structural contexts of the settlements: perimeter fence, enclosures, and houses (species abbreviations are based on scientific names in Table 7.2).

		B2		B8		B14		B21		E43		B45	
Structural contexts/species		Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
Fence	Aco	33	(26.49)	72	(53.58)	19	(28.90)	4	(5.42)	50	(57.79)	2	(7.83)
	Mas	0	(1.47)	5	(2.98)	0	(1.61)	2	(0.30)	3	(3.21)	0	(0.43)
	Ele	10	(6.03)	2	(12.20)	26	(6.58)	3	(1.23)	0	(13.16)	0	(1.78)
	Tera	1	(0.88)	0	(1.79)	1	(0.96)	0	(0.18)	2	(1.93)	2	(0.26)
	Croc	0	(0.44)	0	(0.89)	0	(0.48)	0	(0.09)	3	(0.96)	0	(0.13)
	Rillus	0	(0.88)	0	(1.79)	0	(0.96)	0	(0.18)	0	(1.93)	6	(0.26)
	Gra	0	(1.77)	10	(3.57)	2	(1.93)	0	(0.36)	0	(3.85)	0	(0.52)
	Ger	0	(6.03)	0	(12.20)	0	(6.58)	0	(1.23)	38	(13.16)	3	(1.78)
Enclosures	Aco	23	(11.04)	15	(22.32)	13	(12.04)	9	(2.26)	13	(24.08)	2	(3.26)
	Mas	1	(3.53)	18	(7.14)	0	(3.85)	4	(0.72)	1	(7.71)	0	(1.04)
	Ele	4	(1.47)	0	(2.98)	0	(1.61)	6	(0.30)	0	(3.21)	0	(0.43)
	Tera	0	(0.15)	0	(0.30)	0	(0.16)	0	(0.03)	1	(0.32)	0	(0.04)
	Croc	3	(0.88)	0	(1.79)	0	(0.96)	1	(0.18)	2	(1.93)	0	(0.26)
	Rillus	0	(0.15)	1	(0.30)	0	(0.16)	0	(0.03)	0	(0.32)	0	(0.04)
	Gra	0	(1.03)	7	(2.08)	0	(1.12)	0	(0.21)	0	(2.25)	0	(0.30)
	Ger	0	(0.88)	0	(1.79)	0	(0.96)	0	(0.18)	6	(1.93)	0	(0.26)
Houses	Aco	4	(3.13)	23	(36.94)	14	(10.02)	9	(5.63)	22	(14.40)	0	(1.88)
	Mas	0	(0.57)	8	(6.67)	2	(1.81)	0	(1.02)	0	(2.60)	3	(0.34)
	Croc	1	(0.04)	0	(0.51)	0	(0.14)	0	(0.08)	0	(0.20)	0	(0.03)
	Gra	0	(1.22)	28	(14.37)	0	(3.90)	0	(2.19)	0	(5.60)	0	(0.73)
	Ger	0	(0.04)	0	(0.51)	0	(0.14)	0	(0.08)	1	(0.20)	0	(0.03)

I also computed standardized deviates based on chi-squared tests of the five species that occurred in all three of the structural contexts as an aid to visual evaluation of the deviations of expected from observed species frequencies in each of the three contexts (Figure 7.9). As in the analysis of all species chi-squared tests for the five species that occurred in all three of the contexts are significant ($\chi^2_{\text{fence}}=109.227$; $df=29$; $p<.001$; $\chi^2_{\text{enclosure}}=143.440$; $df=29$; $p<.001$; $\chi^2_{\text{house}}=92.906$; $df=29$; $p<.001$). The charts in Figure 7.9 show that different species occur in varying degrees of association with the settlements depending on the context. Patterns of association are clearest in the perimeter fences and houses and for spiny mice, which were captured in all of the settlements and in some cases in relatively high frequencies. A consistent decrease in the association of spiny mice with the settlements with increasing settlement age can be noted in the perimeter fences (Figure 7.9a). A generally contrasting trend can be observed in the houses (Figure 7.9c). The pattern in houses is disrupted by lower than expected frequencies of spiny mice in the houses of settlements B8 and B45. In the former settlement, narrow-footed woodland mice show a distinct association with the houses whereas multimammte rats show a distinct association with the houses in settlement B45.

Figure 7.9. Standardized deviates for observed *versus* expected species frequencies in the three structural contexts of the settlements: perimeter fence (a), enclosures (b), and houses (c) (species abbreviations are based on scientific names in Table 7.2).



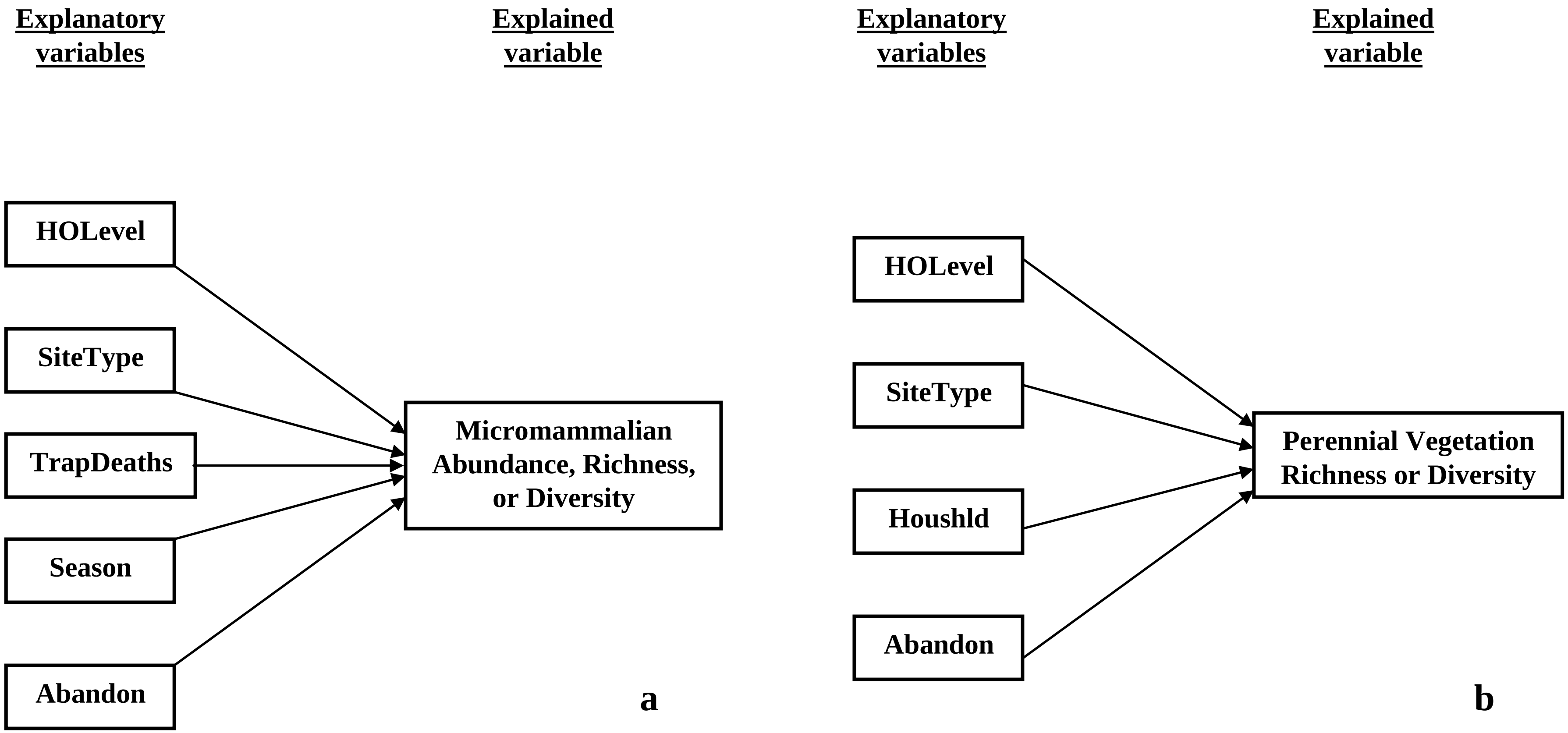
7.6 Simultaneous Analysis of Environmental and Human Occupation Effects on Variability in Micromammalian Community Organization across the Study Sites: A Multiple Regression Approach

In this section I use a multiple regression technique to simultaneously evaluate the effects of settlements *versus* control sites and increasing level of occupation in the settlements on variability in micromammalian abundance, richness, and community diversity among the twelve study sites. This technique provides a solution to the problem of accounting for the complexities inherent in the data given the multiple planned and unplanned factors that may affect observed variability in micromammalian community organization across the study sites in contrasting or confounding ways. The analysis is specifically designed to test two expectations related to the testing of Tchernov's commensalism model. These state that: 1) seasonal Maasai settlements are expected to have a significant effect on micromammalian community structure as compared to background levels and 2) no significant increase is expected in micromammalian population sizes, richness, and diversity with increasing level of human occupation in settlements that are occupied intermittently on a systematic seasonal basis and have stable human population size.

Accordingly, the two main explanatory factors that I include in the analysis are the differences between settlements and controls expressed as a dichotomous categorical variable (controls coded as 1 and settlements as 2) and the level of human occupation in the study settlement as a scale variable. A number of additional factors are included in the analysis as control variables in order to account for the following unplanned potential effects on variability in micromammalian community parameters: abandonment (i.e., extended lack of occupation) of settlements B8 and E43, seasonal variability during the study period, and cases of micromammalian deaths that resulted from trapping. I conducted a mathematical transformation of three of the scales of level of human occupation that include the variable of settlement age by logging settlement age in order to improve normalization in the distribution of ages that are somewhat skewed by the two oldest settlements, E43 and B45.

Figure 7.10a presents a multiple regression model (Model I) that is based on the five explanatory and control variables mentioned above and designed to examine the effects on variability in micromammalian community parameters. Thus, the model examines the combined effect (overall R^2) of level of human occupation (HOLevel) and differences between settlements and controls (SiteType) in conjunction with the control variables of abandonment (Abandon), seasonal variability (Season), and micromammalian trap deaths that occurred in each preceding session (TrapDeaths). This model also examines the unique effects of each of the explanatory variables (partial correlation coefficients, sr^2) or set of variables (increments to explained variability, IR^2) once the effects of all other explanatory and control variables in the model have been accounted for. The seasonality factor is represented in the analysis by a set of three coded variables with scores of 0-1. These three coded variables are the minimum necessary to adequately distinguish among the four trapping sessions. The factor of abandonment is represented as a categorical variable distinguishing between the two study settlements that remained unoccupied throughout the study period (code=2) and the rest of the study settlements (code=1). The data for testing Model I consists of all of the samples that were collected in the twelve study sites in four separate trapping sessions (N=48).

Figure 7.10. Multiple regression models: Model I, N=48 (a) and Model II, N=12 (b) (explanation of variable abbreviations in text).



In addition, a second model in Figure 7.10b (Model II) evaluates the possibility that the impact of the settlements *versus* the controls (SiteType) and level of human occupation (HOLevel) have affected micromammalian community parameters in part through their long term effect on the richness and diversity of perennial vegetation (see Appendix 4 for detailed vegetation data). Model II examines the unique effects of both the impact of the settlements and level of occupation on vegetation while accounting for additional effects of abandonment (Abandon) and variability in numbers of households among the study settlements (Houshld). I tested Model II with a dataset consisting of 12 cases given that, unlike trapping data on micromammals, vegetation data was recorded only once during the study in each site and not repeatedly during the four sessions. I also examined four variations of Models I and II in order to represent the different scales of level of human occupation. The three primary scales of level of occupation were entered into the analyses as sets of two variables: 1) occupation duration together with the two-category scale of intensity of seasonal occupation (Age-Int2Cat) and 2) occupation duration with the four-category scale of intensity of seasonal occupation (Age-Int4Cat). The two derived scales of level of occupation that are based on the multiplication of duration and intensity were entered as AgeInt2Cat and AgeInt4Cat.

The specific questions that I address through multiple regression analysis are:

Question 1. When also controlling for variability that is related to the effects of abandonment, additional unplanned factors, and differences that are related to the long-term effects of level of human occupation do differences between settlements and controls account for a significant proportion of explained variability in micromammalian abundance, richness, or diversity among the study sites? (Model I)

Question 2. Does the level of human occupation in the settlements account for a significant proportion of explained variability in micromammalian abundance, richness, or diversity among the study sites over and above the contribution of differences between settlements and controls, effects of abandonment, and effects of additional unplanned factors such as seasonality? (Model I)

Question 3. Do the differences between settlements and controls and level of human occupation in the settlements each separately account for a significant proportion of explained variability in richness or diversity of perennial vegetation over and above the contribution of variability in the number of households and effects of abandonment? (Model II)

Here I report on these analyses and examine the consistency of the statistics in terms of the significance, relative magnitude, and direction of the effect across the different sets of data and variations of the models. Appendix 5 also includes a number of post-hoc statistics and visual aids that provide an evaluation of whether the models uphold the basic assumptions of regression analysis.

The following analysis results address Questions 1 and 2. Table 7.9 presents the overall proportion of explained variability (R^2) that was obtained for the different variations of Model I and shows that in all cases the model accounts for a significant proportion of explained variability in micromammalian abundance, richness, and diversity. A relatively large effect size of between 0.4 and 0.6 (40%-60%) can be observed in all cases. The effect size also varies little across the variations of the model that are based on the different scales of level of occupation. Table 7.10 presents the unique contribution to explained variability (sr^2) of differences between settlements and controls for the four variations of Model I and shows that the contribution is significant in all cases. The magnitude of this effect is highly stable and ranges between 0.4 and 0.6. Table 7.11 shows that the unique contribution or increment added (IR^2) to explained variability of level of human occupation is significant for micromammalian abundance but not for richness and diversity. Table 7.12 shows that the effect size of the factor of abandonment ranges between 0.2 and 0.5 for abundance, richness, and diversity and is significant only for some of the variations of Model I. The seasonality factor has a significant effect on micromammalian richness and diversity but not on abundance (Table 7.13) which supports the observation made above that micromammalian community dynamics in the settlements mainly involve recruitments from new species rather than through population growth of the same species. The factor of numbers of trap deaths was not a significant contributor to explained variability in all cases.

Table 7.9. Overall proportion of explained variability in micromammalian abundance, richness, and diversity for variations of Model I[a].

Scale of human occupation level	Abundance		Richness		Diversity	
	R^2	*p*	R^2	*p*	R^2	*p*
AgeInt4Cat	.489	**.000**	.557	**.000**	.430	**.001**
AgeInt2Cat	.501	**.000**	.559	**.000**	.431	**.001**
Age-Int4Cat	.485	**.001**	.557	**.000**	.439	**.002**
Age-Int2Cat	.510	**.000**	.597	**.000**	.483	**.001**

[a] Significant statistics are highlighted in bold.

Table 7.10. Unique contribution of the difference between settlements and controls to explained variability in micromammalian abundance, richness, and diversity for variations of Model I[a].

Scale of human occupation level	Abundance		Richness		Diversity	
	sr²	*p*	*sr²*	*p*	*sr²*	*p*
AgeInt4Cat	.484	**.001**	.553	**.000**	.449	**.003**
AgeInt2Cat	.487	**.001**	.553	**.000**	.448	**.003**
Age-Int4Cat	.482	**.001**	.553	**.000**	.452	**.003**
Age-Int2Cat	.489	**.001**	.569	**.000**	.464	**.002**

[a] Significant statistics are highlighted in bold.

Table 7.11. Unique contribution (sr^2) of or increment added (IR^2) by level of human occupation to explained variability in micromammalian abundance, richness, and diversity for variations of Model I[a].

Scale of human occupation level	Abundance		Richness		Diversity	
	Statistic	*p*	Statistic	*p*	Statistic	*p*
AgeInt4Cat (sr^2)	-.422	**.005**	-.192	.224	-.051	.750
AgeInt2Cat (sr^2)	-.444	**.003**	-.199	.207	-.053	.738
Age-Int4Cat (IR^2)	.107	**.025**	.017	.481	.010	.708
Age-Int2Cat (IR^2)	.132	**.009**	.056	.078	.054	.142

[a] Significant statistics are highlighted in bold.

Table 7.12. Unique contribution of abandonment to explained variability in micromammalian abundance, richness, and diversity for variations of Model I[a].

Scale of human occupation level	Abundance		Richness		Diversity	
	sr²	*p*	*sr²*	*p*	*sr²*	*p*
AgeInt4Cat	.384	**.012**	.454	**.003**	.368	**.017**
AgeInt2Cat	.426	**.005**	.469	**.002**	.373	**.015**
Age-Int4Cat	.354	**.023**	.315	**.045**	.213	.182
Age-Int2Cat	.271	.087	.233	.143	.126	.431

[a] Significant statistics are highlighted in bold.

Table 7.13. Increment added (IR^2) by seasonality to explained variability in micromammalian abundance, richness, and diversity for variations of Model I[a].

Scale of human occupation level	Abundance		Richness		Diversity	
	IR^2	p	IR^2	p	IR^2	p
AgeInt4Cat	.040	.389	.148	**.009**	.190	**.009**
AgeInt2Cat	.039	.383	.148	**.009**	.190	**.009**
Age-Int4Cat	.039	.406	.148	**.010**	.191	**.009**
Age-Int2Cat	.039	.390	.146	**.007**	.189	**.006**

[a] Significant statistics are highlighted in bold.

The direction of the effect of the explanatory variables is an additional important attribute of the results of the multiple regression analysis. The coefficients in Table 7.11 show that the direction of the effect of the level of human occupation on micromammalian abundance, richness, and diversity is uniformly negative. This implies that abundance, richness, and diversity decline as the level of human occupation in the settlements increases. This trend is statistically significant only in the case of abundance, however. The effect of settlements *versus* controls is positive in all cases (Table 7.10) indicating that micromammalian abundance, richness, and diversity significantly increase as we move from the controls to the settlements. The partial unstandardized regression slope coefficient (*B*) can be used to estimate the rate of change in micromammalian abundance, richness, and diversity in conjunction with any given amount of change in level of occupation based on its unique effect. These coefficients are presented in Table 7.14 and provide an idea of the magnitude of change in the explained variables in relation to increasing levels of human occupation. These coefficients are not interpretable in terms of unit change in level of occupation, however, because the variables representing the factor of level of occupation lack defined units of measurement and should be considered as relative scales only (see Chapter 6). It is important to note the general stability in all parameters of the analysis across the four variations of Model I representing the different scales of level of occupation. This consistency suggests that the relationships observed among level of occupation and the different properties of micromammalian community structure are robust and that the various ways proposed for quantifying level of occupation in a system of seasonal mobility do not appreciably differ in the manner in which they represent the observed relationships.

Table 7.14. Partial unstandardized regression slope coefficients (*B*) for variations of Model I[a].

Scale of human occupation level	Abundance		Richness		Diversity	
	HOLevel	SiteType	HOLevel	SiteType	HOLevel	SiteType
AgeInt4Cat	**-4.304**	**5.282**	-.324	**1.140**	-.034	**.352**
AgeInt2Cat	**-5.291**	**5.267**	-.393	**1.139**	-.042	**.351**
Age-Int4Cat[b]		**5.276**		**1.141**		**.352**
Age-Int2Cat[b]		**5.253**		**1.133**		**.349**

[a] Significant statistics are highlighted in bold.

[b] Coefficients not provided for HOLevel because the factor was considered as a set of two variables rather than as an individual variable.

The results of the analysis of Model II are presented in Table 7.15 and show that in all four of the variations of the model more than 80% of the variability in vegetation richness and diversity among the study sites is jointly accounted for by the level of human occupation, differences between settlements and controls, the effect of abandonment, and variability in the number of households. Differences between the settlements and controls contribute the largest effect size. The negative direction of the coefficients for this effect indicates that vegetation richness and diversity decrease significantly as we move from the controls (code=1) to the settlements (code=2). The unique contribution or increment added to explained variability in vegetation richness of level of human occupation is significant in all of the variations of Model II but only in one of the variations of the model for vegetation diversity. The factor of level of occupation exhibits the second largest effect size (c. 0.1-0.4) and also represents a negative effect on vegetation richness. The effect sizes of the factors of abandonment and number of households are relatively small and are not significant in most of the variations of Model II.

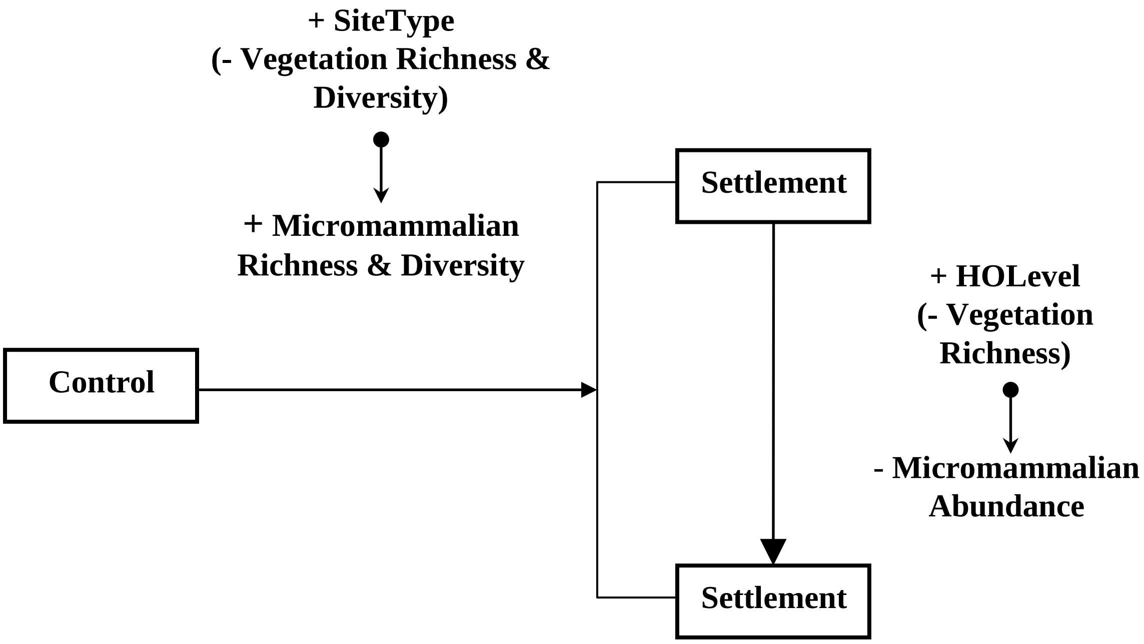
Figure 7.11 presents a diagrammatic depiction of the direction of the main effects on micromammalian community organization. The diagram combines information from Models I and II that together demonstrate how the factors of differences between settlements and controls, level of occupation, and related vegetation richness in the settlements have impacted local micromammalian communities when controlling for unplanned effects of additional factors such as abandonment and seasonality. These main effects represent two separate processes or axes of variability. First settlements are associated with significantly lower richness and diversity of perennial vegetation and greater micromammalian richness and diversity than the controls. Second, the gradient of increasing level of human occupation in the settlements is associated with a significant decrease in both vegetation richness and micromammalian abundance. According to the results of the analyses, micromammalian richness and community diversity as well as the diversity of perennial vegetation did not decrease significantly along the same gradient. However, the observed effects on vegetation and micromammals do not necessarily indicate a causal relationship between vegetation changes and micromammalian communities.

Table 7.15. Results of multiple regression analysis for variations of Model II[a].

Scale of human occupation level	Overall variability		HOLevel		SiteType		Abandon		Houshld	
	R^2	p	sr^2/IR^2	p	sr^2	p	sr^2	p	sr^2	p
Richness										
AgeInt4Cat (sr^2)	.876	**.003**	-.368	**.028**	-.772	**.001**	-.320	**.047**	-.231	.126
AgeInt2Cat (sr^2)	.882	**.002**	-.375	**.023**	-.772	**.001**	-.283	.066	-.253	.092
Age-Int4Cat (IR^2)	.915	**.004**	.174	**.035**	-.772	**.001**	-.073	.560	-.291	.050
Age-Int2Cat (IR^2)	.955	**.001**	.214	**.005**	-.772	**.000**	.010	.910	-.370	**.005**
Diversity										
AgeInt4Cat (sr^2)	.818	**.010**	-.638	.065	-.879	**.002**	-.578	.103	-.068	.861
AgeInt2Cat (sr^2)	.814	**.011**	-.627	.071	-.876	**.002**	-.527	.147	-.115	.768
Age-Int4Cat (IR^2)	.839	**.023**	.146	.105	-.890	**.003**	-.282	.498	-.227	.589
Age-Int2Cat (IR^2)	.906	**.005**	.213	**.029**	-.932	**.001**	-.148	.726	-.655	.078

[a] Significant statistics are highlighted in bold.

Figure 7.11. Diagrammatic depiction of the main effects (+/-) on micromammalian community organization (abundance, richness, and diversity) and their direction based on multiple regression analysis of Models I and II. Small arrows represent direct and indirect effects of the factors of level of human occupation and richness and diversity of perennial vegetation.



CHAPTER 8

TAPHONOMY

8.1 Introduction

In this chapter I use data on micromammalian skeletal remains, fecal pellets, and gnaw marks to examine processes through which information on the association of micromammals with Maasai settlements may become incorporated into the archaeological record. These include *in situ* (autochthonous) accumulation of such materials as a result of the presence of micromammals in the settlements. Here I document the deposition of micromammalian skeletal remains or fecal pellets on surfaces or in the substrates of the settlements in order to asses the potential for preservation of such evidence in the archaeological record. Predators of micromammals may also deposit the remains of prey in human settlements. From a taphonomic perspective, it is of interest to determine whether the remains of micromammalian prey from owl pellets and mongoose scats from the vicinity of settlements can be used to assess the degree to which such predators and potential taphonomic agents record the impact of settlements on local micromammalian communities. Such prey assemblages from the environment of Maasai settlements are expected to represent a considerably broader spatial context than the settlements and their immediate surroundings. They may, therefore, provide an additional benchmark with which to compare data on micromammalian community structure from the study settlements. These data represent a preliminary contribution towards the identification of key taphonomic processes affecting accumulation and preservation of evidence for micromammalian ecological relations between humans and micromammals in Maasai settlements.

8.2 Taphonomic Consequences of the Association of Micromammals with Maasai Settlements

My investigation of settlement contexts for material evidence of the presence of micromammals yielded micromammalian fecal pellets but no skeletal remains or gnaw marks. I present patterns of occurrence or absence of these types of evidence in conjunction with additional information on contexts examined and on various formation processes that can affect accumulation in these contexts. Observations during the study showed that micromammals deposit fecal pellets along runways within the branch fences of settlements (Figure 8.1). Fecal pellets are more likely, though, to be accumulated and incorporated into the substrate of the settlements in the more protected contexts of houses. The inevitable collapse of houses following the termination of human use and rapid formation of a substantial deposit is more likely to seal and better preserve these materials (Figure 8.2). Furthermore, house contexts in Maasai settlements are of particular interest from a taphonomic perspective because only a limited number of species of micromammals were recorded inside houses through trapping when either occupied or unoccupied.

Figure 8.1. Micromammalian fecal pellets (dark globules surrounding scale) adjacent to runway (cleared path across top left corner) within branch fence in study settlement B8. It should be noted that this portion of the branch fence of the settlement had been constructed relatively recently on virgin ground and therefore did not contain the accumulation of livestock dung that is typical of more established fences and which would obscure the small pellets. Scale: 5 cm.

Figure 8.2. Exposed compact ground level floor of collapsed Maasai house overlain in section by a 10-15 cm thick deposit of loose sediment and other materials from the house structure such as the now horizontal wood support poles (above). Depressions in the floor represent postholes for wall, roof, and raised bed supports. Scale: .5 m. Concentrated accumulation of debris from the collapse of a Maasai house in the center of the photograph (below). The dark stretch with scattered branches in the forefront of the photograph represents the remains of the original circumference fence of the settlement.

I noted a number of processes, however, that are likely to impede the accumulation of micromammalian fecal pellets inside Maasai houses. For example, the floors of houses are habitually swept while in occupation. Moreover, close inspection of house floors in study settlement B8, which had remained unoccupied for a number of months prior to the study period, revealed no fecal pellets even though high numbers of micromammals were captured in traps in the same houses and at the same time. Deposited pellets may be removed by some of the micromammalian species that depend on recycling their food through secondary ingestion of fecal pellets (see Kingdon 1974a: 365). I also noticed during the study that ants can remove micromammalian fecal pellets. This suggests that accumulation and preservation of fecal pellets in Maasai houses will occur mainly in parts of the houses that are less accessible to sweeping and/or in conjunction with the termination of human occupation and the final collapse.

Data that I collected on the occurrence of micromammalian fecal pellets in the context of an abandoned and collapsed Maasai house is presented here, together with information on the structural organization and burial history of the house. The preserved layout of the abandoned settlement including the collapsed house is shown in Figure 8.3. Figure 8.4 shows part of the floor plan of the house, which had collapsed approximately five years before the study and was exposed through systematic excavation. The collapsed house was excavated in 1 m^2 units and was exposed to an extent that allowed an understanding of the internal organization of the original structure. Personal observations on the structure of intact Maasai houses and on-site interviews with the original inhabitants of the collapsed house also contributed to reconstructing the internal organization of this house. The exposed floor plan of the elongated structure (Figure 8.4) reveals remnants of the typical tripartite division of

Maasai houses. This plan consists of a central area containing a stone enclosed hearth where most of indoor daily domestic activities take place (Figure 8.5). This central area is flanked on both sides by separate "bedrooms" for the men and women that are each composed of a raised wooden platform roughly 40 cm above the surface and that extend between the enclosing walls. The location of the hearth in the floor plan of the excavated house is associated with a concentration of ash and charcoal deposits in squares B3-4 and C3-4 (Figure 8.4). Remains from the hearth structure including scattered stone fragments and a metal spring of a motorized vehicle were found adjacent to these deposits on the floor as well as at ground level (see Figure 8.2a; compare with photograph of intact hearth in Figure 8.5). This central area of the house is flanked on both sides by less cluttered areas containing mainly small postholes that would have supported the raised bed platforms. The area underneath these platforms may be considered relatively inaccessible for daily sweeping of the floors and most other forms of disturbance from human activities during occupation of the house.

Figure 8.3. Partly preserved layout of abandoned settlement showing the location of the excavated collapsed house (hatched). The site included remains of the original settlement in varying stages of decomposition as well as more recent remains from transitory use by migrating herders. The two categories of house deposits depicted in the settlement plan reflect differences in the appearance of the deposits. "House remains" involves visible remains of the original structure mainly in the form of abundant wood debris whereas "Earth mound from house collapse" involves a shallow mound of sediment that covers any remains of the original structure.

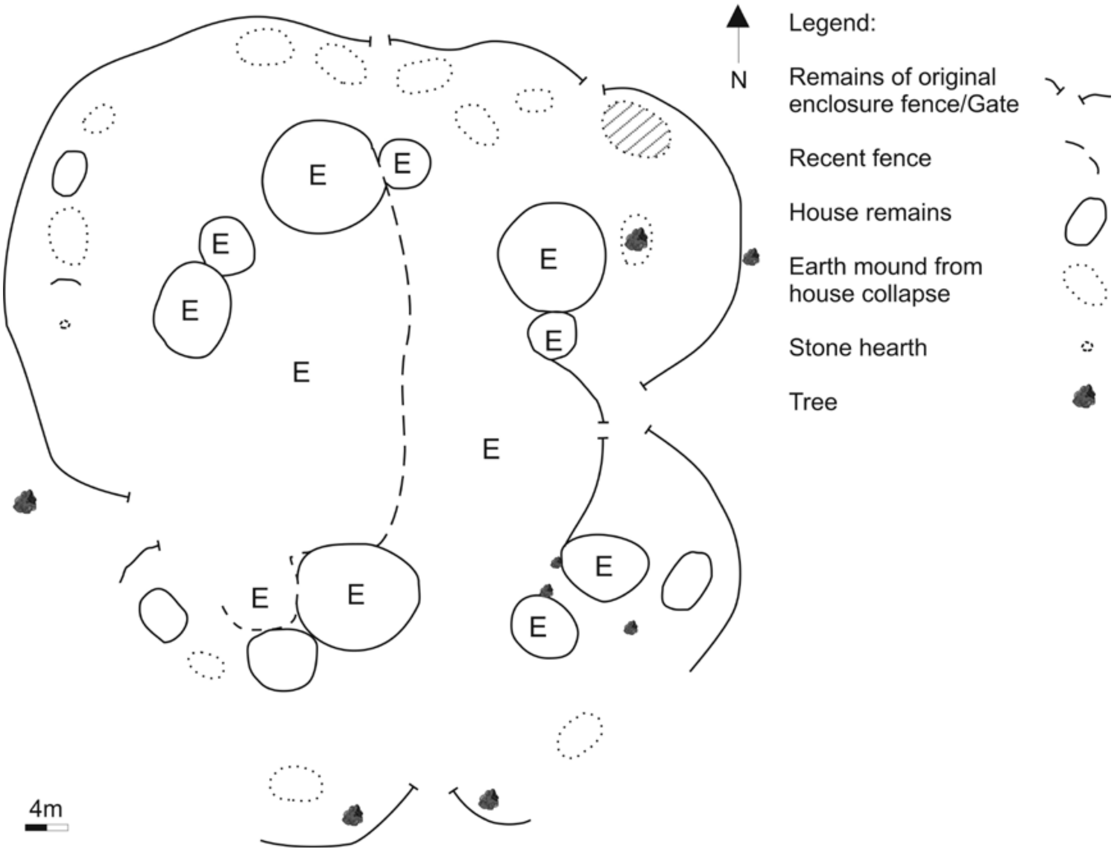


Figure 8.4. Exposed floor plan of a collapsed Maasai house showing structural remains of the walls, roof and bed supports, and the central hearth area. A 1 m^2 grid is overlain on the floor plan. Hatched square represents area of sampling of fine-screened material for sorting.

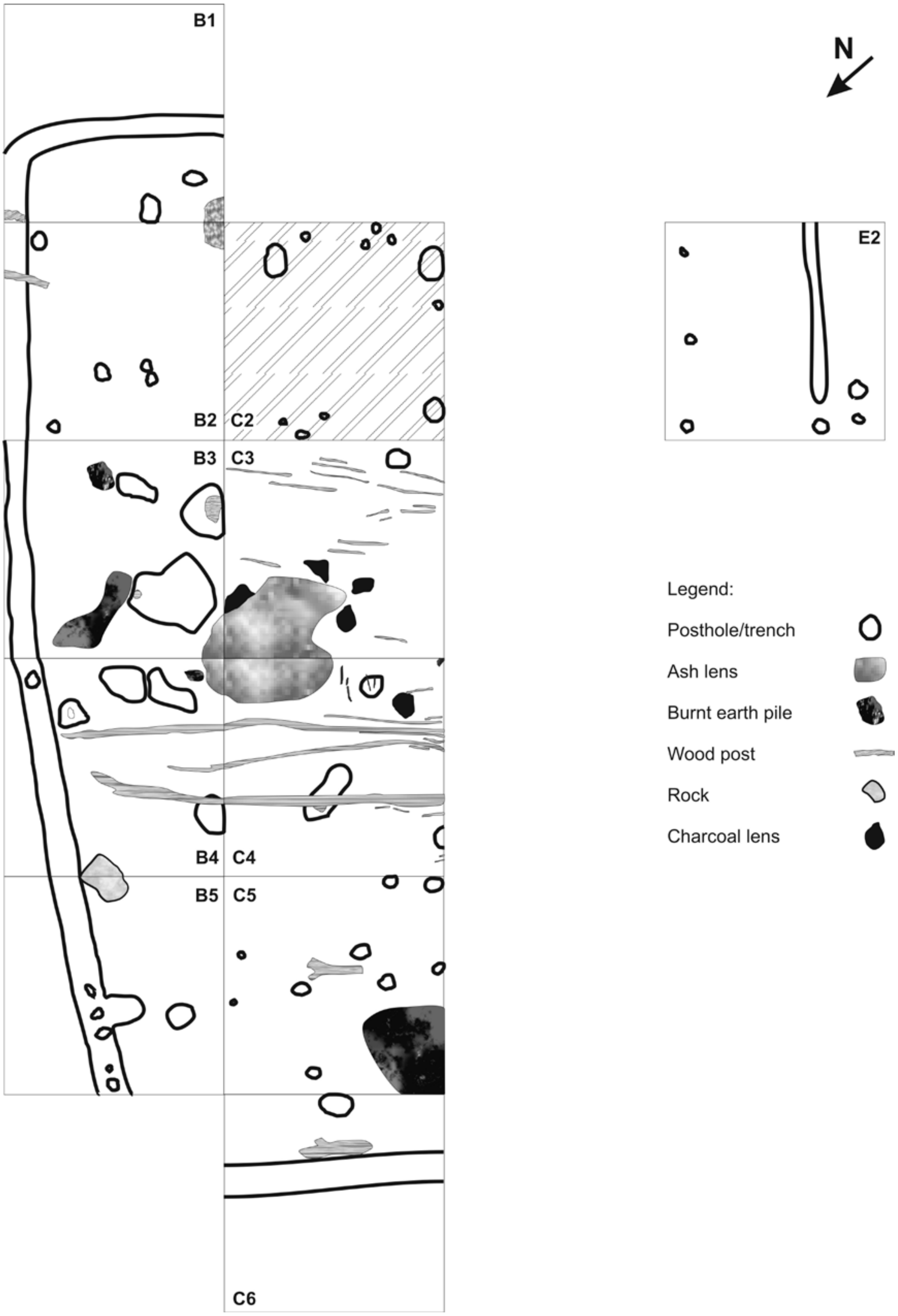


Figure 8.5. Stone enclosed hearth associated with white ash deposits located in the central area of an intact Maasai house. See also exposed remains of hearth from collapsed house in Figure 8.2a: white ashy sediment adjacent to section in top left corner and scattered stones and a metal spring of a motorized vehicle from the hearth structure. Some of the stones assumed to have belonged to the hearth structure can be seen at ground level above the section in top left corner whereas a single large stone and the metal spring were found on the floor of the original house.

Additional information on the burial history of the collapsed house was obtained during exposure of the deposit overlying the original house floor and living surface (c. 10-15 cm thickness). During excavation, it was possible to vertically separate the deposit in most 1 m^2 excavation units into three layers based on a varying degree of looseness of the sediment and proportion of soft vegetal material that it contained. The sediment became more compact and generally contained less soft vegetal material with depth and proximity to the underlying living surface. This living surface overlaid the sterile substrate that exhibited the greatest degree of compaction and was barely penetrable by trowels used in the excavation. Following the excavation of each of these vertical sub-units the sediments from each were separated into three fractions through screening – 1-3 mm, 3-5 mm, and >5 mm. The largest fraction contained no sediment and could be promptly examined for the presence of fecal pellets or skeletal remains and discarded. The fine-screened fractions from a single 1 m^2 unit was selected from the eastern "bedroom" of the excavated house for analysis of micromammalian fecal pellets and skeletal remains (Figure 8.4: Square C2). This part of the deposit was selected for sampling because of the expected greater potential for accumulation of such materials. Furthermore, unlike the adjacent hearth deposits this area did not reveal evidence for post-depositional disturbance through micromammalian burrowing. The fine fractions from the eastern "bedroom" unit were sorted more carefully in laboratory conditions. The 3-5 mm fraction consisting of c. 6 L of sediment was sorted in its entirety and produced a total of 32 intact micromammalian fecal pellets from the three sub-units combined. Additional sorting of a portion of the finer 1-3 mm fraction (400 ml) yielded no additional intact fecal pellets.

Table 8.1 presents the densities of fecal pellets in the three vertical sub-units of the 1 m^2 sample of the collapsed house deposit together with the densities of a range of other 3-5 mm materials that were identified during fine sorting and of >5 mm materials from all horizontal excavation units combined (see Appendix 6 for sample size and measurement data on fecal pellets). Table 8.1 shows that the densities of fecal pellets are lowest in the topsoil layer 1 and greatest in layer 3 overlying the original living surface. The densities of various small as well as large artifacts including specimens of bone, plastic, glass, rubber, stone, metal, paper, and shell show the same pattern of vertical distribution although the difference in density between layers 2 and 3 for the smaller artifacts (c. ×2) is not as marked as for fecal pellets and the larger artifacts (c. ×4).

Table 8.1. Frequency and density of micromammalian fecal pellets and additional materials in the 3-5 mm fraction from a 1 m^2 sample from collapsed Maasai house in addition to all >5 mm materials from excavation.

		Level		
Materials		Layer 1	Layer 2	Layer 3
Volume (L)		2	2.8	0.9
Fecal pellets	No.	3	13	16
	Density (No./L)	1.50	4.64	17.78
Artifacts 3-5 mm	No.	8	12	8
	Density (No./L)	4.00	4.29	8.89
Gastropods	No.	0	2	3
	Density (No./L)	0.00	0.71	3.33
Seeds	No.	152	125	380
	(No. types)	(10)	(11)	(8)
	Density (No./L)	76.00	44.64	422.22
Chared wood	Weight (g)	0.47	0.72	0.11
	Density (g/L)	0.12	0.17	0.01
Artifacts >5 mm	No.	14	51	76
	Density (No./L)	7.00	18.21	84.44

Other materials that were collected from the 3-5 mm fraction – gastropods and seeds of various types – also occur at their highest density in layer 3. Unlike fecal pellets, the density of seeds is lowest in layer 2 rather than layer 1, however. A different pattern can be observed for pieces of charred wood whereby the lowest density is in layer 3 and the greatest density in layer 2. The low density of charred wood in layer 3 may reflect the fact that the sample was collected from the "bedroom" area, which is situated away from the central hearth area of the house (Figure 8.4) where wood burning activity would have been concentrated. It is possible that the higher densities of charred wood in layers 2 and 1 derived from the roof deposit and are related to the Maasai practice of adding ash to dung roofs for water proofing. The varying vertical distributions of different materials in the house deposit indicate that certain materials including the micromammalian fecal pellets are associated to a greater degree with the original living surface of the house than with overlying deposits from the collapse of the house and post-depositional accumulation.

I also analyzed the shape of fecal pellets in order to link the data on the occurrence and taphonomic context of sub-fossilized fecal pellets in the collapsed house to specific species of micromammals and information on their association with varying levels of human occupation in the settlements. It can be expected that the main contributors to the accumulation of fecal pellets in Maasai house deposits are the species most distinctly associated with houses when either occupied or unoccupied by people. These species include spiny mice, narrow-footed woodland mice, and multimammate rats. I showed in the previous chapter that their occurrence in houses in the trapping study was related to varying levels of human occupation based on the following observations. First, spiny mice were dominant in the houses of settlements B2 and E43 that had either low overall levels of occupation or low intensity of seasonal occupation, respectively. Second, in the houses of settlement B8 that had an intermediate level of occupation, narrow-footed woodland mice and multimammate rats were on average more prevalent than spiny mice. Finally, multimammate rats were absent from the houses of settlement E43 where the intensity of seasonal occupation was the lowest among the study settlements but predominated in the houses of settlement B45 that had the highest overall level of occupation.

Canonical variate analysis (CVA) of fecal pellet measurements was conducted in cooperation with Annat Haber of the University of Chicago. The CVA analysis was based on 442 specimens of fresh fecal pellets from 38 individuals of seven species (see Appendix 6). Measurements were entered into the analysis as averages for each of the individual animals. Figure 8.6 plots these averaged measurements from the seven known species according to two disciminant axes that best separate among the species. The distribution of the specimens from the collapsed house (taxonomically unknown) is overlain on the distribution of the taxonomically known specimens. The CVA analysis reveals considerable overlap in fecal pellet size and shape characteristics among the species. I extracted from the combined plot the clusters of three species that were distinctly associated with the houses based on the trapping study (Figure 8.7a) and visually compared this to the cluster of the unknown fecal pellets from the collapsed house (Figure 8.7b).

This comparison indicates that despite the considerable overlap among all four clusters the distribution of unknown specimens most closely corresponds to that of multimammate rats, which occupy the upper right-hand sector of the graph. I expect that the cluster of unknown fecal pellets would substantially extend to other sectors of the graph if it had included contributions from the other two species that were associated with houses – spiny mice and narrow-footed woodland mice. Additional species that occupy this part of the graph in Figure 8.6 – naked-soled gerbils and elephant shrews – were never trapped inside houses and were mainly trapped in perimeter fences rather than in internal enclosures. It should be noted, however, that the hearth area of the collapsed house showed signs of disturbance from burrowing micromammals, which could also have contributed fecal pellets to the deposits after abandonment. In particular, naked-soled gerbils are known to burrow extensively.

Figure 8.6. Canonical variate analysis of fecal pellet shape of seven species of micromammals and of taxonomically unknown specimens from the collapsed house based on four measurements: height, width, area, and circumference. Data points for species represent averages of measurements per individual animals from which samples of fecal pellets were collected. Data points for unknown fecal pellets represent individual specimens. Species designations are abbreviated according to first three letters in the genus name.

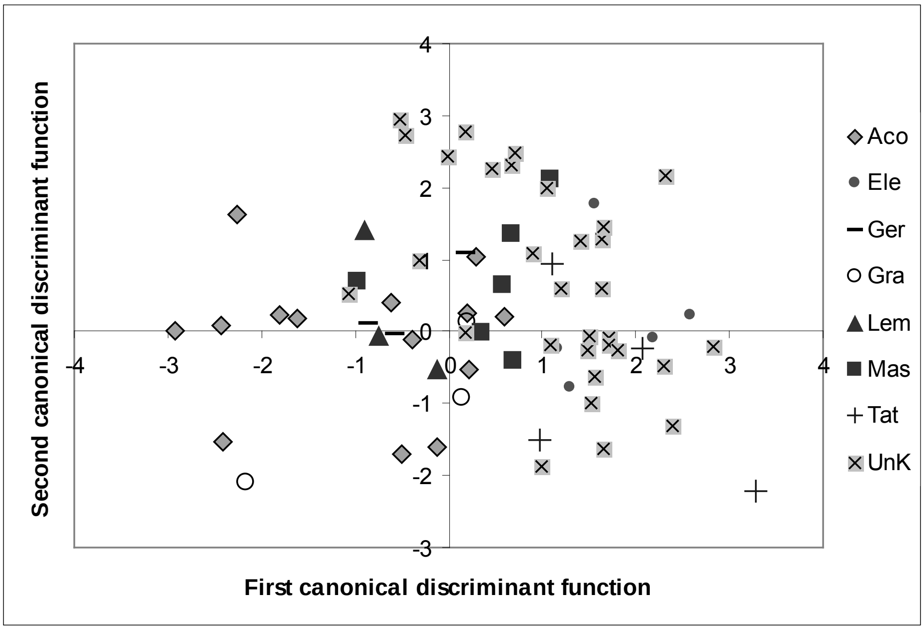
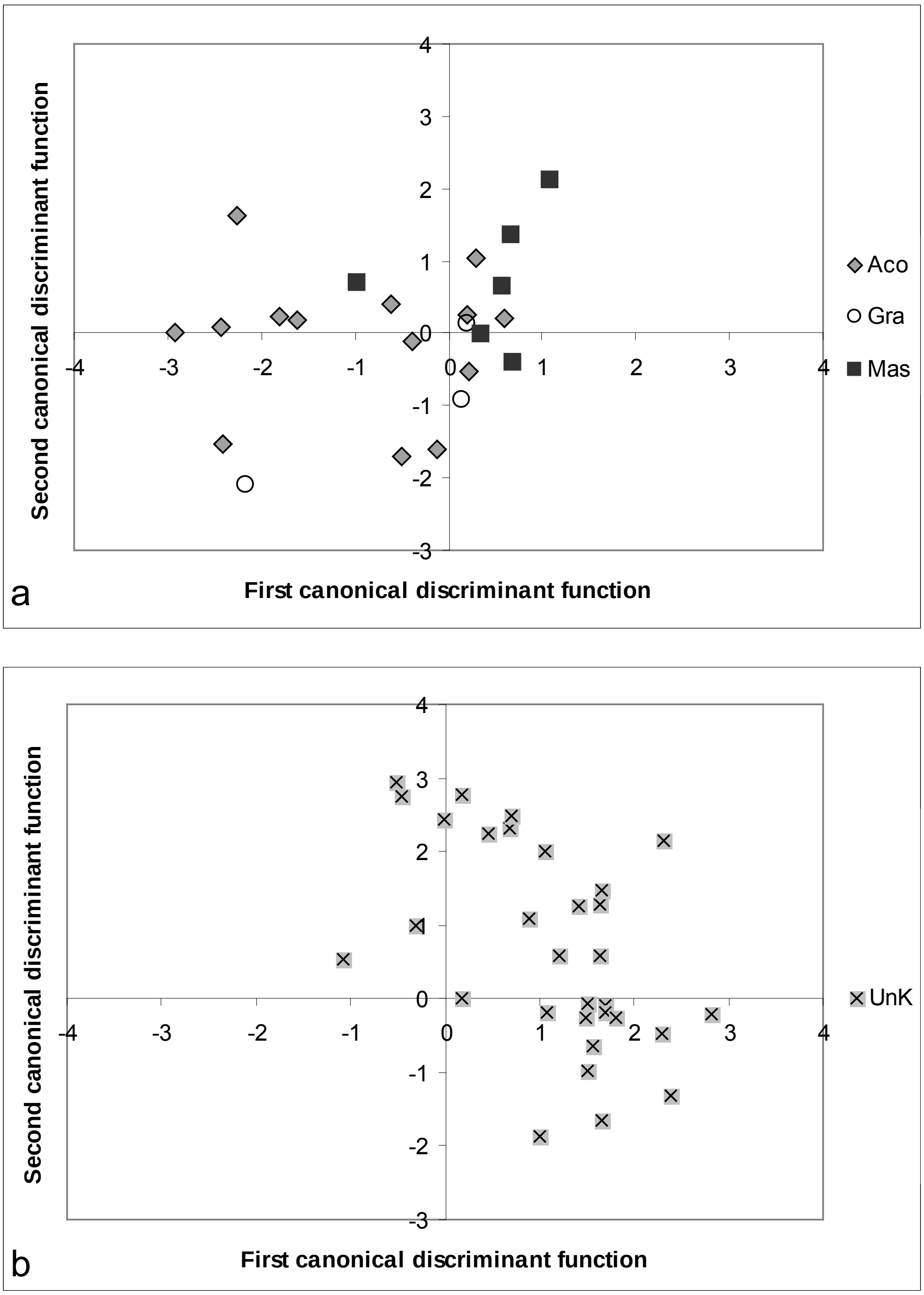


Figure 8.7. Clusters of data points extracted from overall canonical variate analysis of fecal pellet measurements to facilitate visual comparison among: three species that were distinctly associated with houses in the trapping study (a) and unknown specimens from the collapsed house (b).



A table of posterior probabilities from the CVA analysis providing an estimate of the likelihood of group membership of the unknown specimens is presented in Table 8.2. The rows for the different fecal pellet specimens generally show a broad distribution of the probabilities among the seven species in the analysis and except for a single specimen (Sp.562) the probability of association with a specific species does not surpass c. 70%. The right hand column of group membership shows, nonetheless, that over 60% of the specimens are associated with two of the species. These are multimammate rats and naked-soled gerbils. In particular, two of the specimens – Sp.561 and Sp.581 – that are each associated with one of these two species show a relatively high probability of group membership (c. 70%) whereas the probabilities for association of these specimens with all other species are low (c. 10% or less). These findings do not exclude the possibility that fecal pellets were deposited in the collapsed house by additional species but indicate that multimammate rats and naked-soled gerbils likely contributed more of the fecal pellets to this context.

Table 8.2. Posterior probabilities for likelihood of taxonomic association of fecal specimens from collapsed house[a].

	Taxa							
Specimen	Aco	Ele	Ger	Gra	Lem	Mas	Tat	Group membership
Sp.555	.12	.11	.08	.00	.10	**.58**	.01	Mas
Sp.556	.10	.25	.31	.00	.01	.17	.16	Ger
Sp.557	.09	.12	.17	.00	.03	**.58**	.01	Mas
Sp.574	.37	.08	.05	.06	.19	.21	.03	Aco
Sp.575	.14	.27	.11	.02	.02	.20	.24	Ele
Sp.576	.04	.34	.11	.00	.00	.06	.45	Tat
Sp.577	.17	.01	.05	.00	.28	.48	.00	Mas
Sp.578	.14	.04	.07	.00	.13	**.61**	.00	Mas
Sp.579	.04	.47	.01	.01	.02	.14	.30	Ele
Sp.580	.08	.04	.03	.00	.15	**.69**	.00	Mas
Sp.581	.03	.17	.02	.02	.00	.03	**.73**	Tat
Sp.582	.00	.39	.01	.00	.00	.02	**.58**	Tat
Sp.583	.01	**.59**	.03	.00	.00	.30	.07	Ele
Sp.584	.04	.37	.21	.00	.00	.25	.13	Ele
Sp.585	.50	.00	.04	.10	.20	.16	.00	Aco
Sp.586	.13	.08	.13	.02	.00	.02	**.61**	Tat
Sp.558	.14	.01	.03	.00	.30	**.51**	.00	Mas
Sp.559	.03	.38	.05	.00	.00	.08	.45	Tat
Sp.560	.03	.44	.08	.00	.01	.35	.09	Ele
Sp.561	.05	.11	.03	.00	.09	**.72**	.00	Mas
Sp.562	.02	.00	.00	.00	**.86**	.12	.00	Lem
Sp.563	.46	.03	.28	.01	.06	.16	.01	Aco
Sp.564	.04	.31	.01	.08	.02	.35	.18	Mas
Sp.565	.04	.32	.06	.00	.01	.49	.07	Mas
Sp.566	.01	.28	.00	.01	.00	.02	**.68**	Tat
Sp.567	.15	.22	.22	.00	.02	.32	.06	Mas
Sp.568	.06	.20	.10	.00	.00	.03	**.61**	Tat
Sp.569	.01	.35	.02	.00	.00	.03	**.59**	Tat
Sp.570	.04	.22	.02	.00	.09	**.61**	.01	Mas
Sp.571	.06	.42	.04	.01	.02	.16	.29	Ele
Sp.572	.04	.49	.03	.01	.02	.25	.17	Ele
Sp.573	.05	.33	.04	.01	.01	.09	.46	Tat

[a]Probabilites greater than 50% highlited in bold.

The possibility that multimammate rats were among the main contributors to accumulation of fecal pellets within the collapsed house is of particular interest given that this species was distinctly associated with houses in study settlement B45 that had a relatively high overall level of human occupation. Information on occupation patterns in the settlement that included the collapsed house and in the wider neighborhood of that settlement sheds more light on the association among multimammate rats, houses, and high levels of occupation. Information from the original inhabitants of the collapsed house shows that the settlement was established in 1987 and was abandoned in 2001, five years prior to the time of the study. Hence, the age or duration of occupation of this settlement should have been 14 years which is equivalent to that of study settlement B14. Although the abandoned settlement had been in use for a much smaller number of years than study settlement B45 there are indications that the intensity of seasonal occupation in settlements in the surrounding neighborhood has been just as high. It is significant that the neighborhoods of both of these settlements contain boreholes that provide a permanent and close supply of water, which can sustain year round occupation of at least some of the human population of the settlements. Both neighborhoods also support stores with basic supplies and relatively permanent structures of tin, brick, and concrete. These are absent or rare in most other settlement neighborhoods in the study area. As a result, the combination of data from trapping in the living context and from the accumulation of fecal pellets in the collapsed house supports the association of multimammate rats, houses, and high levels of human occupation. This provides a preliminary framework for linking data on fecal pellets and other types of materials such as skeletal remains from house deposits to inferences regarding the level of human occupation. In addition, I think that more detailed descriptions of fecal pellet size and shape characteristics than I attempted in this study might improve the potential for taxonomic identification of micromammalian fecal pellets and for reconstruction of micromammalian communities associated with ancient settlements from archaeological fecal pellets.

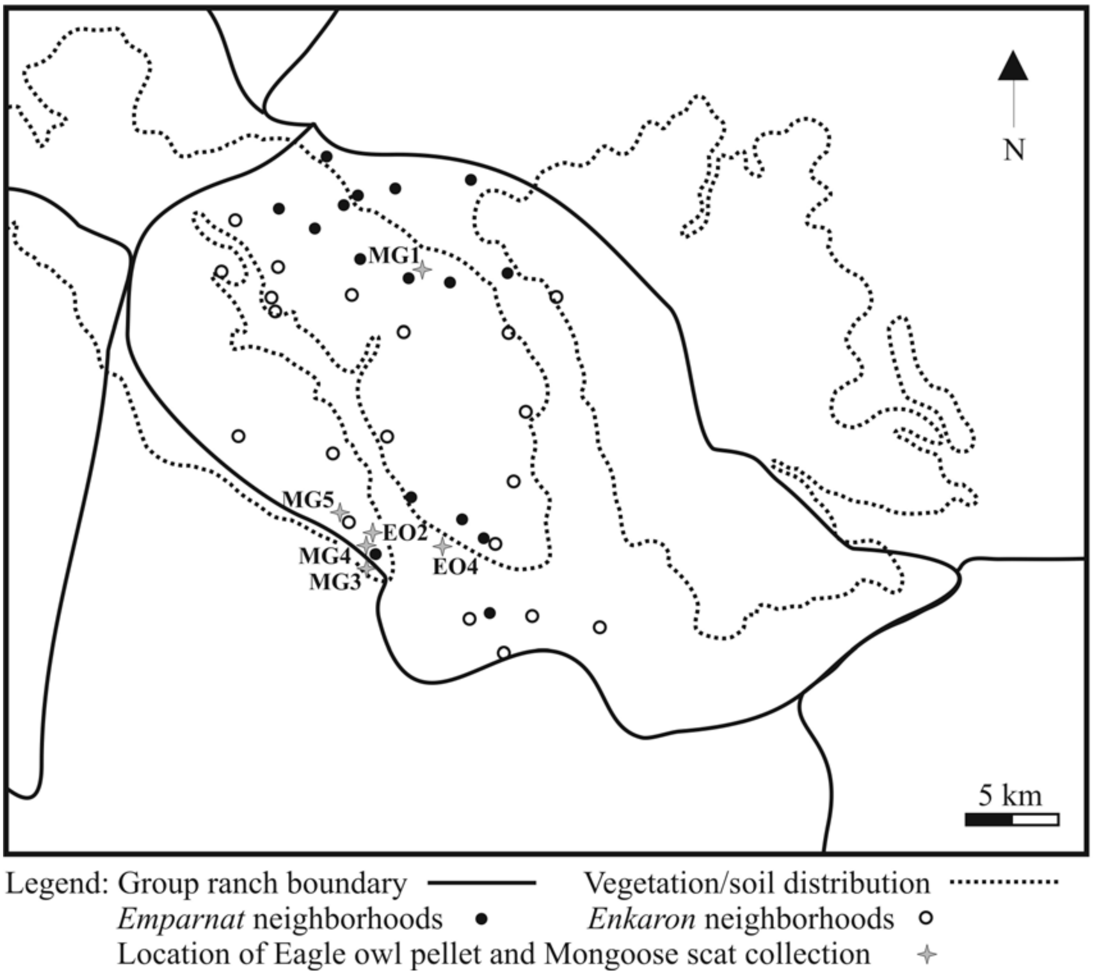
The absence of micromammalian skeletal remains in the samples that I analyzed from the 1 m^2 unit of the collapsed house may be due to the small sample size. It is reasonable to assume, based on low densities of micromammalian remains that are typically found in open-air archaeological sites (pers. obs.; see also Tchernov 1984), that the rate of potential deposition of such remains in Maasai settlements is relatively low. Low densities of micromammalian remains in open-air settlement sites may be a product of *in situ* (autochthonous) depositional processes with few contributions from predators or other agents that can concentrate large amounts of prey remains in their roosting or denning sites. A more comprehensive effort to sample and analyze deposits from houses and other types of contexts would be required in order to accurately determine the potential for accumulation of micromammalian skeletal remains and the densities of such remains in Maasai settlements and similar archaeological sites.

The failure to retrieve data on the occurrence of micromammalian skeletal remains or gnaw marks in settlement contexts is also informative. I inspected a total of 2,764 livestock skeletal specimens from the six study settlements for distinctive micromammalian parallel tooth grooves that are diagnostic of gnawing. This included all bones that I saw on the surface of the settlements. The fact that this systematic and comprehensive search effort did not reveal diagnostic gnaw marks suggests that they are either absent or very rare in the context of Maasai settlements in the study area. Thornton and Fee (2001) have shown that under experimental conditions approximately 11% of rodent damage to bones of large mammals is of the diagnostic parallel groove type. It is therefore possible that the micromammalian species that are associated with settlements in the study area do not or only seldom utilize bones to grind incisors and obtain minerals (see Thornton and Fee 2001). Reasons for this are unclear, however, and may be related to the environment or species' habits. I did observe, however, micromammalian gnaw marks in the study area on hard seed coats in middens surrounding burrow entrances. People also reported some damage from micromammalian gnawing on leather and gourd containers that are kept inside houses.

8.3 Assessment of the Impact of Maasai Settlements on Micromammalian Communities through Analysis of Prey Assemblages

During the study period I collected six assemblages of micromammalian prey remains — two of eagle owl pellets and four of mongoose scats — from a number of different locations in the vicinity of settlements in the southern and northern parts of the study area (Figure 8.8). Five of the assemblages were located at a distance of less than 1 km from either *emparnat* or *enkaron* settlement neighborhoods and I found only one assemblage, one of the eagle owl assemblages (EO4), at a greater distance of approximately 2 km from the nearest settlements. Based on information on range sizes of owls and mongoose from the literature the home ranges of the eagle owl and mongoose individuals that deposited the assemblages may be expected to encompass some settlements and their immediate environments (see Brain 1981: 127; Kingdon 1997: 253; Reed 2003: 139). It is therefore likely that the composition and abundance of micromammalian prey in the six assemblages that I collected was mainly influenced by the following sources of variability: 1) differences between the two predator types in terms of prey and/or foraging habitat preferences, 2) differences between the two main collection areas due to the distance separating them (15 km), and 3) differences among locations of collection adjacent to settlement clusters with varying levels of human occupation. All of these effects must be considered in comparing the prey communities with micromammalian communities recorded through trapping in the study settlements and control sites. In addition, it is important to keep in mind that the comparison of prey and trapping communities of micromammals is not straightforward due to expected differences between predation and trapping in the comprehensiveness of sampling of micromammalian communities. Some of these differences include the extent of the area sampled and the duration of sampling (see Torre et al. 2004).

Figure 8.8. The location of eagle owl pellet and mongoose scat collections in relation to settlement neighborhoods in the study area in Eselenkei group ranch. Settlement data in part from J. Worden (pers. comm. 2006; see also Worden 2007: 57, Figure 2) based on survey in 2000. Boundary of main vegetation/soil zone in the study area from Touber et al. (1978a, b).



The basic frequencies of micromammalian species in the prey assemblages based on MNI derivations from molar counts are presented in Table 8.3 (see also Appendix 7 for database of molar specimens from the prey assemblages). A distinguishing aspect of the prey assemblages is the predominance of one or more of the different species of gerbils. The combined frequency of common gerbils, naked-soled gerbils, and Taterillus gerbils is >50% in all of the assemblages. This indicates that gerbils are a highly abundant group in the study area, which accords well with the generally arid environment and sparse vegetation cover (see Kingdon 1974a: 507).

Gerbils also account for considerable differences among the prey assemblages. Common gerbils, for example, dominate the eagle owl assemblages (>70%) but account for only 0-47% of prey items in the mongoose assemblages. The other two gerbil types occur in relatively high numbers in some of the mongoose assemblages and especially in the two assemblages with the lowest frequencies of common gerbils (MG1 and MG5).

The conspicuous absence of common gerbils from the single assemblage from the northern part of the study area (MG1) indicates that there may be some difference in environmental conditions between the two parts of the study area. This may be related to the slight north-south gradient in precipitation that characterizes the wider region encompassing the study area (see Worden 2007: 26). The data suggest overall that gerbils are highly abundant in the study area and/or are the preferred prey for the two predators that were examined and especially for eagle owls. In addition, mongoose may be switching from common gerbils to other species of gerbils where the former are scarce or absent as in the northern part of the study area. The particularly high abundance of common gerbils in the eagle owl assemblages may reflect the preference of these owls for foraging in areas with sparse vegetation cover (e.g., Fry et al. 1988: 127). The predominance of gerbils that characterizes the prey communities is matched among the trapping communities only in settlements B45 and E43, which produced captures with >50% of one or more of the gerbil species during three of the trapping sessions. Settlement B45 produced mainly Taterillus gerbils whereas the community at settlement E43 was dominated by common gerbils.

Table 8.3. Micromammalian frequencies, richness, diversity, and distribution in mongoose and eagle owl prey assemblages based on MNI counts of molar teeth.

	MG1		MG3		MG4		MG5		EO2		EO4		Distribution[a]
Genus	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Spiny mouse	4	16.67	1	4.00	3	6.67	6	9.84	1	5.56	-	-	U
White-toothed shrew	6	25.00	4	16.00	3	6.67	4	6.56	1	5.56	-	-	U
Common mouse	1	4.17	4	16.00	7	15.56	5	8.20	1	5.56	4	11.43	U
Naked-soled gerbil	4	16.67	-	-	-	-	8	13.11	-	-	1	2.86	S
Taterillus gerbil	9	37.50	2	8.00	9	20.00	16	26.23	1	5.56	3	8.57	U
Climbing mouse	-	-	1	4.00	-	-	-	-	-	-	1	2.86	R
Common gerbil	-	-	11	44.00	21	46.67	21	34.43	14	77.78	26	74.29	U
Narrow-footed mouse	-	-	2	8.00	1	2.22	1	1.64	-	-	-	-	S
Elephant shrew	-	-	-	-	1	2.22	-	-	-	-	-	-	R
Total	24		25		45		61		18		35		
No. of taxa (richness)	5		7		7		7		5		5		
Shannon-Wiener Diversity	1.44		1.61		1.50		1.66		0.88		0.84		

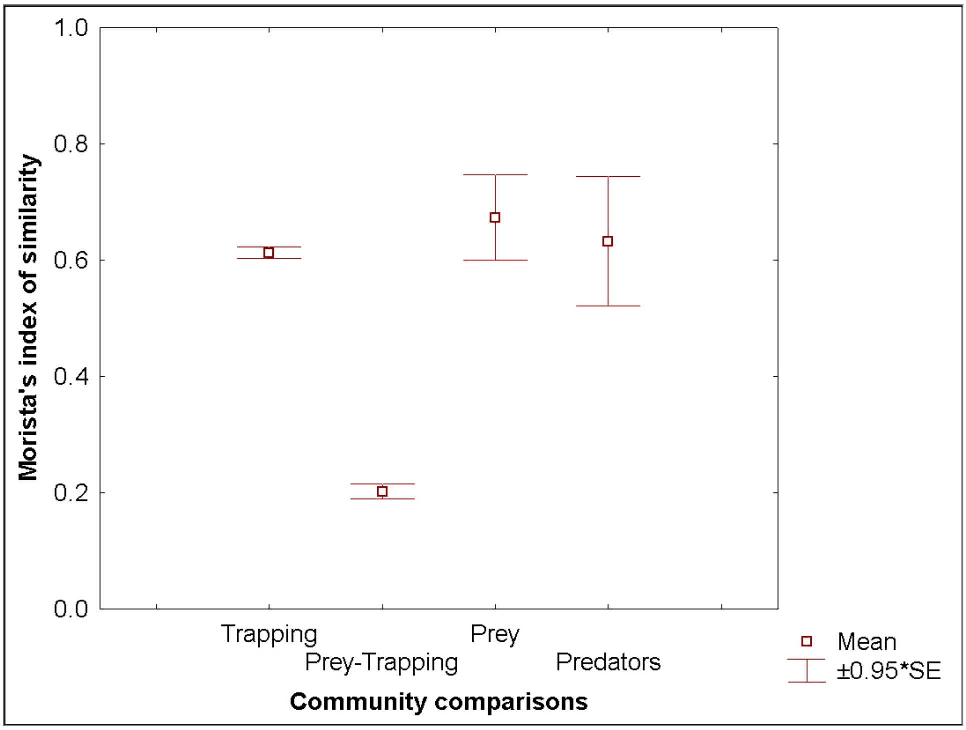
[a] **U**biqutous - occurs in high or low numbers in many assemblages.
Sporadic - occurs in low numbers but in many assemblages.
Rare - occurs in low numbers in one or a few assemblages.

A comparison of the prey communities with the trapping communities shows that two species that occur in the former are absent from the latter or the opposite. Thus, common mice (*Mus* sp.) and climbing mice (*Dendromus* sp.) occurred only in the prey communities and multimammate rats and zebra mice occurred only in traps. The absence of two species that occurred in traps from the prey assemblages contrasts with results of a study by Torre et al. (2004), which compared data on micromammalian communities from trapping and the prey of owls and small mammalian carnivores in a Mediterranean region of Spain. In their study, Torre et al. (2004) obtained significantly fewer and no new species through trapping than were recorded in the prey of owls and carnivores. Although the results of this study may relate to relatively small sample sizes, specific reasons can be identified for the absence of the two species that occurred in traps from the prey assemblages. The absence of zebra mice can be accounted for by the fact that they are strictly diurnal and not readily available for nocturnal predators such as eagle owls and some species of mongoose (see Fry et al. 1988: 127; Kingdon 1997: 253). In addition, the results of the trapping study showed that multimammate rats rarely occurred outside settlements, which indicates that these rodents may be highly restricted to settlement environments in the study area. This would reduce the susceptibility of multimammate rats to predation. This possibility is discussed further in the following chapter.

A number of important differences between the prey assemblages and trapping communities in the study settlements can also be identified through a comparison of the distributions of species (Table 8.3). The difference in distribution between the prey assemblages and trapping communities is most marked for elephant shrews, which are rare among the prey assemblages but ubiquitous among the settlements.

They occurred in frequencies of 3-34% on average per site. Similarly, narrow-footed woodland mice do not exceed a frequency of 8% in any of the prey assemblages (sporadic) but in one of the settlement sites (B8) had an average frequency of >20% (localized). Nonetheless, these mice occur in a similar number of prey assemblages and settlement sites (three and two, respectively). Spiny mice are ubiquitous among both the prey assemblages and settlement sites but reached markedly greater frequencies among the settlements (18-69% on average per site). They were also the most abundant species in four of the six settlement sites and only the second to fourth most abundant among the prey assemblages. The effectiveness of spiny mouse spines in deterring predators may contribute to the relatively low representation of spiny mice in the prey assemblages (see Kingdon 1974a: 656). In contrast, three other species are more commonly distributed among the prey assemblages. White-toothed shrews occurred in five of the six prey assemblages with a range of frequencies of 6-25% (ubiquitous) whereas among the settlement sites they occurred in only three of six sites at frequencies of <10% on average per site (sporadic). Taterillus and common gerbils had a localized distribution among the settlement sites but were ubiquitous among the prey assemblages, reaching frequencies as high as 38 and 78%, respectively, and occurring in nearly all of the assemblages. Naked-soled gerbils are the only species with similar distributions among both the prey and trapping communities.

Figure 8.9. Means of similarity fitted with standard error bands for the following comparisons: 1) among trapping communities, 2) among the prey and trapping communities, 3) among the prey communities, and 4) among the prey communities of eagle owls and mongoose.



I also used a measure of community similarity — Morisita's similarity index –– to examine quantitatively the different aspects of variability among the prey assemblages and to compare them with the trapping communities. Figure 8.9 presents the means of similarity values within each of the two groups of prey and trapping communities separately (within-groups), among the prey communities of owls and mongoose (between-groups), and among the two groups of prey and trapping communities (between-groups). Trapping communities used in these comparisons exclude seven cases from trapping sessions in the control sites that had zero captures and thus amount to 41 cases. The within-group means of similarity as well as the mean similarity among the two predator types fall within a relatively narrow range of 0.6-0.7, whereas the mean similarity between the prey and trapping communities is considerably lower than this range (0.2). The differences among the four means of within- and between-group similarity are significant according to an analysis of variance (ANOVA) test (*F*=140.718; *p*=.000). The relatively wide standard error bands for the two means of similarity among the prey communities in Figure 8.9 may be accounted for by the small number of communities and hence much smaller number of paired comparisons among this group of samples (N=6), than among the trapping communities (N=41), and between the two groups of prey and trapping communities (N=41×6).

The similarity among the prey and trapping communities can be further examined by decomposing the overall comparison between the two groups according to different components of the variability within each of the groups including northern compared with southern parts of the study area and settlement compared with control sites. In the following comparisons I lumped the three types of gerbils into a single category (subfamily Gerbillinae) in order to minimize the effect of variability among the communities related to differences in environmental conditions between the two study areas and to differences in prey/foraging habitat preference between the two predator types. Figure 8.10 presents the means of similarity among prey community MG1 from the northern part of the study area and four sub-groups of the trapping communities. The mean similarity among prey community MG1 and the trapping communities from the southern study settlements (>.7) is noticeably higher than among community MG1 and trapping communities from the northern study settlements (<.3). The means of similarity among community MG1 and the two corresponding groups of trapping communities from the control sites are intermediate compared to the above values. The difference among the four means are significant (*F*=13.982; *p*=.000). A similar outcome can be observed for the comparison among the five prey communities from the southern part of the study area and the same four sub-groups of trapping communities (Figure 8.11), with significant differences among the four means (*F*=96.065; *p*=.000). These comparisons indicate that when controlling for potential differences in environmental conditions between the two areas the prey communities, irrespective of their location within the study area, are most akin in composition and frequencies of micromammalian species to the trapping communities in the southern study settlements. The settlements in the southern study neighborhoods are at least twenty years older than in the neighborhoods of the northern part of the study area. These patterned affinities among the prey and trapping communities do not appear to reveal the influence of varying histories of occupation in the two parts of the study area.

Figure 8.10. Means of similarity fitted with standard error bands for comparisons among the prey community MG1 and the following subsets of trapping communities: 1) control sites of the northern study settlement, 2) northern study settlements, 3) control sites of the southern study settlements, and 4) southern study settlements. Abbreviations are used to designate control sites (Ct) and settlements (St).

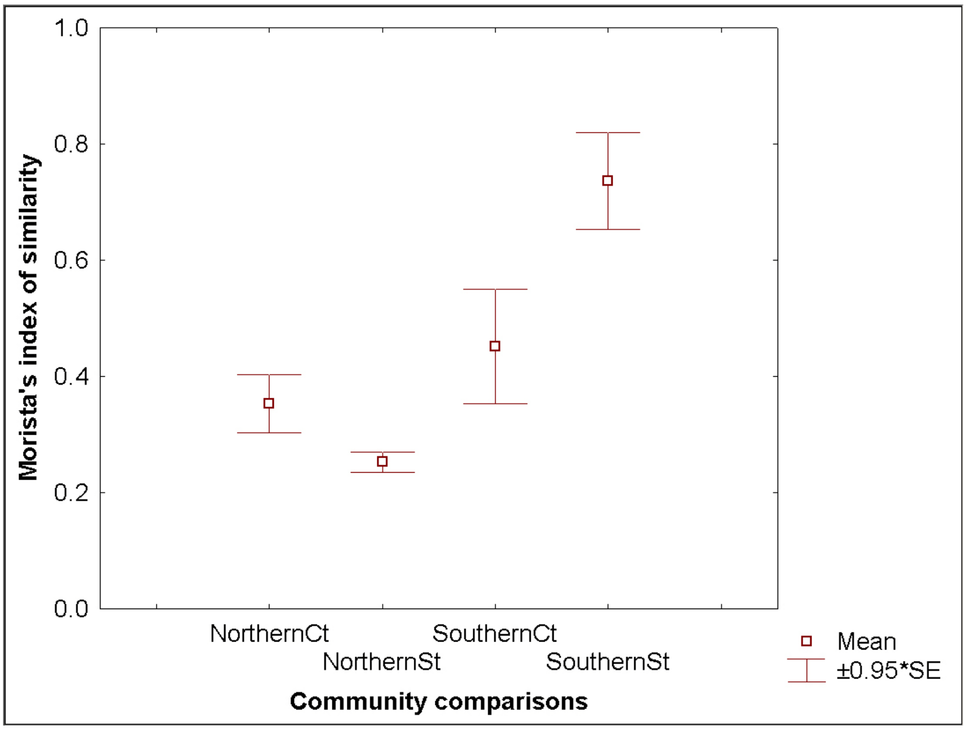
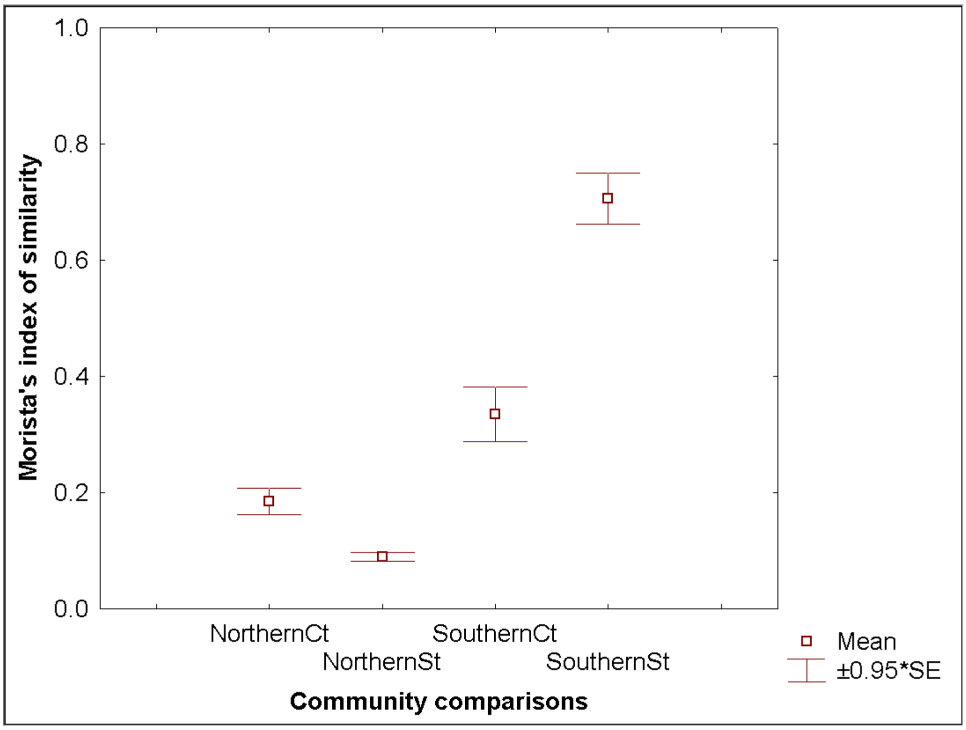
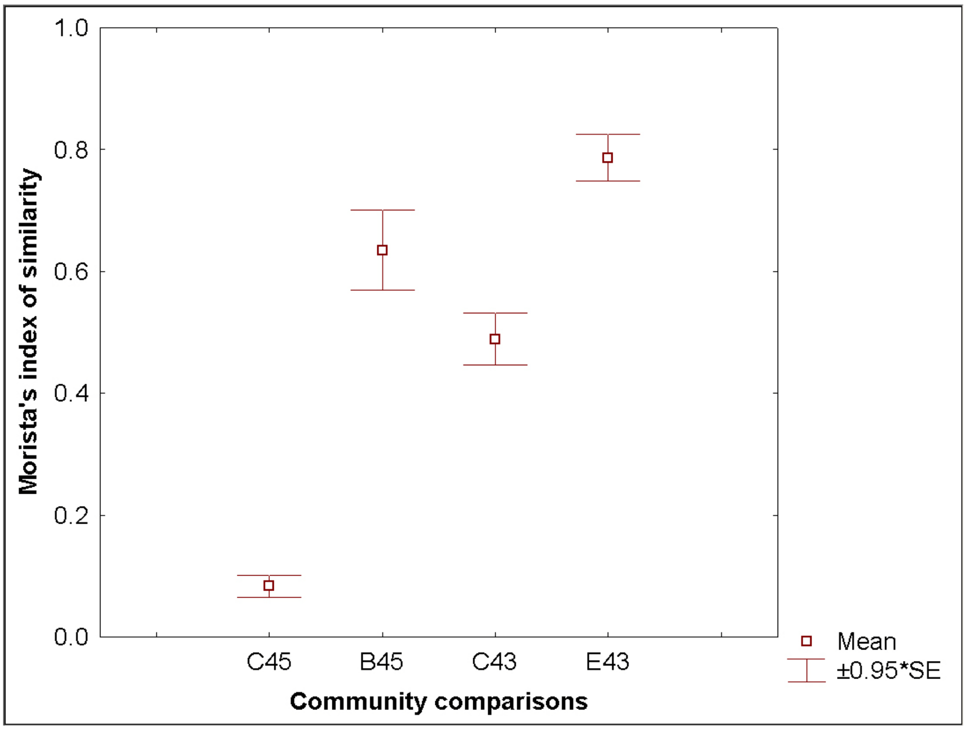


Figure 8.11. Means of similarity fitted with standard error bands for comparisons among the prey communities of the southern part of the study area and the following subsets of trapping communities: 1) control sites of the northern study settlement, 2) northern study settlements, 3) control sites of the southern study settlements, and 4) southern study settlements.



Further examination of similarity among the prey and trapping communities within the southern part of the study area further considers whether the degree of similarity may vary in relation to differences in the intensity of seasonal occupation among the two southern study settlements. Here I compare the means of similarity among all prey communities and the trapping communities from each of the four southern settlement and control sites. Figure 8.12 reveals a particularly high mean similarity among the prey communities and trapping communities of settlement E43 (0.79) and somewhat lower similarity with trapping communities of settlement B45 (0.63). Similarity with the control sites is lower than in the settlements in both cases and is especially low for the control of settlement B45 (0.08). The differences between the four means are significant (*F*=23.738; *p*=.000). The high mean similarity among the prey and trapping communities for settlement E43 can be attributed in large part to the high proportion of gerbils in both groups (Avg.>50%). Despite the relatively high proportion of gerbils in settlement B45 as well, the lower mean similarity of this site with the prey communities may be due to the fact that during one of the trapping sessions no gerbils were captured in the settlement. This reduced their average proportion.

Figure 8.12. Means of similarity fitted with standard error bands for comparisons among all prey communities and trapping communities from each of the settlement and control sites of the southern part of the study area.



In addition, in order to asses the effect of proximity to the settlements on the level of similarity with the trapping communities I compared eagle owl assemblage EO4, which was collected at a distance of >2 km from settlements, to EO2 collected at a distance of <0.5 km from settlements (Figure 8.8). A Student's t-test between the means of similarity for each of the two eagle owl prey communities and the trapping communities of the southern part of the study area obtained no significant difference (*t*=-.310; *p*=.759). In general, it appears that a relatively high degree of similarity among prey and trapping communities in the area of the southern study settlements is related to long-term occupation and in particular to low intensity of seasonal occupation in settlement E43. Common gerbils, which were abundant in most of the prey assemblages and in settlement E43, contributed substantially to the similarity among the communities. Moreover, the particularly high values of similarity may be an outcome of long-term depletion in vegetation cover inside and around settlements as a result of lengthy duration of occupation and relatively low intensity of seasonal occupation.

It is also of interest to compare the prey and trapping communities in terms of species richness and community diversity. The results of the trapping study showed that levels of these two indices of community structure were significantly higher in settlements than in the control sites but did not vary significantly among the settlements. Values of richness and diversity in the prey communities (Table 8.3), however, correspond to the high end of the range and/or are somewhat greater than the range of the trapping communities. The number of species in the trapping sites was 0-4 (Avg.=2) and Shannon-Wiener diversity estimates are 0-1.321 (Avg.=.531) when considering all sessions separately (N=48). Cumulative richness taking into account all species that were recorded in each trapping site over the four trapping sessions (N=12), is somewhat greater with a range of 1-5 (avg.≅4). In the prey assemblages, the range for richness is 5-7 species (Avg.=6) and for diversity 0.838-1.664 (Avg.=1.322). Comparisons of means by Student's t-tests show that mean richness in the prey communities (N=6) is significantly greater than in the trapping communities when considering all sessions separately or when sessions are combined (*t*=-8.290, *p*=.000; *t* =3.480, *p*=.004; respectively). Diversity is also significantly greater in the prey communities (*t*=-4.847, *p*=.002).

Such differences in richness and diversity may be attributable to some extent to varying comprehensiveness of sampling between trapping and predation. In their comparative study of micromammalian sampling by different predators and through trapping, Torre et al. (2004) obtained twice as many species from barn owl pellets and 1.5 as many from genet scats as in traps. Traps also had no unique species (see also Balčiauskienė and Naruševičius 2006 for similar results). The differences among the prey and trapping communities in this study are not as marked: 1) the overall numbers of species in the prey and trapping communities were the same (N=9), 2) only two additional species were recorded in the prey assemblages, but also 3) two species that were recorded through trapping did not occur in the prey assemblages. The comparison of trapping communities from the study settlements and control sites with prey communities from the wider habitat encompassing the sites suggests that micromammalian richness and diversity in the settlements are maintained at or slightly below background levels as reflected through predation. Although, species composition and specific frequencies may vary significantly between the trapping and prey communities.

Given the marked differences that can be expected in the spatial scale of sampling represented by the two types of communities, the above finding of high levels of richness and diversity in the study settlements is quite significant. In contrast, environments immediately adjacent to the settlements where control sites were located support lower levels of richness and diversity than the settlements and likely also have lower than background levels as represented by predation. The data overall provide no indication that settlements have an effect in terms of variability in composition and frequencies of micromammalian species on prey assemblages of eagle owls and mongoose in the study area in spite of the fact that these predators occur in conjunction with settlement environments. This is supported by patterns of community similarity among the prey assemblages and trapping sites, the absence of multimammate rats from the prey assemblages, and relatively low frequencies of spiny mice in the prey assemblages. It would appear instead that localized settlement areas with long-term human occupation such as the southern study settlements support communities with relatively high populations of gerbils, which are also characteristic of the wider habitat of the study area.

CHAPTER 9

DISCUSSION I:

VARIABILITY IN MICROMAMMALIAN COMMUNITIES

9.1 Introduction

The implications of this study for archaeological and taphonomic research on micromammalian assemblages depend upon factors affecting the observed variability in micromammalian communities associated with Maasai settlements. In this chapter I consider the differences between settlements and control sites and among the settlements focusing on characteristics of micromammalian communities of abundance, richness, and diversity. I also examine population characteristics of specific species and spatial use of habitats. The focus of this section is on the ecological impact of seasonal Maasai settlements and the effect of increasing levels of human occupation on micromammalian community structure. In order to examine the ecological roles of different micromammalian species across the study sites I discuss data on distributions, relative frequencies, and associations of micromammalian species. Finally, I will discuss the implications of the ecological data from the study in light of important concepts in community ecology, which provide a basis for linking micromammalian archaeofaunas to specific levels of human occupation.

9.2 The Impact of the Study Settlements on Micromammalian Communities

The inventory of all the micromammals that were recorded inside settlements during the study or eight species present suggests that potential species richness in Maasai settlements is rather high. This is especially evident when the settlement species list is compared to that from the control sites which show an equal number of species. A list that I complied based on my sightings and on analysis of predator assemblages also numbers nine species. Only a single species in the trapping study, zebra mice (*Lemniscomys* sp.) was not also captured inside the settlements although even this species was reportedly observed inside settlements in the study area following heavy rainfall (El Niño event) in 1997/1998. Though I did not see them I think that the eyewitness accounts of these sightings are accurate because zebra mice are conspicuous due to their striped coat and diurnal activity pattern. In addition three species, common mice (*Mus* sp.), African dormice (*Graphiurus* sp.), and climbing mice (*Dendromus* sp.) that were recorded through sightings or analysis of predator assemblages were never captured in any of the settlement or control sites. These may be rare or highly localized within the study area and/or not amenable to ground-level trapping due to a distinctly arboreal adaptation (see Kingdon 1997: 183, 197; see also Woodman et al. 1995 on under-representation of arboreal species in CMR trapping). I noted, for example, that arboreal dormice and climbing mice were either absent or occurred in low frequencies in owl pellets and mongoose scats from the study area.

Common mice, on the other hand, occurred in varying frequencies in all of the predator assemblages (4-16%) but were absent from traps and this is more difficult to account for. I think that remains of these rodents found in the pellets and scats likely belong to the native group of African common mice species rather than to the introduced commensal house mouse of the same genus. At least one of the more common of the native African mouse species (*Mus minutoides*) has been documented in farmland in both West and East Africa (Delany and Happold 1979: 371-373) as well as inside agricultural villages in East Africa where it occurred in low frequencies of < 1% (e.g., Misonne 1963: 106; Christensen 1996). The commensal house mouse

(*Mus musculus*), on the other hand, is known strictly from urban and agricultural settings in East Africa (Kingdon 1974a: 604; Fiedler 1994: 44).

In contrast, a number of species appear to have been exclusively or distinctly associated with the study settlements and were either absent from or rare in the control sites and/or predator assemblages. Taterillus gerbils (*Taterillus* sp.) were the only species that was exclusively captured inside the settlements although numbers were particularly low (N_{Total}=7 individuals). Moreover, these gerbils were common in pellets and scats (6-38%). Similarly, four other species including elephant shrews (*Elephantulus* sp.), white-toothed shrews (*Crocidura* sp.), narrow-footed woodland mice (*Grammomys* sp.), and common gerbils (*Gerbillus* sp.) were captured in considerably greater numbers inside settlements than in the controls. Among these species, white-toothed shrews and especially common gerbils were relatively common in the predator assemblages (up to c. 25 and 78%, respectively) whereas elephant shrews and narrow-footed woodland mice were rare (< 2% on average). The circumstances are more clear-cut in the case of multimammte rats (*Mastomys* sp.). Twenty five of the individuals of which were trapped inside settlements, whereas only a single individual was captured in one of the control sites. It is also significant that multimammte rats were absent from owl and mongoose prey assemblages in the study area although they are one of the most abundant prey item in assemblages of owls in various savannah and agricultural regions of West and East Africa (Weissbrod and Braude pers. obs.; Reed 2003: 85; Granjon and Traoré 2007).

A comparison of micromammalian communities rather than of individual species from the settlements and controls revealed further information on the ecological differences between the two site types. Throughout the duration of the study settlements had consistently greater average levels of overall abundance of micromammalian individuals, numbers of species (richness), and community diversity as measured by the Shannon-Wiener Function than did controls. Repeated measures analysis of variance showed that the differences in means are statistically significant at a probability level of $\alpha<.05$ for richness and diversity but not for abundance. I demonstrated that these results can be explained by examining the difference when all sessions are pooled between each of the settlements and their adjacent controls. In all of the settlements, richness and diversity were higher than in the controls, which explains the significant results of the analysis of variance in both cases. In the case of abundance, although the differences were appreciable between most settlements and their respective control sites (> 100%) they were relatively small for settlements B2 and B45 (< 10%). Moreover, settlement B2 is the only case where micromammalian abundance in the settlement was lower than in the adjacent control, although even here the difference is relatively small (Δ_{Total}=4 individuals).

Pooling the values of abundance, richness, and community diversity from the settlements and controls for each of the four trapping sessions also revealed some patterned variation in community dynamics throughout the study period. Although, caution is necessary in interpretation because the averaged values mask considerable variation in seasonal patterns among the sites. Seasonal variability in average levels of abundance, richness, and diversity among the four trapping sessions was not significant as shown through repeated measures analysis of variance. Nevertheless, some important differences could be detected. The settlements and controls both saw a marked increase in average levels of all three indices between the first and second trapping sessions that is likely attributable to the intervening rainy season. This indicates that addition of individuals into the communities, to a considerable extent, was through immigration from 'new' species that contributed to overall diversification.

The increase in average richness and diversity in the settlements at this time appeared less pronounced than in the controls, however, due to the decrease in abundance and especially richness in settlement B2. This may have resulted from the fact that, following an extended period in which the settlement remained unoccupied, the settlement was reoccupied by its owners relatively late in the season and only one week prior to the second session of trapping.

During the later sessions of the study, the differences between the settlements and controls in micromammalian community dynamics were more marked. In the control sites, average levels of abundance, richness, and diversity did not increase between the second and final sessions. There was also a general leveling off in average abundance in the settlements. In contrast, however, richness and diversity in the settlements continued to increase. This indicates that settlement communities continued to be replenished with individuals from 'new' species and became more diverse. Immigration of individuals from 'new' species or 'species recruitment' appears to be an important aspect in the community dynamics of the study sites during the study period, but more so in the settlements than in the controls. The only indication of a significant influence of either intrinsic population growth or immigration of additional individuals from species already present in the community in a preceding trapping session was noted in the controls during the third session. Here, there was some decrease in both average richness and diversity associated with only a very slight decrease in abundance. The maintenance of average abundance at a nearly constant level while richness and diversity decrease can be attributed mainly to a sharp rise in the numbers of spiny mice (*Acomys* sp.) during this time in the control of settlement B2.

This evidence for dynamic micromammalian communities suggests that the level of stability in community composition across the different settlement and control sites is an important aspect of the comparison between settlements and controls. An assessment based on the occurrence and average abundance of each species in each of the study sites revealed that, in general, settlements had greater consistency than controls in distribution of species across sites, as well as greater average levels of abundance. Nearly all species occurred across more of the sites and/or in greater numbers on average in the settlements than the controls. This was especially true of multimammate rats, which occurred in all of the settlements but in only a single control site (C8). Elephant shrews also occurred in only four of the settlements (B2-B21) and in two of the control sites (C2 and C43). The pattern is somewhat more complicated for spiny mice. This species was the most ubiquitous species in the trapping study occurring in all of the settlements and controls and in relatively high average abundance in most of the sites. Their average abundance was greater in the settlements than in the controls in most cases but in settlements B2 and B45, however, the average abundances of spiny mice were lower than in the adjacent controls. The difference in overall numbers of spiny mice for these two settlements was five and six individuals, respectively, although the settlement-control ratio varied greatly from session to session.

A measure of the configuration of species in communities from each of the sites through the use of Morisita's similarity index provided an additional indication that the study settlements had a substantial impact on the structure of local micromammalian communities. The index showed that each control site had consistently a greater degree of similarity with the control of the next oldest settlement than with the settlement adjacent to it. This similarity was also greater than that among settlements. Analysis of community similarities among settlements and controls as well as among the settlements indicated that settlements had a marked impact on the configuration of species in micromammalian communities and that this impact increased significantly with increasing level of occupation.

The overall impact of the settlements on micromammalian community structure was further examined through multiple regression correlation (MRC) statistics. In these analyses I factored out the effects of other sources of variability among the sites such as level of human occupation, extended lack of occupation in settlements B8 and E43, and seasonality. The results of the analyses showed that human settlement had a significant effect on micromammalian richness and diversity. Moreover, settlements had an overall positive direction of impact relative to the control sites. In this study I did not collect direct evidence on the immediate causes for this enrichment of micromammalian communities. Statistical analysis of the effects on vegetation in the study sites showed, however, that settlements reduced the richness and diversity of local plant communities of perennial trees and shrubs. In the MRC analysis, I controlled for differences related to level of human occupation, extended lack of occupation, and varying number of households and size of the effect of settlements on vegetation *versus* that of the controls was relatively large. These four factors jointly accounted for more than 80% of the variability in perennial vegetation ($\alpha < .05$). It is difficult to precisely link and account for the effects of settlements on micromammalian and vegetation communities based on the available data. Nonetheless, the fact that high richness and diversity of micromammals is associated with low richness and diversity of plant species inside settlements may be tied to fundamental restructuring in spatial patterns of vegetation cover inside settlements and the possibility that such restructuring opens up a greater variety of niches than previously existed. These new niches are subsequently exploited by more species of micromammals than present in less disturbed habitats outside of the settlements.

Owing to their ubiquity in both the settlement and control sites my examination of differences in micromammalian population characteristics and intensity of habitat use focused mainly on data from spiny mice. Although the overall number of spiny mice that were captured in the settlements was greater than in the controls, a repeated measures analysis of variance showed that the difference in mean is not significant. This result can be accounted for in large part by the particularly high number of spiny mice from the control of settlement B2. However, the relationship between numbers in the control of settlement B2 and the settlement also changed considerably from session to session. Therefore, it is difficult to asses precisely the impact of the settlements on population size of spiny mice. The control of settlement B2 had more than half of the number of spiny mice from the six control sites combined; and during the third session produced the second highest of the population estimates in the study. This was based on the Schumacher and Eschmeyer estimation formula (18 [15-22] individuals). The control of settlement B2 also produced all recorded cases of juvenile and sub-adult individuals of spiny mice among the controls (N=5). Settlement B2 provided the only higher estimate for spiny mouse population size, which was recorded during the first session (28 [20-49] individuals). This last estimate was judged less reliable, however, due to an indication of an unstable population in the settlement during trapping in the first session. These data indicate that both settlement B2 and its adjacent control site represent high-potential habitats for spiny mouse populations.

Additional data on the average distance moved by spiny mice between successive captures indicated that use of habitats was more spatially bounded and intensive in the control of settlement B2. The average distance moved was also greater in all other control sites than in their respective settlements. In general, greater intensities of habitat use may indicate smaller home ranges and larger and possibly denser populations (Hayne 1949). The spatial arrangement and structure of habitats may, however, strongly influence the shape of home ranges or which portions of them are normally used. This, in turn, may bias estimations of intensity of habitat use when habitat structure differs considerably. This may be the case here because settlement and control sites that I studied appeared to have markedly different habitat structure. The data on spiny mouse populations and habitat use, therefore, does not necessarily imply that settlements do not have the potential to support population growth and consequently reach population densities at least as high as some background levels.

9.3 The Effect of Level of Human Occupation on Micromammalian Communities in the Study Settlements

Considerable variability was detected among the study settlements in terms of micromammalian community structure, species composition, spatial use, and population size of spiny mice. Important sources of variability among the settlements that I considered include differences in the level of human occupation and the effect of significant lack of occupation on settlements B8 and E43. I also considered differences among the trapping sessions related to seasonality and its effect on the coming and going of households from each of the settlements. When I controlled for the effects of these other factors multiple regression analysis showed that each of these factors had significant effects on some or all of the aspects of micromammalian community structure. It is important to call attention to the fact that the multiple regression analysis included data from both the settlements and control sites, and that I controlled for the differences between them. This allowed me to examine ecological variability across the entire series of study sites in relation to the level of occupation in the settlements. The combination of all of the factors that were included in the analysis accounted for between 40 and 60% of the variability in micromammalian abundance, richness, and community diversity ($\alpha<0.01$).

Differences among the trapping sessions that were included as an additional factor (seasonality) in the multiple regression analysis had an overall significant effect on variability in richness and diversity, but not on abundance of micromammals. Variability in richness and diversity may be related to both environmental aspects of seasonality and the pattern of intermittent occupation of settlements by their inhabitants throughout the duration of the study. The effects of these two aspects of temporal variability cannot easily be differentiated within the analysis, however. The reason for this is that the temporal factor is represented in a rather coarse manner by the four trapping sessions and also because the effects overlap to a large extent. For example, most of the settlements were unoccupied during the drought period at the beginning of the study (1st session) and most were reoccupied following the rainy season (2nd session). It is also significant that the timing of reoccupation after the rains varied considerably among the study settlements. At the same time compared to the first session the numbers of individual micromammals that were captured differentially increased or decreased across the study sites. As a result, although a general trend of increasing numbers was detected in most of the settlements and control sites, in settlements B2, B21, and B45 the numbers decreased in the second trapping session. The decrease was particularly conspicuous in settlement B2 where the numbers dropped from 16 to 6. This settlement also experienced the least amount of occupational stability prior to second session trapping as it was reoccupied by people and relatively large herds of livestock only one week before the beginning of trapping. Although somewhat greater occupational stability was observed for the other two settlements with decreasing second session numbers of captures – B21 and B45 – the populations recorded there during the preceding first session were also very low and it seems did not recover following reoccupation by some or all of the people and herds in the intervening period. It should be noted that settlement B21 had already transitioned from being unoccupied to being reoccupied by people and livestock in late January, whereas settlement B45 was continuously occupied and was repopulated by additional people and livestock sometime between February-May.

There is also indication that extended lack of occupation had a significant influence on the structure of micromammalian communities in settlements B8 and E43, which remained unoccupied throughout all or nearly all of the study period. The effect was most marked when looking at the numbers of captures from all species combined in each of the study sites. These numbers were consistently the highest in settlements B8 and E43 between the second and final trapping sessions. During the first session, only settlement B2 had higher numbers of captures than the latter two settlements. At that time, most of the settlements had remained unoccupied for a number of months and the difference in average number of captures between settlements B8 and E43 combined and the other four settlements was the lowest among the trapping sessions ($\Delta_{\text{Average[Session I]}}$=4.75 individuals). The difference in averages between the two groups of settlements increased during the following three sessions to between 8 and 14 individuals. During this period only settlements B8 and E43 remained unoccupied and the other settlements were reoccupied. It is also of interest to note that among the control sites, the overall number of species that were recorded over the four sessions was highest in the controls of the two unoccupied settlements (N=4-5 species). Multiple regression analysis revealed that the contrast between the unoccupied and other study settlements (i.e., the factor of abandonment) had a significant effect on micromammalian abundance as well as richness and diversity once other sources of variability among the study sites were factored out. Levels of all three indices increased significantly in the two unoccupied settlements as compared to the other settlements.

In order to examine the separate effect of the level of human occupation on micromammalian communities it was necessary to control for variability due to the effects of seasonality and extended lack of occupation. Multiple regression analysis showed that the level of human occupation negatively affected micromammalian abundance, richness, and community diversity, but that this effect was statistically significant only for abundance. Similarly, when I accounted for other sources of variability additional analysis indicated that increasing occupation levels significantly negatively impacted vegetation richness and diversity.

The fact that micromammalian species richness and diversity do not significantly change with increasing levels of occupation whereas abundance does, suggest that there should be some turnover in the configuration of micromammalian communities in settlements. This is also suggested by the fact that similarities among each settlement communities and their adjacent controls decrease significantly with increasing occupation levels, at the same time that the similarities among the controls themselves do not. The most distinct trend that was detected in the distributions and average abundances of species across the study settlements is the continuous decline in the prominence of spiny mice with increasing occupation levels. In the two oldest of the study settlements, spiny mice are replaced as the most abundant species on average by two species of gerbils – common gerbils in E43 and Taterillus gerbils in B45. At the same time, spiny mice remain the most abundant species on average in all of the control sites. Similarly, elephant shrews are relatively important in the younger study settlements but are absent from the two oldest settlements. Although they are rare in the control sites, one individual was captured in the control of settlement E43. It was absent, however, from the settlement.

Examining the distributions and abundances of species in relation to the level of human occupation does not reveal the whole picture, however. Extended lack of occupation also had a marked impact on these patterns. Three species including multimammate rats, narrow-footed woodland mice, and common gerbils reached particularly high abundances in settlements B8 and E43 where there was significant lack of occupation. Reasons for this association with the unoccupied settlements may differ for each of the species. For multimammate rats, the combined number of captures in settlement B8 (N=15 individuals) was as much as four times greater than the maximum in any of the other settlements. Nearly all of these individuals (N=14) were captured in the final trapping session in September 2006, indicating a reproductive and/or colonization spurt, the timing of which corresponds to the known seasonality of reproduction of these rodents in East Africa (see Leirs et al. 1994). The average abundance of multimammate rats was relatively low in other settlements although they were the only other species besides spiny mice that occurred across all of the study settlements. In contrast, narrow-footed woodland mice and common gerbils maintained relatively high numbers during three of the trapping sessions in either settlement B8 or E43, respectively, but were absent from most other settlements. This suggests that the latter two species were distinctly associated with lack of occupation.

It is also of interest to consider why two different species were associated with one of each of the two settlements – narrow-footed woodland mice in settlement B8 and common gerbils in settlement E43 – and with significant lack of occupation. One possible explanation for this may be the fact that settlement E43 in the southern part of the study area was located relatively close to the boundary of the continuous vegetation zone that encompassed all of the study settlements; and that this may have locally affected the composition of the micromammalian community. Different vegetation communities surround the area of the southern study neighborhood on three sides (Touber et al. 1978b). In particular, more open grassland to bushed grassland habitats on the southwestern and northeastern sides of area are dominated by grasses of the genus *Pennisetum*. These contiguous areas are also characterized by imperfectly drained alluvial soils that lack a sandy component (Touber et al. 1978a). Conditions in these areas may be especially favorable for species of common gerbils that tend to prefer alluvial areas with seasonal flooding where they utilize deep cracks in the ground for shelter during the long dry season (Kingdon 1974a: 518). Common gerbils were also the most abundant species in the prey assemblages of both mongoose and eagle owls (34-78%) that I collected from the area of the southern study neighborhood. In contrast, this species was absent from the single mongoose assemblage collected in the northern study neighborhood. Neither were any common gerbils captured in the northern study settlements including the unoccupied settlement B8. Narrow-footed woodland mice in this area may, therefore, have substituted for common gerbils in unoccupied settlements and the reverse may have been the case in settlement E43 in the southern study neighborhood.

Spatial analysis of trapping data from structural contexts of the settlements including the perimeter fence, internal enclosure fences, and houses reveals additional detail on variability in micromammalian community organization and association of different species with the settlements. Based on adjusted overall numbers of captures (including recaptures), numbers of species, and diversity of use I show that perimeter fences from each of the study settlements had on average greater levels of intensity of use. Average overall numbers of captures were generally lower in the houses and particularly low in the enclosures. Moreover, average richness and diversity in the enclosures were relatively high in some of the settlements and typically low in the houses of most of the settlements except B8. Here and in settlement E43, the impact of lack of occupation was most clearly seen in the spatial data. In all contexts of these settlements (B8 and E43) distinct peaks in the average of overall numbers of captures and numbers of species were observed. Diversity showed a somewhat more complicated pattern, however. In settlement B8, average levels of diversity peaked in the houses but not in the perimeter fence and the opposite was the case in settlement E43. This may be explained by the fact that spiny mice dominated the perimeter fence in settlement B8 and the houses in settlement E43. Less than 7% of all spiny mouse captures (including recaptures) in settlement B8 were inside houses and it is possible that these rodents typically weighing 10-40 g were excluded from the houses by the larger-sized multimammate rats (12-70 g) and narrow-footed woodland mice (28-65 g). In contrast, in settlement E43 spiny mice co-occurred with the more diminutive common gerbils (15-25 g) and c. 25% of all captures were inside houses that were avoided by the gerbils.

Average abundances of species adjusted to varying efforts of trapping in each of the spatial contexts of the settlements showed that spiny mice were the most abundant species in all contexts. In each of these contexts they were associated with different species, however. In the perimeter fences, spiny mice were mainly associated with elephant shrews (settlements B2-B21) or common gerbils (E43). In the houses, spiny mice occurred singly in many cases (e.g., settlement B21) or in association with species such as multimammate rats and narrow-footed woodland mice as in settlement B8. Sporadic occurrence of white-toothed shrews in houses was recorded only in settlement B2. In settlement B45, only multimammate rats were captured in the houses. Spiny mice and multimammte rats were also the only species that occurred inside houses while occupied by people. In the enclosure fences, spiny mice were associated to some degree with multimammate rats although the pattern was less distinct given that numbers of captures were generally low.

I conducted a number of chi-squared analyses in order to statistically assess the varying spatial patterns in the distribution of species in all three of the spatial contexts. The analyses based on contingency tables of numbers of captures (including recaptures) of the different species by settlements showed the distributions of abundances varied significantly across the study settlements for each of the spatial contexts. A representation of the deviations of observed abundances from expected ones through standardized deviates reinforced the descriptions given above. The results for the perimeter fences showed that the contribution of spiny mice to patterned variation among the settlements decreased with increasing levels of human occupation. However, it increased in the houses along the same gradient. These patterns were interrupted, though, by an under-representation of spiny mice in the houses and enclosures of settlement B8 and in the perimeter fence and enclosures of settlement E43. In general, spiny mice were not the most prominent contributors to variation in perimeter fences and houses. This may be expected given that they occurred in these contexts consistently and in relatively stable and high numbers. Multimammate rats were prominent contributors to patterned variation in the perimeter fence and enclosures of settlements B8 and B21. They also were one of the most prominent contributors to the houses of settlement B45, despite their low numbers there (N=3). Similarly, marked contributions were made by white-toothed shrews in the houses of settlement B2 and by narrow-footed woodland mice in the houses of settlement B8. These results support my general findings of a turnover in configuration of micromammalian communities with increasing levels of human occupation.

9.4 Defining the Ecological Roles of Micromammalian Species in the Study Settlements

In this section I define the ecological roles or niches of micromammalian species in relation to settlement environments by summarizing the data on variability in the distribution of species, their relative frequencies, and intra-specific associations across the study sites. I relate these findings to information on natural histories of relevant micromammalian species, considering the relationships among ecology, environment, human activity, and natural history. The information is organized below according to the different species that were recorded in the study.

9.41 Rodentia - Muridae

Murinae

Spiny Mice (*Acomys* sp.)

I begin with spiny mice, which were the most common member of micromammalian communities in the study sites. These animals occurred in all of the settlements and control sites often in relatively high abundance, a finding that indicates that these rodents are widespread within the *Acacia-Commiphora* bushland/bushed-grassland habitat of the study area. This fits with their known distribution throughout arid semi-desert and savannah environments in East Africa and their association with rocky substrates (Kingdon 1974a: 654; see also Neal 1983; Canova and Fasola 1994; Kanga and Webala 2003; Fanson et al. 2008). Spiny mice are reported among the minor crop pests in agricultural regions of East Africa, but their impact on fields is localized (Fiedler 1994: 50). One species of the genus in particular – *A. cahirinus*, is known as a commensal in villages and towns along the Nile in Egypt and on the periphery of the Judean Desert in Jerusalem, Israel, where they can occur inside houses (Setzer 1959; Tchernov 1984). Canova and Fasola (1994) also recorded a population of these spiny mice living in the semi-desert region of northern Kenya in the pastoralist and tourist town of Loyangalani near Lake Turkana. It appears that at least one or several of the species within the *Acomys* genus can occupy the commensal niche and become relatively successful agricultural pests in drier regions of their range. It is possible that these are areas where smaller commensal rodents such as the house mouse do not occur.

This raises a key question concerning the nature of the association of spiny mice with settlements in the Eselenkei study. Although spiny mouse abundance in the settlements did not differ significantly from the controls, their consistent presence in numbers that were at least as high and in some cases greater than background levels suggests that Maasai settlements are an important habitat for spiny mice. This was especially true for settlement B2, which produced the highest population estimate of spiny mice from any trapping session in the study. One possible explanation for this high population is that environments surrounding settlements with relatively low levels of human occupation such as B2 retain intact high-potential habitats for spiny mouse reproduction that function as reservoirs for the settlements. Such a relationship with reservoir habitats has been demonstrated for house mice in relation to agricultural fields (Newsome 1969a, b) and for African savanna rodents such as unstriped grass rats (*Arvicanthis niloticus*) in relation to grasslands (Delany and Roberts 1978). In these examples, populations crash cyclically in the fields and grasslands as a result of seasonal stress and are revived from adjacent reservoirs following reproductive spurts. The fact that the control for settlement B2 produced the second highest population estimate for spiny mice in the study and provided some evidence for concentrated reproduction indicates that this is a high-potential habitat for spiny mice and a possible reservoir. Unlike in the fields and grasslands, however, the peaks in spiny mouse numbers in settlement B2 and its control site occurred during different times of the year. In the settlement the peak occurred in January 2006 at the height of a prolonged drought period and in the control the peak occurred only in the following July, two months after the rainy season. Moreover, spiny mouse numbers in the settlement dropped sharply after the rains and remained low during and after the peak in numbers in the adjacent control. There was some evidence to suggest that the peak in spiny mice in the settlement was the result of recruitment whereas in the control it was the result of birthing.

Alternatively, settlement B2 and its control site may have fostered separate populations from two sympatric species of spiny mice with diverging habitat preferences. Populations of spiny mice in a similar environment in central Kenya also differ in their reproductive strategies (Neal 1983; see also Alibhai and Key 1985). Neal (1983) demonstrated that a habitat of *Acacia-Commiphora* bush and sparse vegetation cover contained two species of spiny mice – *A. percivali* and *A. wilsoni* –

the first of which was widespread and the latter was encountered in much lower numbers and largely restricted to seasonal drainage channels. A similar situation may have occurred in the present study, with two species of spiny mice coexisting by partitioning the habitat. Settlement B2 and its control site represent fundamentally different microhabitats. The control site had the densest vegetation cover among all of the study sites and bordered on a seasonally inundated water hole and may have provided a microhabitat for one species of spiny mice. The settlement 250 m away may have provided a different type of microhabitat for a second species that was also more widely distributed throughout the bush. The low numbers of spiny mice in most other control sites indicate that densities in the bush at large may be rather low and that they may become locally enhanced in settlement microhabitats. The relative rarity of lactating females in control site samples and their more consistent presence in settlements also indicates that spiny mouse reproduction is more concentrated in settlements than in surrounding areas. Furthermore, the fact that numbers of spiny mice in settlement B2 were at a peak during the severe drought suggests that the settlement may have functioned as a refuge microhabitat for the mice from the wider bush habitat. Demonstrating the precise role of Maasai settlements as microhabitats for spiny mice would require greater detail on populations of distinct species outside of the settlements, however.

In addition to congeneric interactions, there is some evidence to show that the intermittent occupation of settlements by their human inhabitants is a factor affecting the association of spiny mice with settlements. The marked and somewhat anomalous depression in spiny mouse numbers in settlement B2 following the rainy season of March-April 2006 and recent reoccupation is a case in point. It has previously been shown that, in general, numbers of small rodents and shrews in dry grasslands in

Kenya peak during the wet season and slump during the dry season (e.g., Martin and Dickinson 1985; Oguge 1995). I documented this pattern in all of the control sites and some of the settlements in the Eselenkei study but it was clearly reversed in settlement B2. The impacts of reoccupation by people and herds in conjunction with the rains may have also been felt in settlements B21 and B45 where numbers of spiny mice were consistently low throughout the study period. Extended lack of occupation also played an important role in structuring the association of spiny mice with settlements. In settlements B8 and E43 numbers of spiny mice were relatively high but there is also an indication that these rodents were out competed in certain parts of the settlements by species that became locally abundant. Thus, narrow-footed woodland mice seem to have partly displaced spiny mice from houses and the internal enclosure fences of settlement B8 and common gerbils from the circumference fence and enclosures of settlement E43. The presence of houses, whether occupied or unoccupied seems, nonetheless, to have generally contributed to the association of spiny mice with the settlements. As the level of human occupation increased and as their association with the circumference fences declined I found that Spiny mice were increasingly associated with the houses.

Life history strategies of spiny mice are an additional factor that can provide insights into patterns in their association with settlements. Such strategies and especially the extent to which they afford greater adaptive flexibility to the rodents should influence their propensity to colonize, survive, and succeed within the highly dynamic environments of human settlements (see Pocock et al. 2004). Spiny mice are generally terrestrial, nocturnal, and gregarious rodents (Kingdon 1974a: 656). Kingdon (1974a: ix) lists spiny mice among his "specialist" division of East African rodents, presumably because of their confinement to dry regions and preference for insectivorous diets. In several respects, spiny mice may be considered more opportunistic, generalized, and flexible, however. Canova and Fasola (1994) showed that spiny mice inside the pastoralist and tourist town of Loyangalani in the desert region of northern Kenya adjusted their diet to vegetal materials whereas adjacent outdoor populations were mainly insectivorous. In that study densities of spiny mice did not significantly differ inside and outside of the settlement, which calls into question their commensal status. Reproduction in spiny mice can be year-round (e.g., Neal 1983) although recruitment may be somewhat limited by relatively long periods of gestation and small litters (Kingdon 1974a: 658). Data from this study indicates that spiny mice have the capacity to adjust to stresses stemming from the proximity to humans and livestock in settlements and inside houses but also that this may be a limiting factor on population size.

Spiny mice may not be human commensals in Maasai settlements according to formal definitions of commensal interactions. This would require demonstrating a significant positive effect of settlements on the population size of mice at the same time that human population size is unaffected (i.e., a +/0 interaction). Although I could not determine from the available data whether the population size of spiny mice in the settlements was significantly larger than outside populations of the same species, the net effect of settlements including that of increasing levels of human occupation appeared to be a negative or at least a neutral one. Settlements may, nonetheless, significantly contribute to the fitness of spiny mice by providing opportunities for the coexistence of congeners and avoidance of competition within habitats, sustained food resources, and refuge especially during periods of seasonal stress such as drought. In comparison to the wider habitat outside settlements also provide better shelter in the form of houses.

Negative impacts on fitness might include high levels of stress resulting from intermittent occupation of settlements by people and herds. Enhanced competition with species from other genera is also likely in settlements that remain unoccupied for significant periods of time. The combined effect of these costs and opportunities will have consequences in terms of the relative abundance of spiny mice in micromammalian communities in different settlement environments.

Multimammate Rats (*Mastomys* sp.)

These rodents are the predominant indigenous pests and commensals in villages in agricultural regions of sub-Saharan Africa (Kingdon 1974a: 587; Fiedler 1994: 11-12). Kingdon (1974a: 587-588) has even speculated that multimammate rats spread from the savannas of southern Africa to the tropical zones as a result of their association with human activities, although there is little evidence for this. Although multimammate rats are widespread throughout their current range, their distribution in East Africa is confined to areas of human settlement and they are especially dependant on settlements in dry regions. Misonne (1963: 106) demonstrated that multimammate rats can achieve extreme dominance of rodent communities in agricultural villages in the Democratic Republic of Congo where he recorded their relative abundance at more than 98%. This figure decreased systematically with distance from the villages. Misonne (1963: 48) also noted that populations of multimammate rats can persist in sites of abandoned villages for as long as 20 years after abandonment. The commensal status of multimammate rats can be related to their especially high reproductive potential and omnivorous diet (see Kingdon 1974a: 557-559). There is also evidence showing that these rodents are highly mobile and adept and possibly dominant colonizers. This is especially true in environments that have been degraded by fire, overgrazing, or the effects of severe drought (Oguge 1995; Avenant 2000). The social structure of multimammate rats appears to be adjusted to conditions in agricultural villages where it is characterized by close knit organization of populations around demic groups and enhanced agonistic behavior among adult males (Granjon and Duplantier 1993).

In Eselenkei, multimammate rats and spiny mice were the only two species that occurred across all of the study settlements. The abundance of multimammate rats in the settlements was relatively low, however, and only exceeded three individuals in a single trapping session in settlement B8. This occurred a number of months after the rainy season and following prolonged lack of occupation by people and livestock. Indirect evidence for an association between multimammate rats and the settlements is provided by their near absence from control sites and total absence from prey assemblages of eagle owls and mongoose scats from the vicinity of the settlements. Although it is possible that local multimammate rat populations crashed during the extended drought period preceding the study and persisted in highly localized pockets in the bush, their sparse occurrence in settlements (B2 and B45) even before the rains of February-May indicates that settlements provide conditions for persistence of individuals during periods of extreme stress. Given that water is a limiting factor for multimammate rats in dry environments it may be especially significant that in early February when the drought was at its peak one individual was captured in settlement B45 inside a house that was occupied by people and where water should have been available. In settlement B45 multimammate rats were the dominant species inside houses. They seem to have replaced spiny mice, which were dominant in houses in all other settlements except B8. I could not determine from the available data whether this was the result of direct competition between the two species or of other factors that are related to increasing level of human occupation such as reduction in richness and diversity of vegetation. The fact that the highest numbers of multimammate rat captures among the occupied settlements were from settlement B21 provides further support for their association with settlements with high levels of human occupation. Maasai settlements may thus contribute to the fitness of multimammate rats by facilitating avoidance of predators, providing refuge during drought periods, and possibly functioning as high-potential breeding sites in cases where there is a lengthy period of lack of occupation.

Narrow-footed Woodland Mice (*Grammomys* sp.)

The narrow-footed woodland mouse is distributed throughout most of sub-Saharan Africa in a wide variety of grassy and bushed habitats (Kingdon 1974a: 640). This species was not mentioned among the rodent pests of field crops in East Africa although it has been recorded in human dwellings. Narrow-footed woodland mice feed mainly on vegetal material, are nocturnal, and mostly solitary. They are listed in Kingdon's (1974a: viii) "climbers" division of African rodents due to their arboreal adaptation. In this study, narrow-footed woodland mice were distinctly associated with settlement B8 which people did not occupy for a significant period of time. Narrow-footed woodland mice also occurred in particularly high numbers inside the houses of that settlement.

Zebra [Striped Grass] Mice (*Lemniscomys* sp.)

Zebra mice were the only species in the trapping study that were only trapped outside settlements and it is of interest to consider ecological aspects of this negative correlation. Zebra mice occur in a wide variety of grassland habitats throughout many parts of Africa including in semi-arid regions (Kingdon 1974a: 621). In Kingdon's (1974a: viii, 622) classification of East African rodents, zebra mice are placed within the "herbivores" division due to their dietary reliance on grass stems and leaves. They are mainly diurnal, solitary, and markedly seasonal breeders (Kingdon 1974a: 622). Kingdon (1974a: 621) has speculated that the spread of pastoralists or farmers in Africa and the consequent opening up of parts of the landscape may have facilitated the expansion of some species of zebra mice. Fiedler (1994: 29) lists them among the rodent pests of crops in agricultural regions of East Africa. It may be of some significance that in the present study zebra mice occurred in the control sites of the three settlements with the highest levels of human occupation (B21, E43, and B45). Zebra mice appear to benefit from the influence of settlements on the wider environment but do not utilize the settlements themselves, perhaps due to lack of grass cover or variety of grass species.

Gerbillinae

Gerbils: Naked-soled Gerbils (*Tatera* sp.), Taterillus Gerbils (*Taterillus* sp.), and Common Gerbils (*Gerbillus* sp.)

The species of gerbils identified in this study represent the three different genera that are the most widespread in the sub-family of Gerbillinae and occur throughout the arid and semi-arid regions of Africa (Kingdon 1997: 193). Gerbils are generally distinguished by their specialized adaptation to arid environments with sparse vegetation cover and share characteristics such as drought-resistant physiology and extensive burrowing and food storing behaviors that are particularly advantageous in dry habitats. Gerbils typically show a preference for open habitats with sandy well-drained soils that are suitable for maintaining their burrow systems (Kingdon 1974a:

509, 515, 518). These rodents are nocturnal, have moderate rates and relatively pronounced seasonality of reproduction, and have somewhat opportunistic diets that focus on vegetal materials. Common gerbils are more restricted to dry environments than naked-soled and Taterillus gerbils, which also occur in some agricultural regions where they are among the important rodent pests in crop fields (Kingdon 1974a: 515; Fiedler 1994: 31). It has been observed that in agricultural areas gerbils benefit from vegetation clearance, secondary vegetation growth, and loosening of the soil. They have only rarely been reported to occur in association with human dwellings, however (e.g., Christensen 1996).

At Eselenkei, captures of all gerbil species occurred mainly in the circumference fences of the settlements, with only a few in the internal enclosure fences and a single capture of a common gerbil inside a house. Naked-soled and Taterillus gerbils were sporadically to rarely associated with the study settlements and the former species also occurred in greater abundance in control sites than in any of the settlements. Common gerbils may have been restricted to the southern part of the study area, attained relatively high abundance in settlement E43, and were associated with high levels of lack of occupation. I observed some of these gerbils entering a burrow system into soft ashy deposits from a burnt down house that was situated inside a section of the circumference fence of settlement E43. Only in settlement B45 in the southern study neighborhood all three types of gerbils were recorded. Here, they appear to have benefited from a combination of a high proportion of bare ground and the availability of loose soil from degraded dung deposits adjoining the settlement, in which I observed multiple burrow openings.

9.42 Insectivora - Soricidae

White-toothed Shrews (*Crocidura* sp.)

In Africa the genus *Crocidura* represents a highly complex and varied group of species of shrews that are distributed throughout the continent (Kingdon 1974b: 102-109). Although it is difficult to generalize regarding habitat preferences and life-history characteristics across the multitude of species of white-toothed shrews, at least one species, *C. hirta*, has been recorded in agricultural villages as well as inside houses in East Africa (Vesey-Fitzgerald 1962; Kingdon 1974b: 73, 108; Christensen 1996). This species is common in dry grassland and bushland habitats. Vesey-Fitzgerald (1962) suggested that these shrews tend to seek refuge during the dry season in areas of dense vegetation, termite mounds, and various cavities. It is conceivable that this habit could account for the association of white-toothed shrews with Maasai settlements although the exact species that I recorded in Eselenkei settlements is not known. White-toothed shrews occurred in relatively low abundance in three of the study settlements and were trapped in similar frequencies in enclosures and inside houses. In terms of the composition of species inside houses their association with the houses in settlement B2 had an especially prominent impact on variability among the study settlements.

9.43 Macroscelidea - Macroscelididae

[Lesser] Elephant Shrews (*Elephantulus* sp.)

The lesser elephant shrews belong to a uniquely African order of small mammals that are distributed mainly throughout the southern and eastern parts of the continent (Kingdon 1974b: 37). These animals are differentiated from true shrews of the order Insectivora by their anatomical characteristics, but share with the true shrews dietary habits that depend mainly on insect-eating (Kingdon 1974b: 8, 61). In sharp contrast to some of the rodents of the family Muridae that were discussed above, lesser elephant shrews are diurnal, distinctly territorial, have low rates of reproduction, and are highly excitable (Kingdon 1974b: 61-65; Koontz and Roeper 1983). In this study, lesser elephant shrews occurred in low to moderate abundance in settlements B2-B21 and were trapped almost exclusively in the circumference fences of settlements. The association of lesser elephant shrews with the dense branch fences in Maasai settlements can be related to their known dependence on thick vegetation clumps, which provide them with aboveground shelter in dry bushland and woodland habitats (Kingdon 1974b: 61; Koontz and Roeper 1983). Moreover, areas with high densities of wild or domestic herbivores are favorable habitats for lesser elephant shrews due to the high abundance of invertebrates associated with concentrations of herbivore dung (Kingdon 1997: 148). The rarity of elephant shrews in control sites outside of the study settlements indicates that there is a distinct association with the settlements, even though this does not appear to be a commensal relationship.

9.5 Ecological Mechanisms Underlying the Association of Micromammals with Maasai Settlements

Analysis of the ecological roles of species in relation to the study settlements shows that there is little direct evidence for commensalism of any specific species of micromammals in Maasai settlements. Spiny mice may have achieved a particularly high population size in settlement B2, but this decreased significantly with increasing levels of human occupation across the other study settlements. This implies that the net effect of settlements on the population size of spiny mice is either a negative or a neutral one which would rule out commensalism in the strict sense because by definition commensalism requires the establishment of a significant effect on population size (see Dickman 2006a: Box 18.1). This would not, however, rule out the possibility that Maasai settlements contribute to fitness of spiny mice as well as that of other micromammalian species in other more nuanced ways that can be examined in the framework of environmental engineering. In the case of multimammate rats there is some indication of a high degree of dependence on the settlements and suggestions that the relationship persists and intensifies with increasing levels of human occupation. Maasai settlements may, in fact, be providing resources for a wide range of species with widely varying adaptive strategies, habitat requirements, and natural history characteristics. This would account for the significantly greater richness and diversity of micromammalian species in the study settlements in comparison with background levels but lack of significant differences in overall abundance or the abundance of a specific species such as spiny mice.

This study demonstrates that settlements and different levels of human occupation have a significant effect on the structure of micromammalian communities. Here I examine possible mechanisms for the maintenance of patterns of high micromammalian richness and diversity in Maasai settlements without marked growth in population of any specific species in light of two fundamental premises. The first is that Maasai settlements provide a context of facilitation for a wide range of micromammalian species for reasons that are related to the ecological and natural history characteristic of particular species. The second is that the context of facilitation is inadvertently provided by Maasai pastoralists through environmental modification brought about by the creation and maintenance of settlements and influenced by additive effects of settlement use through time.

I argue that the creation and maintenance of settlements by Maasai pastoralists can be considered a case of environmental engineering, with overall positive effects on the structure of local micromammalian communities. A similar dynamic in terms of underlying ecological processes has been discussed in relation to a recent study on the effect of termites and bush clump formations on micromammalian species in an arid region of South Africa. Although in the bush clump case there is little or no human involvement, it provides an interesting example of micromammalian-ecosystem interactions with an overall positive ecological effect at the community level and insight into how vegetation and settlement characteristics are affecting micromammalian communities in Maasai settlements. In this study, Whittington-Jones et al. (2008) demonstrated that isolated clusters of dense vegetation known as bush clumps are associated with a significantly greater abundance and diversity of micromammalian species than adjoining areas of sparse vegetation and extensive tracts of bare ground. They argue that such bush clumps function as refugia for most species of micromammals in the study area by providing higher than background densities of seeds and decreased soil hardness that are important for foraging and burrowing activities. The authors (Whittington-Jones et al. 2008) also suggested that intensive use of the bush clumps should facilitate micromammals in predator avoidance. A particularly important aspect of the bush clump example that links it to ecosystem engineering and Maasai settlements is that the beneficial effects of the microhabitats could be related to a single key species that is expected to control the availability of essential resources for the micromammals. In the example of the bush clumps, these are termites which through their construction of mounds (termitaria) provide a concentrated source of moisture, minerals, and nutrients for the localized development of dense thicket vegetation (Whittington-Jones et al. 2008; see also Fleming and Loveridge 2003).

In the case of the creation and maintenance of Maasai settlements, engineering activities should mainly involve initial clearance of vegetation by households for construction of houses and livestock enclosures and through time the accumulation and concentration of considerable amounts of livestock dung and continued harvesting of vegetation from settlement surroundings through grazing and cutting of wood by women for fires, settlement maintenance, and for other domestic use. I have shown that the compound effect of these activities contributes to micromammalian richness and diversity but these results also raise questions regarding mechanisms that underlie these patterns. The kind of facilitation expected as a result of the creation and maintenance of Maasai settlements includes provision of foraging resources, shelter, greater protection from predators, and in some cases reduced competition for micromammals (e.g., Dethier and Duggins 1984; Dickman 1992; Waterman and James 2007). Maasai settlements provide some or all of these benefits to a wide range of micromammalian species. Potential food, shelter, and protection for micromammals may be found in the concentrations of livestock dung, dense branch enclosure fences, and houses in the settlements.

These expectations can also be supported by additional evidence from the Eselenkei study as well as from other research. Previous research has shown that herbivore dung is typically associated with particularly high densities of insects and seeds that survive rumination and digestion (Mohr 1943; Reid and Ellis 1995). Both insects and seeds are essential food resources for many species of micromammals. The high number of captures of micromammals in the enclosure fences of the settlements together with the observation that these fences contain highly visible micromammalian paths (i.e., rodent runways) indicate that they are systematically used for shelter and foraging. Other foraging resources for micromammals may be provided by vegetation growth inside fences which shelter some plants within settlements from grazing by livestock. The fact that four of the eight micromammalian species that were recorded in the settlements were also recorded in houses, both while the houses were occupied by people and when unoccupied, indicates that these structures provide shelter and possibly food for a wide variety of micromammals. The distribution of elephant shrews in the settlements reveals an additional significant pattern. In this case the elephant shrew is a known specialist exploiting insects in herbivore dung and was found within the fences surrounding the settlements and the livestock corrals. Finally, some degree of predator avoidance may be indicated by the evidence for significant dependence of multimammate rats on the settlements and their absence from the prey of local eagle owls and mongoose.

It is also important to account for changes in other aspects of community structure that were documented along the gradient of increasing levels of human occupation. These include the turnover in the configuration of micromammalian communities and the significant reduction in abundance as richness and diversity were maintained. Some of the processes in micromammalian community structure can be tied to continuous vegetation depletion around settlements. This is supported by the fact that numbers of spiny mice steadily decreased along the gradient of increasing level of human occupation and that various species of gerbils which are less dependant than spiny mice on vegetation cover were common in settlements with high levels of human occupation. The depletion of spiny mice was particularly evident in the extensive zone of bare vegetation surrounding settlement B45 and represents a significant aspect of human engineering of the microhabitat through settlement use and occupation. A pattern of vegetation depletion around settlements with increasing occupation levels may account for the significant reduction that I found in vegetation richness and diversity along this gradient.

An additional aspect of microhabitat engineering in Maasai settlements that varies temporally is the buildup of livestock dung. Muchiru et al. (2008) have suggested, for example, that the level of accumulation of herbivore dung in Maasai settlements can have a marked effect on the rate of recovery of vegetation following settlement abandonment. In general, livestock enclosure sediments have especially high potential plant productivity due to enhanced levels of nutrients and moisture, but this is depressed through continued occupation and dung accumulation that eventually hamper plant establishment because of increased thickness and intolerable levels of nutrients such as nitrogen (Muchiru et al. 2008).

Conditions in areas surrounding Maasai settlements may also affect the association of micromammals with the settlements. Keesing (1998) has shown that micromammalian diversity in an East African savanna habitat can be significantly reduced through disturbance or direct competition for food resources caused by large ungulates. It is conceivable that Maasai settlements function as refugia from disturbance by livestock as well as from competition with other micromammalian species including congeners.

This study demonstrates that Maasai settlements are engineered microhabitats with beneficial consequences for the richness and diversity of local micromammalian communities. Ecological theory predicts that processes of ecosystem engineering with positive effects will involve underlying commensal interspecies interactions between a single unaffected engineer species and a range of species benefiting from modifications of the shared habitat (Dickman 2006a). In the Eselenkei study, it appears that the effects of commensalism of micromammals in Maasai settlements on the population size of any single species are subtle and not readily apparent. They may even be negligible, but the overall beneficial effects caused by people and their herds through occupation of settlements can be detected by looking at patterns in micromammalian communities and considering benefits as well as detrimental effects. These patterns can be explicated by focusing on increased environmental suitability in the context of seasonally occupied settlements and by taking into account the nature and scale of human engineering activities. The results of the Eselenkei study also emphasize the consequences of human microhabitat engineering for micromammalian community structure and enhanced biological diversity of the micromammalian species of Maasai settlements rather than for dominance by any single indicator species or pronounced commensalism.

It may be asked given the absence of clear cut evidence for commensalism whether the evidence from Maasai settlements should be considered in the framework of commensalism, as a separate phenomenon of human/animal interaction, or as a case of lack of human/animal interaction. I think that the Eselenkei Maasai case provides useful perspectives on both commensalism and environmental engineering. From a theoretical standpoint, it has been repeatedly asserted in recent ecological literature that contexts of facilitation, which involve positive contributions by one species to the suitability of the environment for others, are considerably more prevalent in biological communities than hitherto realized. Elias et al. (2008), Stensland et al. (2003) and others (Vandermeer 1980; Dethier and Duggins 1984; Dickman 1992; Bronstein 1994; Stachowicz 2001) also argue that facilitation of this kind may play a critical role in the functioning and evolution of ecosystems. Bilateral interspecies interactions with beneficial outcomes including mutualism (+/+) and commensalism (+/0), can be subsumed within the broader frameworks of facilitation and environmental engineering. But their effects may not always be readily apparent due to the complexity of biological communities that often encompass interaction webs, as well as indirect effects among chains of species (Dickman 2006b; Dickman and Murray 2006). Furthermore, in contrast to more extensively studied interactions such as in competition (-/-) and predation (+/-), that are based on direct trophic exploitation, the mechanisms underlying facilitatory interactions are less well understood (Dickman 2006a). The development of the concept of environmental engineering and the understanding that numerous ecosystem interactions occur indirectly through alterations in the suitability of species' environments represents a theoretical breakthrough in the study of the ecological basis for facilitation in biological systems (Jones et al. 1994, 1997; Dickman 2006a). Facilitation and engineering are especially likely in the case of humanly modified environments because humans are considered as highly specialized environmental engineers capable of a wide variety of modes and levels of modification (Jones et al. 1994, 1997; see also Smith 2007).

I believe that the evidence for the impact of Maasai settlements on micromammalian communities can be considered in the framework of anthropogenic commensalism and expect that different scales of commensalism from subtle to more pronounced will be associated with the variety of contexts of human environmental engineering, levels of site occupation, and degrees of mobility that may be found in human settlements. My findings suggest that it should be possible to measure different scales of micromammalian commensalism and relate them to engineering, site occupation, and mobility by looking at biological diversity, the composition of species, and their ecological roles.

CHAPTER 10

DISCUSSION II:

COMMENSALISM AND IMPLICATIONS FOR ARCHAEOLOGY

10.1 Implications for the Commensalism/sedentism Linkage

I have shown in the previous chapter that even relatively temporarily occupied Maasai settlements have significant and positive effects on the biological diversity of micromammalian communities. Micromammalian species richness and community diversity in these humanly engineered environments (sensu Jones et al. 1994, 1997) were significantly greater than in adjacent control sites at a distance of 200-400 m. I also demonstrated that when duration and intensity of human occupation in the settlements increased this did not reduce biological diversity. The results of the present study should be evaluated in light of the seasonal nature of Maasai settlement occupation and the relatively small and generally stable size of human populations of the settlements, however. Tchernov (1984, 1991a) predicted a different dynamic for the ecological impact of highly sedentary settlements with long-term and continuous occupation and growth in human populations. This includes adverse effects on biological diversity leading to predominance of one or a few species and manifest commensalism. The absence of evidence for reduced biological diversity and marked commensalism from seasonal settlements of Maasai pastoralists is a strong indication that we can expect such effects to be distinctly associated with highly sedentary settlements and substantial human populations. Such distinctions among varying levels of biological diversity and commensalism should provide the basis for distinguishing among varying levels of human site occupation and degrees of mobility in archaeological situations. This raises an important question regarding the precise levels of biological diversity and commensalism that may be tied to either mobility or sedentism and implications for Tchernov's model of the relationship between commensalism and sedentism.

In light of the finding that seasonal Maasai settlements reveal a distinct biological diversity signal that also differs from theoretical expectations for settlements with year-round permanent occupation, an especially relevant comparison may be with data from more sedentary agricultural villages in East Africa. Some form of mobility is an important component of African farming practices such as shifting cultivation (Wilkie and Finn 1990). Nevertheless, farmers in wetter regions are more tied to particular locations than African pastoralists living in areas with low and unpredictable rainfall distribution.

Studies of communities of small rodents and shrews in agricultural regions of Africa have not specifically focused on the impact of settlement environments but a few have included such environments as a comparison to crop fields (Misonne 1963; Christensen 1996) or protected areas (e.g., Caro 2001). One such study by Misonne (1963) examined the ecology of micromammalian communities in a series of different habitats that included agricultural villages and surrounding fields in the Ituri Forest and Rwenzori Mountain Range of northeastern Democratic Republic of Congo. Although Misonne (1963) did not provide details on the ethnographic context of his study area it is a high rainfall region inhabited by agricultural groups such as the Nande, Lese, and Lendu (Wilkie and Curran 1993). Devignat (1946) who contributed data to this study mentioned that villages in the area consisted of between 10 and 100 houses. The study involved trapping of small rodents and shrews inside houses in the villages, in crop fields and grasslands surrounding the villages and at a distance of 50 m from the villages, and in a series of habitats along a gradient of increasing distance from the villages (Figure 10.1). Results of the research showed that a single species—the multimammate rat—was by far the most common in the villages comprising more than 98% of captures (Misonne 1963: 106). Twelve additional species were recorded in the villages in very low frequencies. The frequency of multimammate rats also decreased sharply to 1.5% in habitats surrounding the villages and dropped to zero in habitats farther away.

Misonne (1963) recorded the extreme predominance of a single species—the multimammate rat *(Mastomys* sp.)—in agricultural villages which indicates an exceedingly low level of community diversity. Misonne (1963) did not calculate community diversity but this measure may be derived from the published data. Table 10.1 shows the absolute abundances (where these were made available) and relative proportions of species in the different habitats as reported by Misonne (1963: 94-99) and Devignat (1946). I also computed estimates of community diversity based on the Shannon-Wiener index. These calculations show that the diversity in villages is lower by more than an order of magnitude than in adjacent habitats. Similar results from agricultural villages were obtained in a more recent study by Christensen (1996) from a wide range of regions in Tanzania. In this study, more than 99% of all captures of small rodents and shrews inside houses were made up of a combination of multimammate rats and black rats (*Rattus rattus*). The latter are an invasive commensal with currently limited distribution in Africa (see Kingdon 1974a: 578-581).

Figure 10.1. Comparison of the configuration of species' frequencies in East African agricultural villages and Maasai settlements.

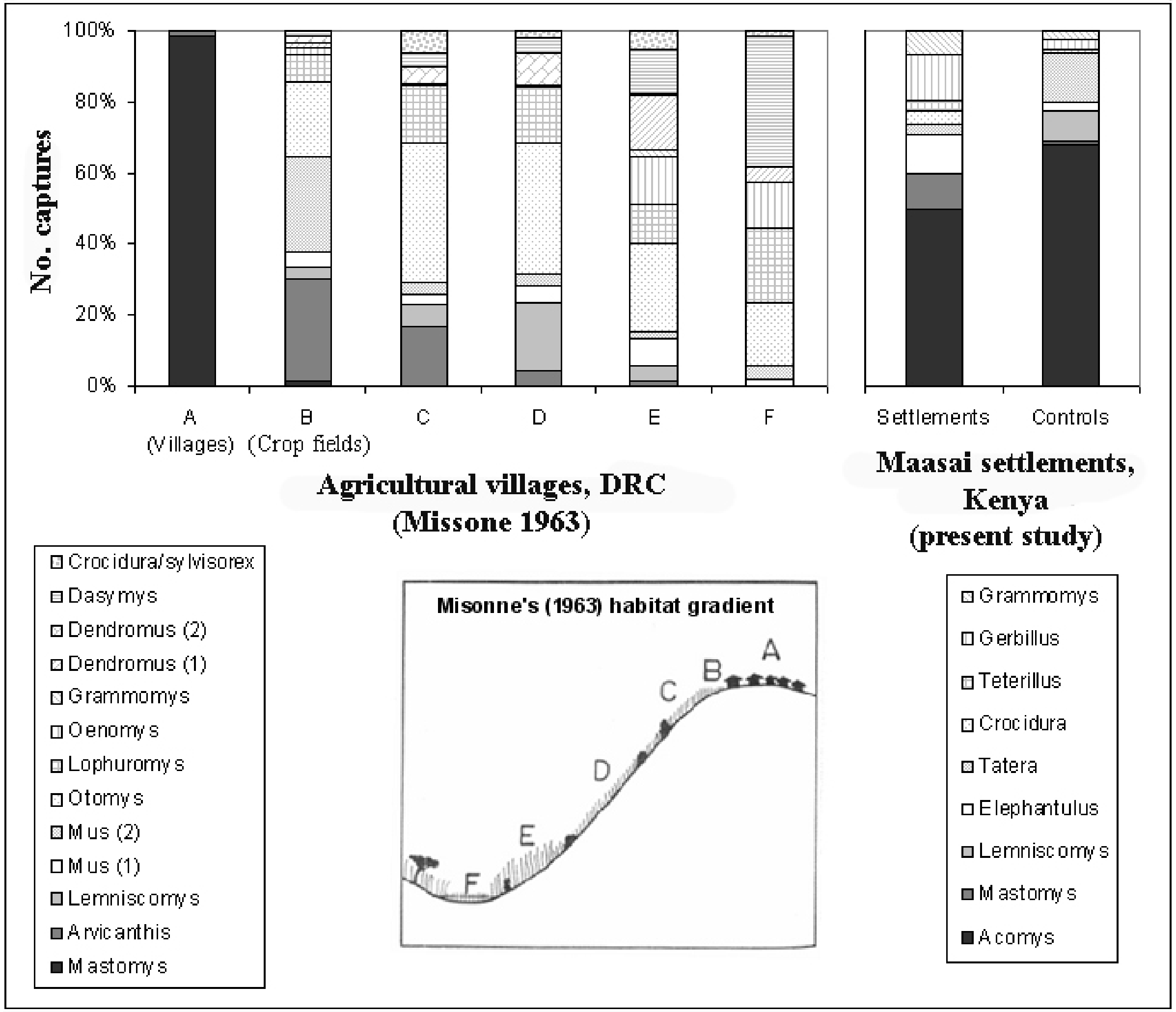


Table 10.1. Absolute abundances and community diversity of micromammalian species in agricultural villages and in a series of habitats at increasing distance from the villages.

	Habitat gradient					
Species/Genera	A (villages)[a]	B (fields)[b]	C	D	E	F
Mastomys natalensis	253,233	-	0	0	0	0
Arvicanthis abyssinicus	4,424	-	29	8	4	0
Lemniscomys striatus	12	-	10	31	11	0
Leggada triton (*Mus* [1])	12	-	6	9	20	1
Leggada minutoides (*Mus* [2])	258	-	5	5	6	2
Otmomys tropicalis	12	-	68	63	64	9
Lophuromys flavopunctatus	12	-	27	26	29	11
Oenomys hypoxanthus	12	-	0	0	35	7
Grammomys dolichurus	12	-	0	1	5	0
Dendromus mystacalis [1]	12	-	1	0	40	2
Dendromus mesomelas [2]	12	-	9	15	1	0
Dasymys incomtus	12	-	6	7	33	19
Sylvisorex/*Crocidura*	26	-	11	4	14	1
Total	258,045		172	169	262	52
Shannon-Wiener Diversity	0.10	-	1.82	1.84	2.14	1.67

[a] Absolute abundances for the genera *Mastomys* sp., *Arvicanthis* sp., and all the rest combined taken from Devigant (1946). For computation of a diversity index missing values were reconstructed from relative proportions provided by Misonne (1963: 106) and were evenly divided among a number of species for which proportions were reported as present at very low numbers.

[b] Absolute abundances could not be accuretly reconstructed from the published data.

[c] Absolute abundances for habitats C-F taken from Misonne (1963: 94-99).

These data demonstrate low levels of micromammalian commensalism in seasonal settlements of pastoralists and high levels of commensalism in more sedentary villages of agriculturalists in East Africa. The differences are illustrated graphically in Figure 10.1, which compares the configuration of species' frequencies from Maasai settlements in this study, agricultural villages from Misonne's (1963) study, and adjacent habitats in both contexts. Figure 10.1 shows an extremely low level of biological diversity in agricultural villages and relatively high level of diversity in Maasai settlements where the most abundant species comprises only 50%

of the overall number of captures. The fact that the two different modes of settlement use occur in very different types of environments should not affect the implications of this comparison because it is conducted first and foremost between the settlements in each type of environment and adjacent habitats within the same environment (i.e., a controlled comparison). It is also important to note that even though environments of small-scale subsistence farming societies have been shown to be associated with high levels of biological diversity of small rodents and other species (Jeffrey 1977; Nabhan et al. 1982), this high diversity was detected within managed environments such as agricultural fields and in less managed environments in a National Monument but not inside nucleated settlements. These results contrast, therefore, with those obtained from Maasai settlements or agricultural villages in the DRC (Misonne 1963).

Earlier in this thesis I used the data from Maasai settlements compared with controls to show that the level of human occupation is a key factor influencing the structure of micromammalian communities of the settlements. Human populations and basic economic activities were largely constant in my study and I did not examine the role of additional potential influencing factors in this tightly circumscribed setting. Nonetheless, based on the contrast between seasonal settlements of herders and sedentary farming villages I think that differences in the size, density, and growth rate of human populations of the settlements are significant. Furthermore, differences in the nature of systematic human activities, such as the accumulation of dung from corralling of livestock by herders, or the large-scale storage of food crops by farmers also play a role in affecting micromammalian communities. Quantitative aspects of the *level* of human settlement occupation include duration, seasonal intensity, and population size. More qualitative factors related to the *mode* of occupation such as livestock corralling and food storage are more difficult to quantify. Fully differentiating the effects of level and mode of human occupation is a complicated task and would require examination of the ecological effects of a wide diversity of levels and modes of settlement occupation in both pastoral and agricultural contexts.

In the remainder of this chapter I also use data on the association of different micromammalian species with Maasai settlements and varying levels of occupation and data on the ecological role of species to develop methods of identifying varying degrees of mobility or sedentism. I also address taphonomic questions of preservation and aspects of micromammalian commensalism in archaeology. Finally, I will discuss broader theoretical implications of the results of the study for understanding of relationships among long-term developments in human settlement occupation and impacts on biological diversity and human-animal relations.

10.2 Micromammals as Quantitative Indicators of Human Settlement Occupation in Archaeology

Substantiation of the link between pronounced levels of micromammalian commensalism and significant sedentism documents the extreme end of the range of effects of human mobility/sedentism on micromammalian communities. The distinction that I detect between the biological diversity signals of seasonal and relatively sedentary settlements suggests a framework for deriving specific expectations for biological diversity and commensalism signals of a wide range of cases along the mobility-sedentism continuum. It remains largely unknown, for example, what levels of biological diversity and commensalism we may expect in settlement contexts of societies with relatively low mobility or moderate levels of sedentism such as complex hunter-gatherers or agro-pastoralists. Establishing such broader linkages should have considerable value for archaeologists seeking additional and independent types of evidence for identifying the level of economic and social organization of the inhabitants of ancient settlements. Tchernov (1984) himself argued that it should be possible to quantitatively establish the link between varying levels of human settlement occupation and micromammalian indicators. He, nonetheless, focused on indicators of one end of the spectrum only. Morphological change and the abundance of highly commensal species such as the now cosmopolitan house mouse (*Mus musculus domesticus*), for example, are unlikely to occur or to be readily detectable in any but the most permanent settings and will reveal only incomplete information on diversity in ancient settlement environments.

This study demonstrates that a focus on the community structure of micromammals and the spectrum of species present reveals more nuanced and potentially quantifiable indications of mobility and levels of occupation among pastoral Maasai seasonal settlements. Relevant information from the micromammalian communities includes: 1) varying distributions of species among settlements and outside control sites, 2) some turnover in the composition of species with increasing levels of human occupation, 3) varying intensities of use of the settlement by various species, and 4) the fact that certain species were especially abundant in settlements that had significant periods of lack of occupation. In the previous chapter these data were combined with published information on the natural histories and habitats of the different species to delineate the ecological roles or niches of the species in relation to the study settlements. The settlement niche characterizations of micromammalian species in the study are summarized in Table 10.2 and are used here to establish a number of generalizations for linking variability in the composition of micromammalian communities to patterns of human settlement occupation in the context of pastoralism, either contemporary or archaeological.

Table 10.2. Niche characterization of micromammalian species in relation to Maasai settlement environments in East Africa.

	Distribution					
Taxa	Settlements	Controls	Habitat	Agricultural pest status	African settlement environments	Maasai settlement association
Spiny mouse	Ubiqutous	Ubiqutous	Semi-desert & savannah; bushland/ bushed grassland	Minor pests	Occurs in vilages and towns in some regions	Low occupation levels
Multimammate rat	Ubiqutous	Rare	Wide distribution: mainly settlements & crop fields	Major pests	Dominant commensal; range extension	High occupation levels; abandonment
Zebra mouse	Absent	Sporadic	Wide distribution: grassland/bushalnd	Medium pests	Range extension	-
Elephant shrew	Ubiqutous	Rare	Dry bushland	None known	-	Circumference fences
Naked-soled gerbil	Sporadic	Localized	Open habitats in arid and semi-arid areas	Major pests	Rare occurance in houses	High occupation levels
White-toothed shrew	Sporadic	Rare	Wide distribution: grassland/bushland	None known	Rare occurance in houses	Low occupation levels
Teterillus gerbil	Localized	Absent	Open habitats in arid and semi-arid areas	Major pests	-	High occupation levels
Common gerbil	Localized	Rare	Open habitats in arid and semi-arid areas	None known	-	Abandonment
Narrow-footed mouse	Localized	Rare	Wide distribution: grassland/bushland	None known	Rare occurance in houses	Abandonment

Table 10.2. Cont.

Taxa	Facilitation	Intensity of use	Detrimnetal effects	Life history characteristics	Strength of association with settlements
Spiny mouse	Refuge habitats; competition avoidance; shelter	Enclosures and houses (occupied & abandoned)	Stress; vegetation depletion	Terrestrial, nocturnal, gregarious, opportunistic feeder	Intermediate-high
Multimammate rat	Refuge habitats; predation avoidance; shelter	Enclosures and houses (occupied & abandoned)	Dependance on settlements	High reproductive potential, omnivorous, dominant colonizers, tolerance of disturbance, flexible social structure	High (abandonment)
Zebra mouse	Habitat expansion	-	-	Terrestrial, diurnal, herbivorous, solitary	None
Elephant shrew	Shelter; food (dung insects)	Mainly external circumferance fences	Unknown	Insectivorous, diurnal, low reproduction rate, excitable, territorial	Intermediate
Naked-soled gerbil	Vegetation depletion - habitat expansion	Mainly external circumferance fences	Unknown	Semi-fossorial, nocturnal, mainly herbivorous	Low
White-toothed shrew	Refuge habitats; shelter	Enclosures and houses	Unknown	Highly variable (insectivorous)	Low-intermediate
Teterillus gerbil	Vegetation depletion - habitat expansion	Mainly external circumferance fences	Unknown	Semi-fossorial, nocturnal, mainly herbivorous	Low
Common gerbil	Shelter	Mainly external circumferance fences	Unknown	Semi-fossorial, nocturnal, mainly herbivorous	Low (abandonment)
Narrow-footed mouse	Shelter	Enclosures and houses	Unknown	Arboreal, nocturnal, herbivorous, solitary	Low (abandonment)

As a preface to formal generalization I briefly summarize and then discuss the main patterns that emerge from consideration of the overall variability in micromammalian community composition in the study. One of the most distinctive patterns in the data is the decline in predominance of spiny mice with increasing levels of human occupation in the settlements in general and inside houses in particular. This decline is accompanied by the increasing importance of a number of species including elephant shrews, multimammate rats, and gerbils in other spatial contexts. Elephant shrews are recorded in relatively significant proportions in the periphery of settlements with intermediate levels of occupation such as B14 and B21 whereas multimammate rats are significantly associated with the oldest and most sedentary settlement in the study (B45). In this long-term settlement, multimammate rats became the only species to occur inside houses and their association with the houses was relatively consistent throughout the study period. These patterns are especially marked when considering the near uniform absence of elephant shrews and multimammate rats from control sites adjacent to the settlements. With long-term occupation at B45 and substantial vegetation depletion at the periphery of the settlement three species of gerbils (naked-soled gerbils, Taterillus gerbils, and common gerbils) also achieved predominance. Unoccupied settlements, on the other hand, were particularly associated with communities dominated by multimammate rats, common gerbils, and narrow-footed woodland mice. It is significant that the community compositions of these settlements were not mirrored in the control sites where the predominance of spiny mice remained largely intact. There was some reduction in their numbers, though, in the controls of the southern part of the study area.

On the basis of these patterns and information summarized in Table 10.2 on niche characterization of micromammalian species in relation to Maasai settlements in East Africa I draw a number of broad connections between micromammalian species and the occupation of settlements of Maasai pastoralists. I present these in the form of general predictions and it is important to emphasize that these connections cannot be substantiated statistically based on data from the present study. First, spiny mice may be considered early and successful colonizers of Maasai settlements. This is probably because they are an important member of the micromammalian communities surrounding the settlements and because of their sociability and opportunistic feeding habits. Spiny mice are, nonetheless, relatively specialized in terms of habitat preferences and may be negatively affected by the instability of settlement occupation. These fluctuations result from the seasonal coming and going of people and livestock and from progressive vegetation depletion that results from long-term settlement activities. In contrast, multimammate rats are highly omnivorous generalists. These flexible rodents are late colonizers of Maasai settlements that become established in conjunction with the decline of early colonizers. Multimammate rats are also dependant on the settlements, as demonstrated by their near absence from traps in outside control sites and complete absence from the prey assemblages of local predators. This dependence may also be related to the fact that multimammate rats are less suited to relatively dry environments, however.

It is difficult to find comparisons with which to assess the generalizable features of the Maasai case study because so little research has been conducted on the relationships between mobile or semi-permanent settlements and micromammalian communities. Nevertheless, a somewhat similar dynamic was documented by Courtney and Fenton (1976) in their study of the micromammalian community associated with a seasonally utilized garbage dump in rural Canada. The garbage dump situation resembles the circumstances of Maasai settlements in the present study in the seasonal nature of human activities lasting during the holiday season of each year (May-October) and in the relatively low density of the human population consisting of only 4-5 families. The two situations differ in that the garbage dump study focused on a single site during a single season and therefore represents a short-term dynamic. Moreover, the Canadian garbage dumping activities represented the human occupation of the area only indirectly and involved much larger volumes (>200 L/week) and different composition than I observed in garbage dumps around Maasai settlements where very little if any food refuse was discarded.

Even though the time-scale and factors affecting the ecological dynamics in the two situations differ fundamentally, it is of interest to note the similarities in the ecological processes themselves. Courtney and Fenton (1976) showed that a local and highly abundant rodent species – white-footed mouse (*Peromyscus leucopus*) – was an early colonizer of the dump during the seasonal cycle but that it was eventually out competed by commensal house mice that were introduced seasonally with the garbage and died out following the termination of dumping each year. They hypothesized that the white-footed mice initially benefited from their omnivorous feeding habits but that house mice had the advantage of greater flexibility in social structure and an ability to maintain denser populations. Although there was limited evidence for direct competition between spiny mice and multimammate rats in the Eselenkei Maasai study, the data from the Canadian garbage dump provides some support for the connections that I hypothesize exist between the dynamics of colonization of settlements and the ecological roles of micromammalian species which incorporate or are based on their natural history – feeding habits, social structures, and population densities.

I classify the strength of association of spiny mice with Maasai settlements intermediate-high (see Table 10.2), which reflects their relationship with relatively low levels of human occupation and their role as early colonizers. I attribute a strong association of multimammate rats and Maasai settlements, which reflects their relationship with higher levels of occupation and their role as late colonizers. Other species were classified in low to intermediate categories and reflect more specific contexts of association of micromammals with Maasai settlements. These include the association of multimammate rats, common gerbils, and narrow-footed woodland mice with unoccupied settlements and utilization of the periphery of settlements on a more opportunistic basis by elephant shrews and other gerbils. The only species that was not recorded in the study settlements but was found in adjacent control sites is the zebra mouse. This animal is a specialized herbivore, which may depend on the more extensive vegetation cover away from the settlements. The fact that zebra mice occurred in the control sites of settlements with high levels of occupation may indicate that the impact of long-term settlement activities on the wider habitat has a positive affect on the populations of zebra mice. In summary, when considered from the perspective of the ecological community, the concept of the niche, and the settlements as engineered habitats the full spectrum of species in Maasai settlements provides a range of different types of information on the mode and level of human occupation.

Ascertaining the generalizability of information from the specific context of the study, its limitations, and its relevance for the archaeology of ancient pastoral settlements and other contexts will depend on a number of factors. First, there is clearly a need for additional studies designed to examine the configuration of micromammalian niches in a number of pastoral contexts in order to demonstrate the repeatability of the observed patterns under varying circumstances including varied environmental conditions, micromammalian communities of varied species composition, and among varied human social and economic systems. Second, research is needed in contexts that differ fundamentally from those of the settlements of subsistence pastoralists such as hunter-gatherer camps, agricultural villages, or urban towns and cities. In all of these we may expect a somewhat different configuration of micromammalian niches. The role of a specialist exploiting dung insects on the periphery of settlements that in Maasai settlements is filled by the elephant shrew, for example, may not occur in contexts that are not constructed around livestock keeping.

Based on these results I propose a number of generalizations for linking indicators from micromammalian assemblages to varying degrees of sedentism or mobility and intensities of pastoral settlement use:

I – Substantial abundance of remains of species that do not commonly occur in occupied settlements will indicate significant periods of lack of occupation or low intensity of seasonal occupation (e.g., *emparnat* B8 or *enkaron* E43).

II – Predominance of remains of early colonizing species will indicate relatively low duration of occupation and intensive seasonal use of settlements (e.g., *imparnati* B2 and B8).

III – More substantial abundance of remains of late colonizers and of opportunistic periphery species will indicate older intensively used settlements (e.g., *imparnati* B14 and B21).

IV – Predominance of remains of late colonizers will indicate old and relatively sedentary settlements (e.g., *emparnat* B45).

Ultimately these predictions should be tested against data on variability in micromammalian assemblages from the archaeological record of the Pastoral Neolithic period of the central Rift Valley region in East Africa (4,000-1,250 bp). Before doing so it is important to consider the taphonomic processes that are responsible for the accumulation of the remains of micromammals in settlement substrates and considerably impact the way that micromammalian indicators are used in archaeology. These can alter the living assemblages during their incorporation into the archaeological record (see Valdez and Valdez 1997; Weissbrod et al. 2005).

10.3 Taphonomic Evidence for Accumulation and Preservation of Micromammalian Assemblages in Maasai Settlements

Analysis of taphonomic indicators on contemporary Maasai settlements in Eselenkei provides significant insights into problems of accumulation and preservation of material evidence for the presence of micromammals in Maasai settlements. The examination of large samples of livestock skeletal elements from the surface of the study settlements revealed the absence of damage attributable to gnawing by micromammalian species. This may be related to specific environmental or ecological circumstances in the study area but in any case indicates that gnawing cannot always be used as an indicator of the presence of micromammals on pastoral sites. A second significant finding is that micromammalian fecal pellets can accumulate and potentially preserve in the context of Maasai houses. This likely occurs in conjunction with the final stage of abandonment and just prior to the collapse of the mud, dung, and wood framework and virtually instantaneous formation of a sealed deposit. I attempted to identify micromammalian species from such a fecal pellet assemblage through morphometric comparison with known specimens from live-trapped species. A comparison of size and shape characteristics of the unknown specimens from the collapsed house with those of known specimens from the three species that were live-trapped inside houses in the study showed some correspondence with multimammate rats. Although this finding could not be statistically substantiated due to considerable overlap in size and shape of pellets among the three species it did fit with patterns that could be predicted from the trapping study, which showed a relationship among multimammate rats, houses, extended lack of occupation, and high levels of human occupation. It might be possible, therefore, to use micromammalian fecal pellets in conjunction with other lines of evidence to identify patterns of site use archaeologically.

A third type of material residue that I investigated was the accumulation of skeletal remains of micromammals in Maasai settlements. Despite excavations, I did not retrieve micromammalian skeletal remains from settlement contexts in the study. This may be the result, however, of low rates of deposition of micromammalian remains in the open air environment of Maasai settlements and relatively small volume of deposits that was examined. I also examined the possibility that micromammalian skeletal remains in prey assemblages of eagle owls and mongoose from the vicinity of settlements preserve a record of the impact of settlements on local micromammalian communities. Results showed that the diversity of micromammalian species in such prey assemblages were roughly comparable to that of micromammalian communities of the settlements in the trapping study. The species frequencies and their distribution across samples varied greatly, however, between the prey and trapping communities. In particular, species that were important members of the settlement communities such as multimammate rats and spiny mice were absent or occurred in relatively low frequencies in the prey assemblages. This suggests that impact of Maasai settlements on micromammalian communities was highly localized and did not affect the prey composition of local predators such as eagle owls and mongoose. As a result, archaeological eagle owl or mongoose prey assemblages are good indicators of background ecology, but not of ancient human occupation intensities.

The absence of multimammate rats from predator assemblages from the vicinity of Maasai settlements contrasts with their predominance in predator assemblages from agricultural areas in Africa. A study of a collection of eagle owl pellets from a crop field in the vicinity of agricultural villages in a semi-arid region of Kitui District, central Kenya revealed a frequency of over 40% of multimammate rats (Weissbrod and Braude pers. obs.). Similarly, Granjon and Traoré (2007) found a frequency of nearly 80% multimammate rats in barn owl (*Tyto alba*) pellets from an area of rice cultivation and orchards in the more humid region of the Inner Delta of the Niger River of Mali. It is likely that in such better watered areas with high agricultural potential farming activities and extensive fields affect the prey composition of certain predators. It has been shown, however, through trapping studies that grazing by either domestic livestock or wild ungulates can also significantly affect the abundance of various micromammalian species including multimammate rats in a negative way (Keesing 1998; Yarnell et al. 2007). Whether the absence of multimammate rats from the prey of eagle owls and mongoose in the area of Maasai settlements reflects the high dependence of multimammate rats on settlements due to the dry local environment and low vegetation cover or the effect of grazing pressure outside of settlements cannot be determined based on available data, however.

An important implication of this study for continued investigation of taphonomic pathways of micromammalian assemblages, especially in relation to open-air environments and small-scale seasonal settings such as those of Maasai settlements, is recognition of the need for a focus on modes of accumulation. There is no doubt that identifying contexts where remains of micromammals accumulated in the settlement environment in which they live (*in situ* or autochthonous accumulation; see also Tchernov 1984) will depend on systematic application of fine-recovery techniques in both ethnoarchaeological and archaeological situations. The study of *in situ* assemblages in conjunction with information on the living micromammalian communities of settlements should provide the basis for establishing a specific set of taphonomic criteria for distinguishing such assemblages in the archaeological record. Retrieving such assemblages will also allow more accurate inferences regarding patterns of human occupation. Taphonomic criteria diagnostic of micromammalian settlement community assemblages that formed *in situ* include the context of accumulation and preservation (e.g., houses). The species represented (e.g., species with known association with houses) and the extent of completeness in representation of all parts of the skeleton (e.g., high completeness in relatively undisturbed house contexts) are also important for obtaining taphonomic information on the extent of modification of the skeletal remains during the stage of accumulation (e.g., limited damage in relatively undisturbed house contexts). Representation of individuals from specific age categories (e.g., adult biased assemblages in contexts with high availability of food and shelter such as garbage dumps with organic content, which contribute to survivorship [see Courtney and Fenton 1976]) is also important.

In light of the current dearth of evidence on pathways of accumulation of micromammalian remains in Maasai settlements and in order to consider implications of the Eselenkei Maasai study for research on the Pastoral Neolithic of East Africa I make two fundamental taphonomic assumptions. I assume that remains of micromammals living in seasonal settlements of small-scale subsistence pastoralists such as those of Maasai herders accumulate *in situ* as a result of natural mortality and deposition of individual skeletons within the substrate of the settlements. I also make the assumption that remains of micromammalian species that occur more frequently in settlements and use settlement areas more intensively than other species have a greater chance of accumulating and being preserved into the settlement substrate and consequent archaeological record. Finally, I also attempt to take into account time averaging, or the process through which archaeological assemblages combine remains from multiple stages in the life history of a settlement. It is also important to consider that all settlements regardless of their history go through a final stage of abandonment that may affect the composition of micromammalian assemblages.

10.4 Implications of the Eselenkei Maasai Study for Pastoral Neolithic Sites in East Africa

In this section I examine variability in archaeological micromammalian assemblages from the Pastoral Neolithic period in East Africa and discuss ways in which results from my study can be applied to research on variability in social and economic organization during this period. The available record of recovery of such assemblages is highly fragmentary, however, and this is likely due in large part to limited application of fine-recovery techniques. Systematic screening of sediments has been regularly applied to all sediments in excavations of Pastoral Neolithic sites but typically employs relatively coarse sieves (e.g., 5 mm mesh [e.g., Marean et al. 1994] or 3 mm mesh [e.g., Wandibba 1983]). Table 10.3 presents the available data on occurrence of micromammalian remains in archaeological sites of the Pastoral Neolithic period in the Central Rift Valley of Kenya. The deposits containing the remains all belong to the third millennium bp. They are assigned to different cultural entities that are partly overlapping temporally and derive from sites in widely differing environmental and altitudinal settings and from both open-air and cave or rockshelter sites. According to archaeological interpretations the economic organization of the groups that inhabited the sites or individual temporal horizons also varied widely in the extent of dependence on wild or domesticated resources and in relation to that also in social organization and modes of mobility and settlement occupation as well as in functional variability in settlement use (Ambrose 1984, 2001; Gifford-Gonzalez 1998, 2005; Marshall 1994, 2000).

Table 10.3. Occurrence of micromammalian species in archaeological sites from various cultural entities of the Pastoral Neolithic period in the Central Rift Valley, Kenya.

	Ngenyan (SPN)	Crescent Island Main (SPN)	Prolonged Drift (SPN)	Enkapune Ya Muto Rockshelter (Elmenteitan)	Naivasha Railway Rockshelter (Eburran 5)	Maasai Gorge Rockshelter (Eburran 5)	Enkapune Ya Muto Rockshelter (Eburran 5)	Rigo Cave[b]
Source	Hivernel 1983	Gifford-Gonzalez 1998	Gifford-Gonzalez 1998	Marean et al. 1994	Gifford-Gonzalez 1998	Gifford-Gonzalez 1985	Marean et al. 1994	Wandibba 1983
Genus[a]								
Acomys sp.		1	1					
Aethomys sp.	✓							
Arvicanthis sp.	✓			1	1			
Dasymys sp.								
Mastomys sp.	✓							
Oenomys sp.				3				
Otomys sp.				4	1	1	1	1
Praomys sp.								1
Rattus sp.		1			7			
Saccostomus sp.	✓							
Tatera sp.	✓				1			
Total	-	2	1	8	10	1	1	2

[a] List of genera does not include specialized burrowers or species larger than 300g in adult weight that were also not considered in the trapping study.

[b] Cultural affiliation of the site was not determined by the author who interepreted the material assemblage as representing burial activities.

Although the data in Table 10.3 indicate noteworthy levels of diversity only limited inferences can be drawn from the table. For example, species which we might expect to occur in the context of pastoral settlements in savanna environments such as spiny mice (*Acomys* sp.) and multimammate rats (*Mastomys* sp.) do occur in deposits from sites that are situated in the open savanna plains at the floor of the Rift Valley. They also occur in sites with evidence for substantial dependence on pastoralism and mixed herding and hunting of wild ungulates. The sites of Ngenyan, Crescent Island Main, and Prolonged Drift were occupied by SPN pastoralists (Ambrose 2001). Spiny mice occur at Crescent Island Main and Prolonged Drift and the multimammate rat was identified only at Ngenyan. Crescent Island Main contained substantial quantities of livestock remains (c. 80%) in addition to some remains of wild animals. In contrast, Ngenyan and Prolonged Drift contained considerable quantities of wild animal remains and relatively low proportions of livestock remains. As a result, it has never been clear whether these sites were occupied by hunter-gatherers that also used some domesticated resources or by pastoralists who had lost their herds. The presence of multimammate rats at the SPN site of Ngenyan is interesting given that the site may be considered of moderate size and contained relatively few remains of domestic fauna (Hivernel 1983). Comparisons of micromammalian assemblages from sites with substantial quantities of wild animals and livestock to other sites such as Ngamuriak (Elmenteitan) where livestock constitute nearly 100% of the faunal remains should also be especially revealing.

With more substantial samples of micromammalian remains from Pastoral Neolithic sites it would be interesting to examine for each of the sites whether there is predominance of early colonizers such as spiny mice or of late colonizers such as multimammate rats. Predominance or early colonizers would imply lower levels of occupation and greater degrees of seasonal mobility whereas predominance of late colonizers would imply more permanent occupation and reduced mobility. Such independent evidence on site occupation and mobility would allow archaeologists to test expectations on the precise nature of economic activities at these sites.

Table 10.3 also shows that spiny mice and multimammate rats are absent from the rockshelter and cave sites. These sites are situated close to the escarpment of the Rift Valley or isolated mountains within the valley and are adjacent to more forested environmental zones. Sites or temporal horizons in these settings contain evidence for more substantial dependence on hunting resources and occupation by hunter-gatherer groups of the Eburran phase 5 (Ambrose 2001). In some phases rockshelters were also occupied by small-stock herders with Elmenteitan material assemblages. Among these sites there is some consistency in the occurrence of the genus *Otomys* or groove-toothed rat. This is interesting from a taphonomic perspective because species of this genus are generally specialized herbivores, highly sensitive to disturbances such as noise and degradation of grass through fire or grazing, and solitary or of limited sociability (Kingdon 1974a:562-569). They are also not considered common pests in agricultural regions in Africa. The occurrence of remains of groove-toothed rats in rockshelter and cave sites of the Central Rift Valley may reflect deposition by predators such as owls that could have inhabited the sites and collected the rodents as prey from their native habitats (see Marean et al. 1994).

Economic strategies during the Pastoral Neolithic period ranging from hunting and gathering to specialized pastoralism are expected to have affected the social organization of groups, relations among groups with different economic and social organization, and degrees of mobility and levels of site occupation. Based on a combination of available data on cultural variability in the Pastoral Neolithic and data from this study on the ecological roles of micromammalian species in relation to the environments of seasonal Maasai settlements, a number of expectations can be formulated for patterns of variability in micromammalian assemblages from the Pastoral Neolithic of East Africa. These are summarized in Table 10.4. Archaeologists have developed a range of hypotheses for variability in economic activities in the Pastoral Neolithic. This includes hunting and gathering, specialized pastoralism, combined use of livestock and wild animal resources, and the combination of herding with farming. In order to model expected rodent communites it is useful to relate economic activities to varying levels of site occupation and degrees of mobility, which range from low duration and seasonal intensity of occupation with high degrees of mobility to more permanent occupation and sedentism. Expectations for composition of micromammalian assemblages for the different cultural entities of the Pastoral Neolithic are complicated by the fact that there is some overlap in the range of economic activities that may be associated with the different entities. Thus, the expectations range from hunter-gatherers of the Eburran phase 5 who may have occupied highly ephemeral sites that produced assemblages with predominance of early colonizing species (e.g., spiny mice) and species associated with extended lack of occupation (e.g., narrow-footed woodland mice) to Elmenteitan agro-pastoralists who may have occupied more sedentary sites that produced assemblages with predominance of late colonizing species (e.g., multimammate rats) (summarized in Table 10.4). Establishing the position along this range of mobility of sites with evidence for mixed livestock/wild animal subsistence where economic orientations are less well understood would be of particular interest.

Table 10.4. Expectations regarding relationships among economy, cultural affiliation, and composition and structure of micromammalian assemblages in the Pastoral Neolithic of East Africa.

Mobility	Site occupation level	Economic activities	Eburran	SPN	Elmenteitan
High	**Low** duration & seasonal intensity: a few days to a few weeks, intermitant & widely interspersed	Hunting & gathering	Predominance of early colonizers & abandonment species	Predominance of early colonizers & abandonment species	
Inter-mediate	**Low** duration & **High** seasonal intensity: a few months, repeated for a few years	Hunting & gathering combined with small-scale livestock keeping	Predominance of early colonizers	Predominance of early colonizers	Predominance of early colonizers
Low	**High** duration & seasonal intensity: a few months repeated during each year for > a few years	Pastoralism		Substatial frequencies of early & late colonizers	Substatial frequencies of early & late colonizers
Sedentism	**High** duration & **Year-round**	Agro-pastoralism			Predominance of late colonizers

The relationships among economy, cultural affiliation, and composition and structure of micromammalian assemblages presented in Table 10.4 should be regarded as a set of hypotheses that may be tested through examination of variability among micromammalian assemblages from sites of the Pastoral Neolithic period. Such examination must take into account taphonomic factors including mode of accumulation relating to human occupation of the site *versus* predator-related pathways and depositional environment (open-air *versus* cave settings). Moreover, additional information will be needed on the relationship between the living communities of micromammals in settlement environments and death assemblages that infiltrate into the archaeological record. The results of the Maasai ethnoarchaeological study suggest that predator accumulated assemblages that are typically associated with cave settings will not reflect the ecological impact of settlements except in highly sedentary and possibly agricultural situations.

To fully realize the potential of the new model it will also be necessary to establish the taxonomic identity of species that can potentially fill the various ecological roles in Table 10.4 for each environmental and climatic zone of the central Rift Valley, such as the Rift floor, highland savannahs, or forested escarpments. This can be based in part on available information from the literature on life-history and ecological characteristics of species (e.g., Nabhan et al. 1982; Dean 2005). It stands to reason, however, that additional ethnoarchaeological initiatives of ecological monitoring in settlement environments will also be required. Advances in research on micromammalian assemblages and in establishing frameworks for accurate reconstructions of the composition of species and levels of biological diversity will depend in large measure on application of systematic fine-recovery techniques and retrieval of sufficient samples for quantitative analysis.

10.5 Archaeological Implications of the Demarcation of Contexts of Micromammalian Commensalism and Varying Impacts on Biological Diversity

This study establishes an important distinction among levels of biological diversity and the commensal signal between pastoral contexts of seasonal mobility and sedentary agricultural villages. As a result, I argue that zooarchaeologists should orient analyses towards reconstruction of ancient micromammalian community structure and biological diversity rather than single indicator species. The current practice in southwest Asia and Europe has been to focus on single indicator species such as the house mouse (but see O'Connor 2000, 2003). Moreover, this study suggests that interpretation of levels of site occupation and degrees of mobility from micromammalian faunas should be grounded within the broader understanding of contexts of environmental engineering or niche construction (see Jones et al. 1994, 1997; see also Smith 2007).

In archaeology, the concept of biological diversity has largely been employed to elucidate people's role as active managers of their environments either contributing to or detracting from ecosystem integrity (Stahl 1996; Ford 2000; Fritz 2000). Findings regarding biological diversity have also been used to provide a baseline for management and conservation of current ecosystems (Delcourt and Delcourt 1998; Hayashida 2005). A range of specific case studies have also documented ethnographic or ethnohistorical evidence among small-scale societies for a wide variety of cultural practices that can directly influence the abundance of economically useful animal or plant species. In these cases biological diversity is consciously altered and is either reduced or more often enhanced for the benefit of human use of specific biotic resources (Blackburn and Anderson 1993; Anderson and Moratto 1996; Minnis and Elisens 2000 and papers therein).

The idea that human settlement activities could have indirectly influenced the availability of useful plants was also explored by Anderson (1952: 144). As long ago as the 1950's he suggested that middens with organic refuse (dump heaps) associated with ancient settlements could have facilitated the introduction into the human environment of certain disturbance tolerant plants that were subsequently taken into cultivation. In another example, Linares (1976) showed that house gardens of subsistence cultivators in the lowland tropics of Panama supported higher abundances of a wide variety of small animals than did surrounding less disturbed forests. She argued that these provided a stable food source for more sedentary farmers. The above examples are based on specific engineering mechanisms — formation of dump heaps and cultivation of gardens. They also involve initial indirect ecological effects on biotic communities – increases in abundance and concentration of either plant hybrids or of small animals — as well as eventual feedback effects on human economic fitness. In this study the engineering mechanism that I considered is the overall impact of human site occupation, rather than specific activities that are associated with living in the settlement. I also focused on immediate ecological consequences and the potential for using archaeological micromammalian remains as environmental and ecological proxies for reconstructing aspects of human site occupation in the past.

I used results from the study in Maasai settlements to identify two categorically distinct contexts of micromammalian commensalism and biological diversity and related these to separate systems of settlement occupation that likely are also associated with differing modes of habitat engineering. First, I showed that seasonal settlements of Maasai pastoralists with relatively small and constant human populations contributed positively to the biological diversity of local micromammalian communities and had correspondingly low levels of commensalism. I also argue that the pattern in such seasonal settlements with low human populations is expected to differ fundamentally from agricultural villages where low levels of micromammalian biological diversity and pronounced commensalism can be identified. This finding suggests that year-round occupation produces significantly different micromammalian assemblages than settlements that are used intermittently.

Although the direct contribution to biological diversity of specific aspects of settlement engineering activities were not investigated in this study it can be envisaged that in the first instance activities such as livestock corralling and accumulation of dung are especially important. In agricultural villages storage of agricultural food crops is important for environmental engineering and probably also relatively large scale accumulation of organic refuse.

The Maasai sites also document a range of strategies of mobility, from very short term to significantly longer and more intensive usage. Nevertheless, the micromammalian communities from the longest and most intensively occupied settlement B45, which has been used for 45 years by perhaps a few dozens of inhabitants and had continuous occupation by some of the inhabitants throughout the year – do not approach the reduction in community diversity characterizing these agricultural villages. As a result, the combined data from the Eselenkei study of Maasai seasonal settlements and previous research on sedentary agricultural villages can be taken to support Tchernov's (1991a) model for the development of commensalism in the context of early sedentarization. These findings also support the methodological aspect of the hypothesis and the assertion that high frequencies of commensal animals will indicate significant sedentism (see also Bar-Yosef and Tchernov 1966; Tchernov 1984). The level of commensalism that was documented in agricultural villages may have developed only with the appearance of sedentary agricultural societies, however. The question of what levels of commensalism could have existed in settlements of early complex hunter-gatherers remains open. Information on the ecology of micromammalian communities in diverse contexts is certainly needed in order to establish a comprehensive theoretical framework and set of predictions for biological indicators in varied archaeological circumstances. A major contribution of this study is laying the groundwork parameters for future fieldwork of this kind.

Vast differences in the magnitude as well as nature of settlement occupation and engineering activities can be observed among present day societies. At the low end of the scale we may recognize contemporary groups of hunter-gatherers such as the !Kung occupying semi-arid regions of the Kalahari Desert of South Africa. !Kung short-term camp sites of the wet season documented in the 1960's by Yellen (1977: 54-84) were occupied by only a handful of people for periods of a few days up to a month, were rarely reused, and consisted of ephemeral branch huts that would endure for less than a year, hearths, and shallow clusters of refuse. At the other end of the scale are modern highly urbanized and industrialized cities with permanent and dense human populations that constitute exceedingly heterogeneous, patchy, and complex ecosystems with environments as diverse as remnant forests and parks, entirely built-up areas, and areas with highly polluted substrates (Pickett et al. 2001; Alberti et al. 2005). There has been considerably more research on the ecology of micromammalian communities in environments of industrial cities or towns than in settlements of small-scale societies and none that I am aware of in camps of hunter-gatherers. Studies in highly urbanized environments have focused on the impact of urbanization on local biological diversity or on the consequences of these impacts for disease risks from micromammalian vectors (Dickman 1987; Chernousova 2001, 2002; Baker et al. 2003; Castillo et al. 2003; Mahan and O'Connell 2005; Cavia et al. 2009). Such research has revealed that the impact of urbanization on biological diversity is highly variable and depends on the specific characteristics of different urban environments including the extent of barren ground, degree of patchiness, and intensity of human use and disturbance. Urban areas with high vegetation cover, low patchiness, and little disturbance can sustain relatively high levels of micromammalian biological diversity comparable in some cases to certain surrounding rural habitats (Dickman 1987; Mahan and O'Connell 2005; Cavia et al. 2009). The composition and configuration of frequencies of species can vary greatly along urbanization gradients, however (e.g., Chernousova 2001, 2002).

When considered in light of published data from ecological studies in present day urban centers and small-scale agricultural villages, the data from Maasai settlements can be taken to suggest a non-linear and complex relationship between human societies and micromammalian biological diversity through time. A similar dynamic has been postulated for long-term human/landscape interactions in Mediterranean environments (Naveh 1998; Naveh and Carmel 2004). Naveh (1998) and Naveh and Carmel (2004) have argued that early use of fire by hunters and gatherers and the emergence of agriculture were correlated with distinct stages in the development of the landscape, with varying consequences for biological diversity (Naveh 1998; Naveh and Carmel 2004). In spite of the different spatial scales, I think that the complexity of the relationship and its dependence on engineering activities are interesting parallels between settlement-focused and landscape models.

In terms of broader implications for archaeological research, I believe that the demarcation of varying contexts of micromammalian commensalism and biological diversity will have particular significance for research on long-term developments in mobility and sedentism. Analysis of micromammalian assemblages will also provide an additional source of independent evidence for examining variability within regions where we may expect the development of mosaics of economic and social adaptations following the inception of food production.

In southwest Asia such an approach should entail the comparison of assemblages from sites of complex hunter-gatherers of the Natufian culture with those of preceding less-complex hunter-gatherers, as well as of succeeding agricultural societies in order to gauge more precisely the magnitude and direction of change through time as an alternative to discussions of a series of monolithic developmental stages from mobility to sedentism. A more nuanced approach to the measurement of mobility in archaeology will allow more rigorous evaluation of models for why sedentism developed early in some regions and prior to the emergence of food production (e.g., southwest Asia, North Africa, and Japan) or why the development of food production was associated with increased sedentism in some regions (southwest Asia and Japan) but with increased mobility in others (North Africa). It will also allow archaeologists to examine variability in systems of mobility within regions following the emergence or introduction of food production in these regions and better understanding of continued interactions between hunter-gatherers and food producers and the spread of food production.

CHAPTER 11

SUMMARY AND CONCLUSIONS

In this thesis I present empirical evidence that supports Tchernov’s (1984) hypothesis regarding a theoretical linkage between commensalism and sedentism. These data highlight the utility of remains of commensal rodents as indicators of intensification in site occupation. Data that I collected on the living communities of small rodents and shrews (micromammals) from seasonal settlements of Maasai pastoralists in East Africa revealed the absence of pronounced commensalism and corroborate the hypothesis that manifest commensalism and markedly reduced levels of biological diversity are associated with highly sedentary settlement environments. Maasai seasonal settlements were shown to sustain higher levels of micromammalian biological diversity than surrounding areas. Furthermore, these were not reduced along a gradient of increasing levels of human occupation of seasonal settlements. By contrast, calculations of biological diversity based on data reported for micromammals from agricultural villages in East Africa showed that these micromammalian communities were dominated by a single species and that biological diversity was exceedingly depressed in such permanent settlements.

From a theoretical standpoint I argue that consideration of commensalism in archaeology should be addressed in the broader framework of environmental engineering and that variability in the nature and scale of settlement activities should be taken into account. I use the distinctions in the ecological footprint and biological diversity signal between pastoral settlements and agricultural villages to provide a framework for the demarcation of contexts of commensalism in relation to varying levels of site occupation and associated modes of environmental engineering of settlements. Thus, seasonally occupied Maasai settlements are distinctive in terms of livestock corralling activities, and accumulation of dung, construction and maintenance of dung-and-branch houses, and of branch enclosure fences, ongoing use of surrounding vegetation for grazing and fire wood, and relatively small and stable human populations. These seasonal settlements contrast with agricultural villages with high level of sedentism, dense and growing human populations, and large-scale food storage and accumulation of organic refuse, all of which affect the biological diversity signal. These findings add an additional dimension to recent theoretical discussions of human engineering of habitats and of commensal and mutualistic human-animal interactions and early contexts of domestication (O'Connor 1997; Masseti 2006; Zeder 2006, in press; Smith B.D. 2007).

By providing a direct and independent source of evidence for reconstructing varying levels of site occupation and degrees of mobility analysis of micromammalian assemblages will be a useful tool for archaeologists interested in testing current models of transitions to cultural complexity and food production in different regions of the world. Micromammalian data are especially important for attempts to gauge trajectories of intensification in settlement occupation more precisely. This in turn will improve our understanding of the ways in which change in mobility influenced important social and economic developments.

This study expands the relevance of the commensalism model to a wide range of contexts of mobility including sedentary and mobile settlements. In the case of complex hunter-gatherers of the Natufian culture of southwest Asia, analysis of micromammalian assemblages should be applied to testing theories regarding a shift from early sedentism to increased mobility in the later part of the Natufian and the role of this transformation in the subsequent beginnings of plant domestication and cultivation. In East Africa this tool can be usefully applied to evaluating different theories regarding the spread of food production including the introduction of pastoralism via migration of pastoralists from arid Northern Africa, adoption by local hunter-gatherers, and social and economic interactions among herders and foragers. Archaeologists can utilize micromammalian assemblages to better distinguish degrees of mobility and to discriminate among groups combining both wild and domesticated resources or specializing in hunting and gathering or pastoralism.

Additional directions that I identify for future research on commensalism in archaeology include empirical ethnoarchaeological study of human/animal interactions on different continents in contemporary settlement settings with varying degrees of mobility, levels of occupation, and modes of engineering. Such research will greatly benefit from a combination of ecological, archaeological, and ethnographic approaches. Additional taphonomic investigations should focus especially on elucidating ways that the remains of animals that lived and died in past settlement environments became incorporated into archeological substrates (i.e., *in situ* or autochthonous pathways). Research on micromammalian assemblages from archaeological sites where we expect to find evidence for commensalism should focus on the full spectrum of species and on reconstructing community structure and patterns of biological diversity rather than on single indicator species. Finally, I strongly advocate the routine application of systematic fine-recovery techniques for collection of adequate and quantitatively comparable micromammalian assemblages from archaeological sites. These will form the necessary foundations for research on commensalism.

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Appendix 1. Database of trapping records.

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
1	C	B14	6-Jan	I	2nd	25	F	Aco	6.5	10	-	32	5	27	M	N	-	-	-	-	-	-	-	-
2	C	B14	9-Jan	I	5th	5	F	Aco	-	-	-	37	5	32	-	N	3	-	-	-	-	-	-	-
3	C	B14	9-Jan	I	5th	9	H	Aco	8	9.5	-	27	5	22	F	N	2	-	-	-	-	-	-	-
16	C	B14	7-May	II	7th	8	E	Aco	8	9	-	39	6	33	F	N	-	-	-	-	1	-	-	-
9	C	B14	4-May	II	4th	16	F	Aco	7	8	-	33	5	28	-	N	-	-	-	-	-	-	-	-
11	C	B14	5-May	II	5th	16	F	Aco	8	9	-	35	5	30	F	N	-	-	-	-	-	-	-	-
15	C	B14	7-May	II	7th	4	F	Aco	5	7	-	21	5	16	F	N	-	-	-	-	-	-	-	-
6	C	B14	2-May	II	2nd	5	F	Ele	-	-	-	55	10	45	-	D	-	-	-	-	-	-	-	-
7	C	B14	2-May	II	2nd	19	F	Ele	-	-	-	58	10	48	-	D	-	-	-	-	-	-	-	-
8	R	B14	4-May	II	4th	5	F	Ele	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
14	C	B14	6-May	II	6th	19	F	Ele	-	-	-	55	5	50	-	D	-	-	-	-	-	-	-	-
4	C	B14	1-May	II	1st	5	F	Ele	-	-	-	57	10	47	-	N	-	1	-	-	-	-	-	-
8	C	B14	4-May	II	4th	5	F	Ele	-	-	-	47	5	42	-	N	-	-	-	-	-	-	-	-
12	C	B14	6-May	II	6th	5	F	Ele	-	-	-	48	8	40	-	N	-	-	-	-	-	-	-	-
13	C	B14	6-May	II	6th	25	F	Tera	15	12	3	60	6	54	F	N	-	-	-	-	-	-	-	-
20	R	B14	9-Jul	III	4th	13	E	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
20	R	B14	10-Jul	III	5th	13	E	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
20	R	B14	11-Jul	III	6th	13	E	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
20	R	B14	12-Jul	III	7th	13	E	Aco	-	-	-	-	-	-	-	D	-	-	0	1	-	-	-	-
18	C	B14	6-Jul	III	1st	8	E	Aco	7	9.5	1.5	39	7	32	M	N	-	2	-	-	-	-	-	-
20	C	B14	6-Jul	III	1st	13	E	Aco	7	11	1.6	45	7	38	F	N	-	2	-	-	-	-	-	-
18	R	B14	7-Jul	III	2nd	8	E	Aco	-	-	-	38	7	31	-	N	-	3	0	1	-	-	-	-
18	R	B14	8-Jul	III	3rd	8	E	Aco	-	-	-	-	-	-	-	N	-	1	0	1	-	-	-	-
18	R	B14	9-Jul	III	4th	8	E	Aco	-	-	-	39	9	30	-	N	-	-	0	1	-	-	-	-
20	R	B14	9-Jul	III	4th	13	E	Aco	-	-	-	42	7	35	-	N	-	-	0	1	-	-	-	-
20	R	B14	10-Jul	III	5th	13	E	Aco	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
20	R	B14	11-Jul	III	6th	13	E	Aco	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
19	C	B14	6-Jul	III	1st	11	F	Aco	6	9.5	1.5	38	7	31	M	N	-	2	-	-	-	-	-	-
20	R	B14	8-Jul	III	3rd	13	F	Aco	-	-	-	43	7	36	-	N	-	1	0	2	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
21	R	B14	9-Jul	III	4th	15	F	Aco	-	-	-	-	-	-	-	N	-	-	30	2	-	-	-	-
21	R	B14	11-Jul	III	6th	16	F	Aco	-	-	-	-	-	-	-	N	-	-	20	1	-	-	-	-
19	R	B14	11-Jul	III	6th	19	F	Aco	-	-	-	-	-	-	-	N	-	-	16	2	-	-	-	-
19	R	B14	12-Jul	III	7th	11	F	Aco	-	-	-	-	-	-	-	N	-	-	38	1	-	-	-	-
21	R	B14	6-Jul	III	1st	23	H	Aco	-	-	-	27	7	20	-	D	-	2	0	0	-	-	-	-
21	C	B14	6-Jul	III	1st	23	H	Aco	6	7.5	1.5	26	7	19	F	N	-	2	-	-	-	-	1	-
23	C	B14	7-Jul	III	2nd	7	H	Aco	6	8.5	1.6	36	7	29	M	N	-	3	-	-	-	-	-	-
21	R	B14	7-Jul	III	2nd	23	H	Aco	-	-	-	-	-	-	-	N	-	3	0	0	-	-	-	-
19	R	B14	9-Jul	III	4th	23	H	Aco	-	-	-	38	7	31	-	N	-	-	26	3	-	-	-	-
21	R	B14	10-Jul	III	5th	23	H	Aco	-	-	-	-	-	-	-	N	-	-	30	1	-	-	-	-
25	C	B14	12-Jul	III	7th	23	H	Aco	7	9	1.6	36	7	29	M	N	-	-	-	-	-	-	-	1
17	R	B14	7-Jul	III	2nd	19	F	Ele	-	-	-	-	-	-	-	N	-	3	0	0	-	-	-	-
22	C	B14	6-Jul	III	1st	15	F	Ele	9	11	3.2	57	9	48	M	D	2	2	-	-	-	-	-	-
17	R	B14	6-Jul	III	1st	19	F	Ele	-	-	-	68	7	61	-	D	-	2	30	0	-	-	-	-
17	R	B14	7-Jul	III	2nd	19	F	Ele	-	-	-	-	-	-	-	D	-	3	0	0	-	-	-	-
24	C	B14	8-Jul	III	3rd	2	F	Ele	9	11.5	3.2	55	11	44	F	D	-	1	-	-	-	-	-	-
17	R	B14	8-Jul	III	3rd	19	F	Ele	-	-	-	-	-	-	-	D	-	1	20	0	-	-	-	-
17	R	B14	10-Jul	III	5th	20	F	Ele	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
22	R	B14	10-Jul	III	5th	24	F	Ele	-	-	-	-	-	-	-	D	-	-	36	4	-	-	-	-
17	C	B14	6-Jul	III	1st	5	F	Ele	10	12	3.3	69	9	60	F	N	1	2	-	-	-	-	-	-
17	R	B14	8-Jul	III	3rd	15	F	Ele	-	-	-	-	-	-	-	N	-	1	20	0	-	-	-	-
24	R	B14	9-Jul	III	4th	2	F	Ele	-	-	-	51	9	42	-	N	-	-	0	0	-	-	-	-
17	R	B14	9-Jul	III	4th	3	F	Ele	-	-	-	-	-	-	-	N	-	-	40	0	-	-	-	-
17	R	B14	10-Jul	III	5th	20	F	Ele	-	-	-	-	-	-	-	N	-	-	40	1	-	-	-	-
17	R	B14	11-Jul	III	6th	20	F	Ele	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
17	R	B14	12-Jul	III	7th	20	F	Ele	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
26	R	B14	9-Sep	IV	6th	2	F	Aco	-	-	-	33	9	24	-	D	-	-	0	0	-	-	-	-
26	R	B14	6-Sep	IV	3rd	1	F	Aco	-	-	-	32	7	25	-	N	-	1	10	1	-	-	-	-
26	R	B14	7-Sep	IV	4th	1	F	Aco	-	-	-	32	7	25	-	N	-	1	10	0	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
26	R	B14	9-Sep	IV	6th	2	F	Aco	-	-	-	33	9	24	-	N	-	-	14	1	-	-	-	-
32	C	B14	9-Sep	IV	6th	24	F	Aco	6	8	1.4	30	9	21	F	N	-	-	-	-	-	-	-	-
33	C	B14	10-Sep	IV	7th	11	F	Aco	7	9.5	1.5	41	10	31	F	N	-	-	-	-	-	-	-	-
34	C	B14	10-Sep	IV	7th	19	F	Aco	3	9.5	1.5	35	7	28	F	N	-	-	-	-	-	-	-	-
26	R	B14	6-Sep	IV	3rd	6	H	Aco	-	-	-	35	9	26	-	D	-	1	10	0	-	-	-	-
26	R	B14	7-Sep	IV	4th	6	H	Aco	-	-	-	33	8	25	-	D	-	1	10	0	-	-	-	-
26	C	B14	4-Sep	IV	1st	6	H	Aco	7.5	8.5	1.7	34	7	27	M	N	1	2	-	-	-	-	-	-
26	R	B14	5-Sep	IV	2nd	6	H	Aco	-	-	-	33	7	26	-	N	-	-	0	1	-	-	-	-
26	R	B14	8-Sep	IV	5th	6	H	Aco	-	-	-	32	7	25	-	N	-	-	0	0	-	-	-	-
26	R	B14	10-Sep	IV	7th	6	H	Aco	-	-	-	31	7	24	-	N	-	-	14	0	-	-	-	-
27	C	B14	4-Sep	IV	1st	2	F	Ele	11	12	3.3	69	10	59	F	D	-	2	-	-	-	-	-	-
27	R	B14	5-Sep	IV	2nd	2	F	Ele	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
27	R	B14	5-Sep	IV	2nd	2	F	Ele	-	-	-	64	7	57	-	N	-	-	0	0	-	-	-	-
29	C	B14	7-Sep	IV	4th	21	F	Ele	9.5	11	3.1	53	10	43	M	N	2	1	-	-	-	-	-	-
31	C	B14	9-Sep	IV	6th	11	F	Gra	11	7	1.8	19	7	12	F	N	5	-	-	-	-	-	1	-
31	R	B14	10-Sep	IV	7th	21	F	Gra	-	-	-	20	7	13	-	N	7	-	20	1	-	-	-	-
30	C	B14	8-Sep	IV	5th	23	H	Mas	9	9	2.2	34	7	27	M	N	3	-	-	-	-	-	1	-
30	R	B14	9-Sep	IV	6th	23	H	Mas	-	-	-	34	7	27	-	N	6	-	0	1	-	-	-	-
35	C	B2	12-Jan	I	1st	12	E	Aco	8	9	-	34	5	29	F	N	-	1	-	-	-	-	-	-
37	C	B2	13-Jan	I	2nd	18	E	Aco	7	10	-	35	7	28	M	N	5	3	-	-	-	-	-	-
39	C	B2	14-Jan	I	3rd	9	E	Aco	7	8	-	22	5	17	F	N	6	4	-	-	-	-	1	-
40	C	B2	14-Jan	I	3rd	19	E	Aco	7	8	-	32	5	27	-	N	-	4	-	-	-	-	-	-
44	R	B2	16-Jan	I	5th	16	E	Aco	-	-	-	-	-	-	-	N	-	-	14	1	-	-	-	-
48	C	B2	16-Jan	I	5th	14	E	Aco	7	8	-	23	5	18	F	N	-	-	-	-	-	-	-	-
49	C	B2	16-Jan	I	5th	18	E	Aco	8	10	-	32	5	27	M	N	-	-	-	-	-	-	-	-
51	C	B2	17-Jan	I	6th	6	E	Aco	7	9	-	30	6	24	M	N	-	1	-	-	-	-	-	-
48	R	B2	17-Jan	I	6th	19	E	Aco	-	-	-	-	-	-	-	N	-	1	6	1	-	-	-	-
38	C	B2	13-Jan	I	2nd	22	F	Aco	8	9	-	34	6	28	F	N	-	3	-	-	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
44	C	B2	15-Jan	I	4th	23	F	Aco	7	10	-	33	5	28	F	N	-	15	-	-	-	-	-	-
53	C	B2	17-Jan	I	6th	20	F	Aco	8	9	-	28	5	23	F	N	-	1	-	-	-	-	-	-
54	C	B2	17-Jan	I	6th	22	F	Aco	6	8	-	32	5	27	M	N	-	1	-	-	-	-	-	-
47	C	B2	16-Jan	I	5th	5	H	Aco	8	9	-	28	5	23	F	N	8	-	-	-	-	-	-	-
47	R	B2	17-Jan	I	6th	15	H	Aco	-	-	-	-	-	-	-	N	-	1	20	1	-	-	-	-
36	C	B2	13-Jan	I	2nd	6	E	Ele	11	12	-	53	5	48		N	4	3	-	-	-	-	-	-
43	C	B2	14-Jan	I	3rd	21	F	Ele	11	12	-	66	8	58	-	D	-	4	-	-	-	-	-	-
52	C	B2	17-Jan	I	6th	14	E	Mas	10	9	-	34	5	29	F	N	1-	1	-	-	-	-	-	-
56	C	B2	14-May	II	1st	19	E	Aco	7	10	1.7	36	5	31	M	N	-	1	-	-	-	-	-	-
57	C	B2	14-May	II	1st	22	F	Aco	8	10	1.6	36	6	30	M	N	-	1	-	-	-	-	-	-
58	C	B2	15-May	II	2nd	20	F	Aco	7	10	1.5	36	5	31	M	N	-	3	-	-	-	-	-	-
59	C	B2	15-May	II	2nd	21	F	Aco	7	9	1.6	41	5	36	F	N	-	3	-	-	-	-	-	-
56	R	B2	16-May	II	3rd	21	F	Aco	-	-	-	-	-	-	-	N	-	-	34	2	-	-	-	-
56	R	B2	17-May	II	4th	20	F	Aco	-	-	-	-	-	-	-	N	-	-	46	1	-	-	-	-
66	C	B2	19-May	II	6th	21	F	Aco	7	10	1.6	36	5	31	F	N	-	-	-	-	-	-	-	-
66	R	B2	20-May	II	7th	21	F	Aco	-	-	-	-	-	-	-	N	-	1	0	1	-	-	-	-
61	C	B2	17-May	II	4th	15	H	Aco	6	9	1.5	28	5	23	F	N	-	-	-	-	-	-	1	-
71	C	B2	14-Jul	III	1st	21	F	Aco	6.5	9	1.6	36	8	28	M	N	-	1	-	-	-	-	-	-
82	C	B2	16-Jul	III	3rd	10	F	Aco	7.5	10	1.6	40	7	33	M	N	-	1	-	-	-	-	-	-
71	R	B2	16-Jul	III	3rd	24	F	Aco	-	-	-	33	7	26	-	N	-	1	26	2	-	-	-	-
82	R	B2	17-Jul	III	4th	24	F	Aco	-	-	-	38	7	31	-	N	-	1	38	1	-	-	-	-
71	R	B2	17-Jul	III	4th	21	F	Aco	-	-	-	34	7	27	-	N	-	1	26	1	-	-	-	-
82	R	B2	18-Jul	III	5th	10	F	Aco	-	-	-	-	-	-	-	N	-	3	38	1	-	-	-	-
95	C	B2	18-Jul	III	5th	21	F	Aco	4	8	1.4	26	10	16	M	N	-	3	-	-	-	-	-	-
71	R	B2	19-Jul	III	6th	21	F	Aco	-	-	-	-	-	-	-	N	-	2	0	2	-	-	-	-
99	C	B2	19-Jul	III	6th	15	H	Aco	6	9	1.5	36	7	29	F	N	-	2	-	-	1	-	-	-
72	R	B2	17-Jul	III	4th	4	E	Croc	-	-	-	-	-	-	-	N	-	1	30	3	-	-	-	-
92	C	B2	18-Jul	III	5th	4	E	Croc	5	6	1.3	15	10	5	-	N	-	3	-	-	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
72	C	B2	14-Jul	III	1st	15	H	Croc	5	7	1.3	21	13	8	M	D	-	-	-	-	-	-	-	-
73	C	B2	14-Jul	III	1st	12	E	Ele	6.5	8	2.6	23	7	16	M	D	-	-	-	-	-	1	-	-
93	R	B2	18-Jul	III	5th	14	E	Ele	-	-	-	62	10	52	-	D	-	-	0	0	-	-	-	-
93	C	B2	18-Jul	III	5th	14	E	Ele	10	11	3.2	65	10	55	M	N	-	3	-	-	-	-	-	-
100	C	B2	19-Jul	III	6th	10	F	Ele	9.5	12	3.2	62	11	51	M	D	-	-	-	-	-	-	-	-
101	C	B2	20-Jul	III	7th	10	F	Ele	10	12	3.3	78	8	70	F	D	-	-	-	-	1	-	-	-
105	C	B2	11-Sep	IV	1st	13	E	Aco	6.5	8	1.6	33	7	26	M	N	-	-	-	-	-	-	-	-
106	C	B2	11-Sep	IV	1st	16	E	Aco	7	9.5	1.5	34	7	27	M	N	-	-	-	-	-	-	-	-
106	R	B2	12-Sep	IV	2nd	12	E	Aco	-	-	-	34	7	27	-	N	-	-	12	1	-	-	-	-
105	R	B2	13-Sep	IV	3rd	14	E	Aco	-	-	-	31	7	24	-	N	-	-	14	2	-	-	-	-
106	R	B2	13-Sep	IV	3rd	18	E	Aco	-	-	-	33	7	26	-	N	-	-	12	1	-	-	-	-
105	R	B2	14-Sep	IV	4th	14	E	Aco	-	-	-	31	7	24	-	N	-	-	0	1	-	-	-	-
106	R	B2	14-Sep	IV	4th	18	E	Aco	-	-	-	33	8	25	-	N	-	-	0	1	-	-	-	-
105	R	B2	15-Sep	IV	5th	13	E	Aco	-	-	-	29	7	22	-	N	-	1	14	1	-	-	-	-
106	R	B2	15-Sep	IV	5th	14	E	Aco	-	-	-	32	7	25	-	N	-	1	14	1	-	-	-	-
106	R	B2	16-Sep	IV	6th	12	E	Aco	-	-	-	32	7	25	-	N	-	-	20	1	-	-	-	-
105	R	B2	16-Sep	IV	6th	19	E	Aco	-	-	-	30	9	21	-	N	-	-	12	1	-	-	-	-
105	R	B2	17-Sep	IV	7th	12	E	Aco	-	-	-	29	7	22	-	N	-	-	16	1	-	-	-	-
106	R	B2	17-Sep	IV	7th	19	E	Aco	-	-	-	32	8	24	-	N	-	-	?	1	-	-	-	-
108	C	B2	11-Sep	IV	1st	22	F	Aco	4.5	8	1.4	25	8	17	M	N	-	-	-	-	-	-	-	-
109	C	B2	11-Sep	IV	1st	24	F	Aco	7.5	10	1.6	39	8	31	M	N	1-	-	-	-	-	-	-	-
115	C	B2	12-Sep	IV	2nd	10	F	Aco	-	10	1.5	42	8	34	F	N	-	-	-	-	-	-	-	-
108	R	B2	12-Sep	IV	2nd	22	F	Aco	-	-	-	24	8	16	-	N	-	-	-	-	-	-	-	-
115	R	B2	13-Sep	IV	3rd	10	F	Aco	-	-	-	41	8	33	-	N	14	-	0	1	-	-	-	-
108	R	B2	13-Sep	IV	3rd	21	F	Aco	-	-	-	23	8	15	-	N	-	-	8	1	-	-	-	-
109	R	B2	13-Sep	IV	3rd	22	F	Aco	-	-	-	41	9	32	-	N	-	-	18	2	-	-	-	-
115	R	B2	14-Sep	IV	4th	10	F	Aco	-	-	-	39	7	32	-	N	-	-	0	2	-	-	-	-
109	R	B2	15-Sep	IV	5th	21	F	Aco	-	-	-	38	7	31	-	N	-	1	8	2	-	-	-	-

Individual ID	Capture/Recatpure	Site^{a}	Date	Session	Day in session	Trap no.	Trap context^{b}	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^{c}	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
108	R	B2	16-Sep	IV	6th	21	F	Aco	-	-	-	23	8	15	-	N	-	-	-	-	-	-	-	-
122	C	B2	17-Sep	IV	7th	10	F	Aco	6	7.5	1.5	26	7	19	M	N	-	-	-	-	-	-	-	-
108	R	B2	17-Sep	IV	7th	21	F	Aco	-	-	-	21	7	14	-	N	-	-	0	1	-	-	-	-
116	R	B2	13-Sep	IV	3rd	24	F	Ele	-	-	-	62	12	50	-	D	-	-	0	1	-	-	-	-
116	R	B2	14-Sep	IV	4th	24	F	Ele	-	-	-	64	13	51	-	D	-	-	0	0	-	-	-	-
116	R	B2	15-Sep	IV	5th	24	F	Ele	-	-	-	61	8	53	-	D	-	1	0	0	-	-	-	-
116	C	B2	12-Sep	IV	2nd	24	F	Ele	11	10.5	3.2	62	10	52	F	N	-	-	-	-	-	-	-	-
116	R	B2	14-Sep	IV	4th	24	F	Ele	-	-	-	62	7	55	-	N	-	-	0	0	-	-	-	-
116	R	B2	15-Sep	IV	5th	24	F	Ele	-	-	-	62	10	52	-	N	-	1	0	0	-	-	-	-
119	C	B2	16-Sep	IV	6th	10	F	Ele	12	11.5	3.3	56	8	48	F	N	-	-	-	-	-	-	-	-
107	C	B2	11-Sep	IV	1st	21	F	Tera	17	13.5	3.7	85	8	77	M	N	9	-	-	-	-	-	-	-
209	R	B21	24-Jan	I	5th	8	E	Aco	-	-	-	-	-	-	-	N	-	-	42	3	-	-	-	-
209	R	B21	25-Jan	I	6th	8	E	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
209	C	B21	21-Jan	I	2nd	25	F	Aco	8	10	-	35	5	30	M	N	-	-	-	-	-	-	-	-
210	C	B21	24-Jan	I	5th	3	F	Aco	8	9	-	30	5	25	F	N	-	-	-	-	-	-	-	-
211	C	B21	25-Jan	I	6th	3	F	Aco	8	9	-	36	5	31	F	N	-	-	-	-	1	-	-	1
212	C	B21	26-May	II	4th	19	E	Croc	4.5	8	1.2	24	5	19	-	N	-	-	-	-	-	-	-	-
214	R	B21	28-Jul	III	6th	19	E	Aco	-	-	-	-	-	-	-	D	-	3	0	0	-	-	-	-
214	C	B21	23-Jul	III	1st	24	E	Aco	4	9	1.4	29	7	22	M	N	-	1	-	-	-	-	-	-
217	C	B21	24-Jul	III	2nd	19	E	Aco	3.5	9	1.3	27	8	19	M	N	-	-	-	-	-	-	-	-
217	R	B21	26-Jul	III	4th	13	E	Aco	-	-	-	27	7	20	-	N	-	-	16	2	-	-	-	-
214	R	B21	27-Jul	III	5th	13	E	Aco	-	-	-	-	-	-	-	N	-	-	24	4	-	-	-	-
214	R	B21	28-Jul	III	6th	19	E	Aco	-	-	-	28	8	20	-	N	-	-	16	1	-	-	-	-
214	R	B21	29-Jul	III	7th	19	E	Aco	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
218	R	B21	24-Jul	III	2nd	7	H	Aco	-	-	-	18	7	11	-	D	-	1	0	0	-	-	-	-
218	C	B21	24-Jul	III	2nd	7	H	Aco	4.5	6	1.4	19	8	11	M	N	-	-	-	-	-	-	-	-
218	R	B21	25-Jul	III	3rd	7	H	Aco	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
218	R	B21	26-Jul	III	4th	7	H	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
216	C	B21	23-Jul	III	1st	14	E	Ele	10	13	3.3	61	9	52	F	D	-	2	-	-	-	-	-	-
215	C	B21	23-Jul	III	1st	21	F	Ele	10	13	3.2	71	11	60	F	D	-	2	-	-	-	-	-	-
223	C	B21	29-Jul	III	7th	21	F	Ele	11	13	3.2	70	11	59	M	D	-	-	-	-	-	-	-	-
222	C	B21	28-Jul	III	6th	9	E	Mas	12	12	2.6	70	15	55	M	N	5	-	-	-	-	-	-	-
233	C	B21	25-Sep	IV	6th	21	F	Aco	5	9	1.5	35	7	28	M	N	-	-	-	-	-	-	-	-
225	C	B21	20-Sep	IV	1st	11	H	Aco	-	9	1.5	41	10	31	F	N	-	1	-	-	1	-	-	-
225	R	B21	22-Sep	IV	3rd	11	H	Aco	-	-	-	41	9	32	-	N	-	-	0	2	-	-	-	-
225	R	B21	25-Sep	IV	6th	11	H	Aco	-	-	-	42	9	33	-	N	-	-	0	3	-	-	-	-
225	R	B21	26-Sep	IV	7th	11	H	Aco	-	-	-	41	8	33	-	N	-	-	0	1	-	-	-	-
231	R	B21	22-Sep	IV	3rd	24	E	Ele	-	-	-	59	9	50	-	D	-	1	0	0	-	-	-	-
231	R	B21	24-Sep	IV	5th	24	E	Ele	-	-	-	64	9	55	-	D	19	1	0	2	-	-	-	-
231	R	B21	25-Sep	IV	6th	24	E	Ele	-	-	-	66	9	57	-	D	-	1	0	1	-	-	-	-
231	C	B21	21-Sep	IV	2nd	24	E	Ele	10	12	3.3	66	9	57	F	N	-	-	-	-	-	-	-	-
231	R	B21	22-Sep	IV	3rd	24	E	Ele	-	-	-	60	9	51	-	N	-	-	0	0	-	-	-	-
228	C	B21	21-Sep	IV	2nd	5	F	Ele	9.5	12	3.1	60	11	49	M	N	18	-	-	-	-	-	-	-
229	C	B21	21-Sep	IV	2nd	16	E	Mas	8.5	9	2.1	31	9	22	M	N	-	-	-	-	-	-	-	-
229	R	B21	25-Sep	IV	6th	13	E	Mas	-	-	-	29	7	22	-	N	2-	-	30	4	-	-	-	-
229	R	B21	26-Sep	IV	7th	13	E	Mas	-	-	-	31	8	23	-	N	-	-	-	-	-	-	-	-
226	C	B21	20-Sep	IV	1st	21	F	Mas	8	8	2.2	32	9	23	M	N	-	1	-	-	-	-	-	-
230	C	B21	21-Sep	IV	2nd	21	F	Mas	11	10	2.4	43	9	34	M	N	-	-	-	-	-	-	-	-
267	R	B43	11-Feb	I	3rd	13	E	Aco	-	-	-	-	-	-	-	N	-	-	22	1	-	-	-	-
267	R	B43	12-Feb	I	4th	15	E	Aco	-	-	-	-	-	-	-	N	-	-	8	1	-	-	-	-
271	R	B43	13-Feb	I	5th	15	E	Aco	-	-	-	-	-	-	-	N	-	-	18	1	-	-	-	-
267	R	B43	10-Feb	I	2nd	3	F	Aco	-	-	-	-	-	-	-	N	-	-	6	1	-	-	-	-
272	C	B43	10-Feb	I	2nd	9	F	Aco	8	9	-	34	4	30	M	N	-	-	-	-	-	-	-	-
271	R	B43	11-Feb	I	3rd	9	F	Aco	-	-	-	-	-	-	-	N	-	-	38	1	-	-	-	-
272	R	B43	12-Feb	I	4th	3	F	Aco	-	-	-	-	-	-	-	N	-	-	26	2	-	-	-	1
271	R	B43	12-Feb	I	4th	9	F	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
267	C	B43	9-Feb	I	1st	2	H	Aco	7	10	-	32	4	28	F	N	-	-	-	-	-	-	-	-
271	C	B43	10-Feb	I	2nd	6	H	Aco	6.5	9	-	34	5	29	M	N	-	-	-	-	-	-	-	-
268	C	B43	9-Feb	I	1st	12	E	Ger	11	8	-	24	5	19	F	N	17	-	-	-	-	-	-	-
268	R	B43	10-Feb	I	2nd	12	E	Ger	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
269	C	B43	9-Feb	I	1st	16	F	Ger	11	8.5	2.3	22	5	17	F	N	18	-	-	-	-	-	-	-
270	C	B43	9-Feb	I	1st	22	F	Ger	11	8	2	25	5	20	F	N	19	-	-	-	-	-	-	-
270	R	B43	10-Feb	I	2nd	22	F	Ger	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
275	C	B43	11-Feb	I	3rd	1	F	Ger	11	8	2	24	5	19	F	N	-	-	-	-	-	-	-	-
276	C	B43	11-Feb	I	3rd	16	F	Ger	9	8	2	23	6	17	F	N	-	-	-	-	-	-	-	-
269	R	B43	11-Feb	I	3rd	21	F	Ger	-	-	-	-	-	-	-	N	-	-	12	1	-	-	-	-
277	C	B43	11-Feb	I	3rd	22	F	Ger	11	8	2	24	6	18	F	N	-	-	-	-	-	-	-	-
278	C	B43	11-Feb	I	3rd	25	F	Ger	11	8.5	2	23	5	18	F	N	-	-	-	-	-	-	-	-
275	R	B43	12-Feb	I	4th	1	F	Ger	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
277	R	B43	12-Feb	I	4th	22	F	Ger	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
275	R	B43	13-Feb	I	5th	1	F	Ger	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
283	C	B43	13-Feb	I	5th	4	F	Ger	11	8	2	22	5	17	M	N	-	-	-	-	-	-	-	-
278	R	B43	13-Feb	I	5th	5	F	Ger	-	-	-	-	-	-	-	N	-	-	36	2	-	-	-	-
276	R	B43	13-Feb	I	5th	21	F	Ger	-	-	-	-	-	-	-	N	-	-	8	2	-	-	-	-
284	C	B43	13-Feb	I	5th	22	F	Ger	11	8	2	22	6	16	F	N	-	-	-	-	-	-	-	-
269	R	B43	10-Feb	I	2nd	11	H	Ger	-	-	-	-	-	-	-	N	-	-	6	1	-	-	-	-
286	R	B43	19-Jun	II	3rd	7	E	Aco	-	-	-	-	-	-	-	N	-	-	10	0	-	-	-	-
286	R	B43	21-Jun	II	5th	13	E	Aco	-	-	-	-	-	-	-	N	-	-	14	0	-	-	-	-
286	C	B43	17-Jun	II	1st	1	F	Aco	6	10	1.6	38	7	31	F	N	-	-	-	-	1	-	-	-
289	C	B43	17-Jun	II	1st	19	F	Aco	7	9	1.4	34	7	27	M	N	-	-	-	-	-	-	-	-
290	C	B43	17-Jun	II	1st	20	F	Aco	7	9	1.5	34	7	27	F	N	-	-	-	-	-	-	-	-
291	C	B43	17-Jun	II	1st	21	F	Aco	5	8	1.4	27	7	20	F	N	-	-	-	-	-	-	-	-
289	R	B43	18-Jun	II	2nd	16	F	Aco	-	-	-	33	7	26	-	N	-	-	28	1	-	-	-	-
290	R	B43	18-Jun	II	2nd	23	F	Aco	-	-	-	34	8	26	-	N	-	-	16	1	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
289	R	B43	19-Jun	II	3rd	16	F	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
290	R	B43	19-Jun	II	3rd	20	F	Aco	-	-	-	-	-	-	-	N	-	-	16	1	-	-	-	-
291	R	B43	19-Jun	II	3rd	25	F	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
289	R	B43	20-Jun	II	4th	3	F	Aco	-	-	-	-	-	-	-	N	-	-	28	1	-	-	-	-
290	R	B43	20-Jun	II	4th	19	F	Aco	-	-	-	-	-	-	-	N	-	-	6	1	-	-	-	-
300	R	B43	20-Jun	II	4th	20	F	Aco	-	-	-	-	-	-	-	N	-	-	30	1	-	-	-	-
291	R	B43	20-Jun	II	4th	25	F	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
300	R	B43	21-Jun	II	5th	24	F	Aco	-	-	-	-	-	-	-	N	-	-	10	1	-	-	-	-
291	R	B43	21-Jun	II	5th	25	F	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
286	R	B43	18-Jun	II	2nd	2	H	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
286	R	B43	20-Jun	II	4th	11	H	Aco	-	-	-	-	-	-	-	D	-	-	6	0	-	-	-	-
289	R	B43	20-Jun	II	4th	2	H	Aco	-	-	-	-	-	-	-	D	-	-	6	0	-	-	-	-
286	R	B43	18-Jun	II	2nd	2	H	Aco	-	-	-	36	7	29	-	N	-	-	8	1	-	-	-	-
300	C	B43	19-Jun	II	3rd	11	H	Aco	7	10	1.5	37	7	30	M	N	-	-	-	-	-	-	-	-
286	R	B43	20-Jun	II	4th	11	H	Aco	-	-	-	-	-	-	-	N	-	-	12	1	-	-	-	-
289	R	B43	21-Jun	II	5th	2	H	Aco	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
290	R	B43	21-Jun	II	5th	11	H	Aco	-	-	-	-	-	-	-	N	-	-	28	1	-	-	-	-
295	C	B43	18-Jun	II	2nd	12	E	Croc	3	5	0.9	10	7	3	F	N	13	-	-	-	-	-	-	-
301	C	B43	19-Jun	II	3rd	13	E	Croc	3	5	1	11	8	3	F	N	-	-	-	-	-	-	-	-
297	C	B43	19-Jun	II	3rd	21	F	Croc	3.5	5	1	9	7	2	F	N	-	-	-	-	-	-	-	-
309	C	B43	20-Jun	II	4th	24	F	Croc	3	6	0.9	13	9	4	F	N	-	-	-	-	-	-	-	-
288	C	B43	17-Jun	II	1st	13	E	Ger	11	8	2	27	7	20	M	N	-	-	-	-	-	-	-	-
287	C	B43	17-Jun	II	1st	5	F	Ger	9	7	2.1	21	7	14	M	N	-	-	-	-	-	-	-	-
294	C	B43	18-Jun	II	2nd	3	F	Ger	9	8	2	23	7	16	F	N	-	-	-	-	-	-	1	-
287	R	B43	18-Jun	II	2nd	4	F	Ger	-	-	-	22	8	14	-	N	-	-	12	1	-	-	-	-
298	C	B43	19-Jun	II	3rd	4	F	Ger	10	8	2	20	7	13	M	N	-	-	-	-	-	-	-	-
287	R	B43	19-Jun	II	3rd	5	F	Ger	-	-	-	20	7	13	-	N	-	-	12	1	-	-	-	-
299	C	B43	19-Jun	II	3rd	9	F	Ger	10	8	2	29	7	22	F	N	-	-	-	-	1	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
307	C	B43	20-Jun	II	4th	5	F	Ger	9	8	1.9	27	7	20	F	N	-	-	-	-	-	-	-	-
308	C	B43	20-Jun	II	4th	23	F	Ger	8	7.5	2.3	20	7	13	M	N	-	-	-	-	-	-	-	-
310	C	B43	20-Jun	II	4th	9	F	Ger	11	8	2.2	26	8	18	F	N	-	-	-	-	-	-	-	-
313	C	B43	21-Jun	II	5th	9	F	Ger	10	8	2	26	7	19	F	N	-	-	-	-	-	-	-	-
316	C	B43	15-Aug	III	1st	7	E	Aco	6.5	10	1.5	45	7	38	F	N	-	-	-	-	-	-	-	-
319	C	B43	15-Aug	III	1st	14	E	Aco	7	10	1.5	36	7	29	M	N	-	-	-	-	-	-	-	-
316	R	B43	16-Aug	III	2nd	12	E	Aco	-	-	-	48	7	41	-	N	11	-	5	0	-	-	-	-
318	R	B43	17-Aug	III	3rd	18	E	Aco	-	-	-	41	7	34	-	N	-	-	14	1	-	-	-	-
316	R	B43	18-Aug	III	4th	16	F	Aco	-	-	-	34	7	27	-	D	-	-	0	0	-	-	-	-
317	R	B43	18-Aug	III	4th	19	F	Aco	-	-	-	32	7	25	-	D	-	-	28	0	-	-	-	-
314	C	B43	15-Aug	III	1st	4	F	Aco	6	8	1.6	28	7	21	M	N	-	-	-	-	-	-	-	-
317	C	B43	15-Aug	III	1st	10	F	Aco	7	9	1.5	34	7	27	M	N	-	-	-	-	-	-	-	-
314	R	B43	16-Aug	III	2nd	1	F	Aco	-	-	-	28	7	21	-	N	-	-	22	1	-	-	-	-
314	R	B43	17-Aug	III	3rd	4	F	Aco	-	-	-	28	8	20	-	N	-	-	22	1	-	-	-	-
317	R	B43	17-Aug	III	3rd	10	F	Aco	-	-	-	34	8	26	-	N	-	-	0	2	-	-	-	-
319	R	B43	17-Aug	III	3rd	16	F	Aco	-	-	-	37	7	30	-	N	-	-	18	2	-	-	-	-
314	R	B43	18-Aug	III	4th	1	F	Aco	-	-	-	28	7	21	-	N	-	-	22	1	-	-	-	-
316	R	B43	18-Aug	III	4th	16	F	Aco	-	-	-	34	7	27	-	N	-	-	6	1	-	-	-	-
318	R	B43	18-Aug	III	4th	19	F	Aco	-	-	-	40	8	32	-	N	-	-	14	1	-	-	-	-
319	R	B43	18-Aug	III	4th	21	F	Aco	-	-	-	36	8	28	-	N	-	-	12	0	-	-	-	-
314	R	B43	19-Aug	III	5th	1	F	Aco	-	-	-	27	7	20	-	N	-	-	0	1	-	-	-	-
318	R	B43	19-Aug	III	5th	24	F	Aco	-	-	-	41	7	34	-	N	-	-	16	1	-	-	-	-
316	R	B43	15-Aug	III	1st	11	H	Aco	-	-	-	44	7	37	-	D	-	4	12	0	-	-	-	-
319	R	B43	17-Aug	III	3rd	11	H	Aco	-	-	-	38	7	31	-	D	-	-	6	0	-	-	-	-
319	R	B43	18-Aug	III	4th	11	H	Aco	-	-	-	36	7	29	-	D	-	-	12	0	-	-	-	-
318	C	B43	15-Aug	III	1st	11	H	Aco	7.5	10	1.5	42	7	35	F	N	1-	-	-	-	-	-	-	-
318	R	B43	16-Aug	III	2nd	11	H	Aco	-	-	-	42	7	35	-	N	-	-	0	1	-	-	-	-
316	R	B43	17-Aug	III	3rd	11	H	Aco	-	-	-	38	7	31	-	N	-	-	5	1	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
319	R	B43	19-Aug	III	5th	11	H	Aco	-	-	-	36	7	29	-	N	-	-	0	0	-	-	-	-
327	C	B43	17-Aug	III	3rd	5	F	Croc	3	5	1	12	9	3	F	N	-	-	-	-	-	-	-	-
320	C	B43	15-Aug	III	1st	15	E	Ger	10	7.5	2	22	7	15	F	N	-	-	-	-	-	-	-	1
328	C	B43	17-Aug	III	3rd	13	E	Ger	9	8	1.9	22	8	14	M	N	-	-	-	-	-	-	-	-
328	R	B43	18-Aug	III	4th	13	E	Ger	-	-	-	22	8	14	-	N	-	-	0	1	-	-	-	-
330	R	B43	18-Aug	III	4th	22	F	Ger	-	-	-	25	7	18	-	D	-	-	0	0	-	-	-	-
315	C	B43	15-Aug	III	1st	5	F	Ger	10	8	2.1	27	7	20	F	N	-	-	-	-	-	-	-	-
321	C	B43	15-Aug	III	1st	22	F	Ger	9.5	8	2	21	7	14	F	N	-	-	-	-	-	-	-	-
315	R	B43	16-Aug	III	2nd	5	F	Ger	-	-	-	25	8	17	-	N	-	-	0	1	-	-	-	-
324	C	B43	16-Aug	III	2nd	22	F	Ger	11	7	2.1	28	8	20	F	N	-	-	-	-	-	-	-	-
326	C	B43	17-Aug	III	3rd	3	F	Ger	10	8	2	27	8	19	F	N	-	-	-	-	-	-	-	-
330	C	B43	17-Aug	III	3rd	22	F	Ger	10	8	2	25	7	18	F	N	-	-	-	-	-	-	-	-
315	R	B43	18-Aug	III	4th	5	F	Ger	-	-	-	24	7	17	-	N	-	-	0	2	-	-	-	-
330	R	B43	18-Aug	III	4th	22	F	Ger	-	-	-	25	7	18	-	N	-	-	0	1	-	-	-	-
315	R	B43	19-Aug	III	5th	9	F	Ger	-	-	-	23	7	16	-	N	-	-	12	1	-	-	-	-
323	C	B43	16-Aug	III	2nd	15	E	Tera	19	11	3	62	10	52	F	N	-	-	-	-	1	-	-	-
329	C	B43	17-Aug	III	3rd	21	F	Tera	16	10.5	2.9	51	9	42	F	N	-	-	-	-	-	-	-	-
341	C	B43	12-Oct	IV	2nd	7	E	Aco	5	6.5	1.4	20	9	11	F	N	-	-	-	-	-	-	1	-
342	C	B43	12-Oct	IV	2nd	12	E	Aco	5	6.5	1.4	16	7	9	F	N	-	-	-	-	-	-	1	-
341	R	B43	13-Oct	IV	3rd	12	E	Aco	-	-	-	17	7	10	-	N	-	-	10	1	-	-	-	-
334	R	B43	15-Oct	IV	5th	13	E	Aco	-	-	-	26	7	19	-	N	-	-	14	1	-	-	-	-
337	R	B43	14-Oct	IV	4th	2	F	Aco	-	-	-	32	7	25	-	D	-	-	32	0	-	-	-	-
334	C	B43	11-Oct	IV	1st	10	F	Aco	7	9	1.6	29	7	22	M	N	-	-	-	-	-	-	-	-
337	C	B43	11-Oct	IV	1st	19	F	Aco	7	8	1.6	34	9	25	M	N	-	-	-	-	-	-	-	-
338	C	B43	11-Oct	IV	1st	21	F	Aco	6	8	1.5	28	8	20	M	N	-	-	-	-	-	-	-	-
338	R	B43	12-Oct	IV	2nd	2	F	Aco	-	-	-	27	8	19	-	N	-	-	28	1	-	-	-	-
337	R	B43	12-Oct	IV	2nd	10	F	Aco	-	-	-	33	7	26	-	N	-	-	10	1	-	-	-	-
343	C	B43	12-Oct	IV	2nd	19	F	Aco	7	9	1.3	26	7	19	F	N	-	-	-	-	-	-	-	1

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
337	R	B43	13-Oct	IV	3rd	2	F	Aco	-	-	-	32	7	25	-	N	-	-	32	1	-	-	-	-
338	R	B43	13-Oct	IV	3rd	1	F	Aco	-	-	-	29	10	19	-	N	-	-	6	1	-	-	-	-
334	R	B43	13-Oct	IV	3rd	23	F	Aco	-	-	-	29	9	20	-	N	-	-	24	0	-	-	-	-
338	R	B43	14-Oct	IV	4th	1	F	Aco	-	-	-	26	8	18	-	N	-	-	0	1	-	-	-	-
337	R	B43	14-Oct	IV	4th	10	F	Aco	-	-	-	32	7	25	-	N	-	-	36	1	-	-	-	-
337	R	B43	15-Oct	IV	5th	2	F	Aco	-	-	-	33	9	24	-	N	-	-	0	0	-	-	-	-
334	R	B43	12-Oct	IV	2nd	11	H	Aco	-	-	-	30	10	20	-	D	-	-	28	0	-	-	-	-
335	C	B43	11-Oct	IV	1st	11	H	Aco	7.5	9	1.5	36	8	28	F	N	-	-	-	-	-	-	-	1
334	R	B43	14-Oct	IV	4th	11	H	Aco	-	-	-	27	8	19	-	N	-	-	24	1	-	-	-	-
338	R	B43	15-Oct	IV	5th	11	H	Aco	-	-	-	29	7	22	-	N	-	-	14	1	-	-	-	-
333	C	B43	11-Oct	IV	1st	4	F	Ger	10	7.5	2.1	24	8	16	F	N	-	-	-	-	-	-	-	1
349	C	B43	15-Oct	IV	5th	21	F	Ger	9	9	2	25	11	14	F	N	-	-	-	-	-	-	-	-
336	R	B43	12-Oct	IV	2nd	17	E	Mas	-	-	-	45	7	38	-	N	-	-	8	1	-	-	-	-
336	C	B43	11-Oct	IV	1st	16	F	Mas	10	10	2.3	45	7	38	M	N	-	-	-	-	-	-	-	-
336	R	B43	13-Oct	IV	3rd	10	F	Mas	-	-	-	45	9	36	-	N	-	-	30	1	-	-	-	-
336	R	B43	15-Oct	IV	5th	24	F	Mas	-	-	-	48	11	37	-	N	-	-	24	2	-	-	-	1
348	C	B43	15-Oct	IV	5th	4	F	Tera	18	12	2.9	68	7	61	M	N	32	-	-	-	-	-	-	-
235	C	B45	6-Feb	I	4th	20	E	Aco	4.5	6	-	13	7	6	M	N	14	-	-	-	-	1	-	-
236	C	B45	7-Feb	I	5th	15	E	Aco	4.5	6	-	11	6	5	M	N	15	-	-	-	-	-	-	-
234	C	B45	4-Feb	I	2nd	5	H	Mas	10	12	-	50	5	45	-	N	16	1	-	-	-	-	-	-
238	C	B45	9-Jun	II	1st	3	F	Rillus	15	11	3.5	43	7	36	M	N	-	1	-	-	-	-	-	-
239	C	B45	9-Jun	II	1st	11	F	Rillus	15	11	3.1	55	9	46	M	N	-	1	-	-	-	-	-	1
240	C	B45	9-Jun	II	1st	12	F	Rillus	15	11	3	50	7	43	-	N	-	1	-	-	-	-	-	-
243	C	B45	11-Jun	II	3rd	12	F	Rillus	10	8	2.2	26	7	19	F	N	11	-	-	-	-	-	1	-
250	C	B45	14-Jun	II	6th	1	F	Rillus	14	9	3	42	10	32	M	N	-	1	-	-	-	-	-	-
251	C	B45	15-Jun	II	7th	5	F	Rillus	8	7	1.9	17	7	10	M	N	-	-	-	-	-	1	-	-
248	C	B45	13-Jun	II	5th	3	F	Tera	13	10	3.2	44	7	37	M	N	12	-	-	-	-	1	-	-
254	C	B45	10-Aug	III	3rd	7	F	Aco	4	10	1.5	31	7	24	F	N	-	-	-	-	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
255	C	B45	11-Aug	III	4th	16	F	Ger	9	8	2	29	8	21	F	N	-	-	-	-	-	-	-	-
256	C	B45	14-Aug	III	7th	11	F	Ger	9	6.5	1.8	20	8	12	F	N	-	-	-	-	-	-	-	-
265	C	B45	10-Oct	IV	7th	11	F	Ger	8	6	1.8	18	8	10	F	N	-	-	-	-	-	-	1	-
259	C	B45	6-Oct	IV	3rd	4	H	Mas	9	9.5	2.2	41	9	32	F	N	-	-	-	-	-	-	-	-
262	C	B45	7-Oct	IV	4th	23	H	Mas	10	9.5	2.3	47	8	39	M	N	25	-	-	-	-	-	-	-
263	C	B45	9-Oct	IV	6th	3	F	Tera	16	10	3.2	42	9	33	-	N	26	-	-	-	-	1	-	-
127	C	B8	27-Jan	I	3rd	8	E	Aco	7	8	-	22	5	17	F	N	13	-	-	-	-	-	1	-
132	C	B8	29-Jan	I	5th	14	E	Aco	7	9	-	30	5	25	M	N	-	-	-	-	-	-	-	-
123	C	B8	25-Jan	I	1st	15	F	Aco	6	7	-	15	6	9	M	N	12	-	-	-	-	1	-	-
124	C	B8	25-Jan	I	1st	22	F	Aco	7.5	10	-	33	5	28	M	N	-	-	-	-	-	-	-	-
124	R	B8	26-Jan	I	2nd	6	F	Aco	-	-	-	-	-	-	-	N	-	-	44	1	-	-	-	1
125	C	B8	26-Jan	I	2nd	22	F	Aco	6	10	-	33	6	27	M	N	-	-	-	-	-	-	-	-
129	C	B8	28-Jan	I	4th	3	F	Aco	7	10	-	29	5	24	M	N	-	-	-	-	-	-	-	1
130	C	B8	28-Jan	I	4th	25	F	Aco	8	10	-	37	6	31	M	N	-	-	-	-	-	-	-	1
131	C	B8	29-Jan	I	5th	10	F	Aco	7	9	-	32	5	27	M	N	-	-	-	-	-	-	-	-
125	R	B8	29-Jan	I	5th	25	F	Aco	-	-	-	-	-	-	-	N	-	-	24	3	-	-	-	1
128	C	B8	27-Jan	I	3rd	9	H	Aco	7.5	10	-	34	5	29	M	N	-	-	-	-	-	-	-	-
125	C	B8	25-Jan	I	1st	16	F	Ele	11	13	-	56	5	51	-	N	-	-	-	-	-	-	-	-
133	C	B8	1-Jun	II	1st	1	E	Aco	6	9	1.5	43	7	36	F	N	-	-	-	-	-	-	-	-
133	R	B8	2-Jun	II	2nd	7	E	Aco	6	10	1.6	38	5	33	F	N	-	-	12	1	-	-	-	-
138	R	B8	3-Jun	II	3rd	18	E	Aco	-	-	-	32	6	26	-	N	-	-	16	1	-	-	-	-
137	R	B8	5-Jun	II	5th	7	E	Aco	-	-	-	39	5	34	-	N	7	-	12	1	-	-	-	-
133	R	B8	6-Jun	II	6th	7	E	Aco	-	-	-	44	6	38	-	N	-	-	0	4	-	-	-	-
137	R	B8	6-Jun	II	6th	3	F	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
134	R	B8	6-Jun	II	6th	22	F	Aco	-	-	-	-	-	-	-	D	-	-	8	0	-	-	-	-
134	R	B8	7-Jun	II	7th	22	F	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
134	C	B8	1-Jun	II	1st	21	F	Aco	7	10	1.3	35	5	30	M	N	-	-	-	-	-	-	-	-
138	C	B8	2-Jun	II	2nd	21	F	Aco	7	9	1.5	33	6	27	F	N	-	-	-	-	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
140	C	B8	3-Jun	II	3rd	3	F	Aco	5.5	8	1.5	29	5	24	M	N	-	-	-	-	-	-	-	-
146	C	B8	3-Jun	II	3rd	25	F	Aco	7	8	1.5	32	6	26	M	N	-	-	-	-	-	-	-	-
148	C	B8	4-Jun	II	4th	3	F	Aco	8.5	9	1.5	40	4	36	M	N	-	-	-	-	-	-	-	-
137	R	B8	4-Jun	II	4th	11	F	Aco	-	-	-	37	5	32	-	N	-	-	26	2	-	-	-	-
141	R	B8	4-Jun	II	4th	21	F	Aco	-	-	-	36	6	30	-	N	-	-	56	1	-	-	-	-
151	C	B8	4-Jun	II	4th	22	F	Aco	7	9.5	1.5	31	6	25	M	N	-	-	-	-	-	-	-	-
139	R	B8	4-Jun	II	4th	25	F	Aco	-	-	-	31	6	25	-	N	6	-	0	2	-	-	-	-
144	R	B8	5-Jun	II	5th	3	F	Aco	-	-	-	28	6	22	-	N	7	-	48	2	-	-	-	-
149	R	B8	5-Jun	II	5th	21	F	Aco	-	-	-	40	5	35	-	N	7	-	30	1	-	-	-	-
134	R	B8	5-Jun	II	5th	22	F	Aco	-	-	-	33	5	28	-	N	7	-	8	4	-	-	-	-
137	R	B8	6-Jun	II	6th	3	F	Aco	-	-	-	-	-	-	-	N	-	-	22	1	-	-	-	-
134	R	B8	6-Jun	II	6th	21	F	Aco	-	-	-	-	-	-	-	N	-	-	8	1	-	-	-	-
156	C	B8	6-Jun	II	6th	22	F	Aco	6	9	1.6	33	5	28	F	N	-	-	-	-	-	-	-	-
158	C	B8	7-Jun	II	7th	10	F	Aco	6	9	1.7	29	5	24	F	N	-	-	-	-	-	-	-	-
141	R	B8	7-Jun	II	7th	16	F	Aco	-	-	-	36	5	31	-	N	-	-	26	2	-	-	-	-
134	R	B8	7-Jun	II	7th	22	F	Aco	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
149	R	B8	5-Jun	II	5th	12	H	Aco	-	-	-	-	-	-	-	D	-	-	30	0	-	-	-	-
157	B	B8	6-Jun	II	6th	4	H	Aco	8	9	1.5	43	7	36	F	D	-	-	-	-	-	-	-	-
155	R	B8	6-Jun	II	6th	12	H	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
137	C	B8	2-Jun	II	2nd	2	H	Aco	7	10	1.6	39	6	33	M	N	-	-	-	-	-	-	-	-
141	C	B8	3-Jun	II	3rd	4	H	Aco	8	10	1.7	35	5	30	M	N	-	-	-	-	-	-	-	-
149	C	B8	4-Jun	II	4th	12	H	Aco	9	10	1.7	46	7	39	F	N	-	-	-	-	-	-	-	-
139	R	B8	5-Jun	II	5th	9	H	Aco	-	-	-	31	5	26	-	N	7	-	36	1	-	-	-	-
155	C	B8	6-Jun	II	6th	12	H	Aco	9	10	1.6	39	6	33	F	N	-	-	-	-	-	-	-	-
155	R	B8	6-Jun	II	6th	12	H	Aco	-	-	-	38	5	33	-	N	-	-	0	0	-	-	-	-
135	C	B8	1-Jun	II	1st	22	F	Gra	17	11	2	51	5	46	F	N	3	-	-	-	-	-	-	-
144	C	B8	3-Jun	II	3rd	21	F	Gra	11	10	2	44	5	39	F	N	4	-	-	-	-	-	-	-
143	C	B8	3-Jun	II	3rd	12	H	Gra	-	11	2.3	50	7	43	M	N	-	-	-	-	-	-	-	-

Individual ID	Capture/Recatpure	Site^{a}	Date	Session	Day in session	Trap no.	Trap context^{b}	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^{c}	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
150	R	B8	6-Jun	II	6th	24	H	Gra	-	-	-	42	5	37	-	N	-	-	28	2	-	-	-	-
145	C	B8	3-Jun	II	3rd	22	F	Mas	10	10	2.2	41	5	36	M	N	-	-	-	-	-	-	-	-
142	C	B8	3-Jun	II	3rd	7	E	Rillus	15	11	3	50	7	43	M	N	-	-	-	-	-	-	-	-
164	C	B8	31-Jul	III	1st	19	E	Aco	7	9	1.7	35	8	27	F	N	-	1	-	-	-	-	-	-
159	R	B8	1-Aug	III	2nd	7	E	Aco	-	-	-	37	8	29	-	N	-	-	8	1	-	-	-	-
159	R	B8	2-Aug	III	3rd	7	E	Aco	-	-	-	38	9	29	-	N	-	-	8	0	-	-	-	-
162	R	B8	3-Aug	III	4th	7	E	Aco	-	-	-	37	7	30	-	N	-	-	10	0	-	-	-	-
164	R	B8	3-Aug	III	4th	19	E	Aco	-	-	-	33	9	24	-	N	-	-	12	1	-	-	-	-
159	R	B8	4-Aug	III	5th	7	E	Aco	-	-	-	38	7	31	-	N	-	-	8	1	-	-	-	-
159	R	B8	1-Aug	III	2nd	6	F	Aco	-	-	-	-	-	-	-	D	-	-	8	0	-	-	-	-
162	R	B8	1-Aug	III	2nd	11	F	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
162	R	B8	4-Aug	III	5th	11	F	Aco	-	-	-	36	9	27	-	D	-	-	0	0	-	-	-	-
159	C	B8	31-Jul	III	1st	6	F	Aco	7.5	10	1.6	39	8	31	M	N	-	1	-	-	-	-	-	-
161	C	B8	31-Jul	III	1st	11	F	Aco	7	8	1.6	25	8	17	M	N	-	1	-	-	-	-	-	-
163	C	B8	31-Jul	III	1st	16	F	Aco	7	8.5	1.6	34	8	26	M	N	-	1	-	-	-	-	-	-
165	C	B8	31-Jul	III	1st	21	F	Aco	7.5	9.5	1.6	33	8	25	M	N	-	1	-	-	-	-	-	-
163	R	B8	1-Aug	III	2nd	3	F	Aco	-	-	-	36	8	28	-	N	-	-	40	0	-	-	-	-
167	R	B8	1-Aug	III	2nd	5	F	Aco	-	-	-	28	8	20	-	N	-	-	10	0	-	-	-	-
170	C	B8	1-Aug	III	2nd	10	F	Aco	5.5	8.5	1.6	30	8	22	F	N	-	-	-	-	-	-	-	-
162	R	B8	1-Aug	III	2nd	11	F	Aco	-	-	-	38	7	31	-	N	-	-	6	1	-	-	-	-
164	R	B8	1-Aug	III	2nd	22	F	Aco	-	-	-	33	8	25	-	N	-	-	14	1	-	-	-	-
173	C	B8	2-Aug	III	3rd	6	F	Aco	6	7	1.6	24	8	16	F	N	-	-	-	-	-	-	-	-
163	R	B8	2-Aug	III	3rd	22	F	Aco	-	-	-	-	-	-	-	N	-	-	50	1	-	-	-	1
162	R	B8	2-Aug	III	3rd	11	F	Aco	-	-	-	37	7	30	-	N	-	-	0	0	-	-	-	-
164	R	B8	2-Aug	III	3rd	21	F	Aco	-	-	-	32	7	25	-	N	-	-	8	1	-	-	-	-
167	R	B8	3-Aug	III	4th	5	F	Aco	-	-	-	28	8	20	-	N	-	-	0	2	-	-	-	-
159	R	B8	3-Aug	III	4th	6	F	Aco	-	-	-	37	7	30	-	N	-	-	8	1	-	-	-	-
170	R	B8	3-Aug	III	4th	10	F	Aco	-	-	-	32	7	25	-	N	-	-	8	1	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
168	R	B8	4-Aug	III	5th	3	F	Aco	-	-	-	35	8	27	-	N	-	-	10	1	-	-	-	-
170	R	B8	4-Aug	III	5th	5	F	Aco	-	-	-	31	8	23	-	N	-	-	16	1	-	-	-	-
173	R	B8	4-Aug	III	5th	6	F	Aco	-	-	-	26	9	17	F	N	-	-	8	1	-	-	-	-
162	R	B8	4-Aug	III	5th	11	F	Aco	-	-	-	36	8	28	-	N	-	-	14	1	-	-	-	-
167	C	B8	31-Jul	III	1st	9	H	Aco	6	8	1.6	30	11	19	M	D	-	1	-	-	-	-	-	-
163	R	B8	31-Jul	III	1st	24	H	Aco	-	-	-	37	9	28	-	D	-	1	38	0	-	-	-	-
162	R	B8	2-Aug	III	3rd	12	H	Aco	-	-	-	40	8	32	-	D	-	2	6	0	-	-	-	-
162	C	B8	31-Jul	III	1st	12	H	Aco	8	10	1.6	40	7	33	F	N	-	1	-	-	-	-	-	-
168	C	B8	1-Aug	III	2nd	2	H	Aco	6.5	9	1.6	35	8	27	F	N	-	-	-	-	-	-	-	-
170	R	B8	2-Aug	III	3rd	9	H	Aco	-	-	-	31	8	23	-	N	-	-	8	1	-	-	-	-
166	R	B8	2-Aug	III	3rd	24	H	Aco	-	-	-	48	7	41	-	N	-	-	0	2	-	-	-	-
168	R	B8	3-Aug	III	4th	2	H	Aco	-	-	-	35	7	28	-	N	-	-	0	2	-	-	-	-
167	R	B8	4-Aug	III	5th	9	H	Aco	-	-	-	29	10	19	-	N	-	-	10	1	-	-	-	-
160	C	B8	31-Jul	III	1st	7	E	Gra	14	9	2	30	8	22	F	N	-	1	-	-	-	-	1	-
171	R	B8	2-Aug	III	3rd	13	E	Gra	-	-	-	28	8	20	-	N	-	-	6	1	-	-	-	-
175	C	B8	2-Aug	III	3rd	20	E	Gra	13	9	2.1	30	7	23	M	N	-	-	-	-	-	-	-	-
171	R	B8	3-Aug	III	4th	13	E	Gra	-	-	-	28	7	21	-	N	-	-	0	1	-	-	-	-
175	R	B8	3-Aug	III	4th	20	E	Gra	-	-	-	30	7	23	-	N	-	-	0	1	-	-	-	-
171	R	B8	4-Aug	III	5th	8	E	Gra	-	-	-	28	8	20	-	N	-	-	12	1	-	-	-	-
174	R	B8	3-Aug	III	4th	16	F	Gra	-	-	-	29	7	22	-	N	-	-	10	1	-	-	-	-
160	R	B8	4-Aug	III	5th	16	F	Gra	-	-	-	30	7	23	-	N	-	-	10	1	-	-	-	-
164	R	B8	4-Aug	III	5th	22	F	Gra	-	-	-	32	7	25	-	N	-	-	14	1	-	-	-	-
166	C	B8	31-Jul	III	1st	24	H	Gra	12	11	2.1	47	8	39	F	N	-	1	-	-	-	-	-	-
169	C	B8	1-Aug	III	2nd	4	H	Gra	14	9	2	29	8	21	F	N	-	-	-	-	-	-	-	-
171	C	B8	1-Aug	III	2nd	12	H	Gra	13	8	2.2	28	8	20	-	N	-	-	-	-	-	-	-	-
172	C	B8	1-Aug	III	2nd	17	H	Gra	13	9	2.2	32	8	24	F	N	-	-	-	-	-	-	-	-
169	R	B8	2-Aug	III	3rd	4	H	Gra	-	-	-	30	8	22	-	N	-	-	0	1	-	-	-	-
174	C	B8	2-Aug	III	3rd	12	H	Gra	14	9	2.1	29	7	22	F	N	-	-	-	-	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
169	R	B8	3-Aug	III	4th	4	H	Gra	-	-	-	29	7	22	-	N	-	-	0	1	-	-	-	-
160	R	B8	3-Aug	III	4th	12	H	Gra	-	-	-	30	7	23	-	N	-	-	10	3	-	-	-	-
172	R	B8	3-Aug	III	4th	17	H	Gra	-	-	-	30	7	23	-	N	-	-	0	1	-	-	-	-
174	R	B8	4-Aug	III	5th	12	H	Gra	-	-	-	28	7	21	-	N	-	-	0	2	-	-	-	-
172	R	B8	4-Aug	III	5th	17	H	Gra	-	-	-	31	8	23	-	N	-	-	0	1	-	-	-	-
191	C	B8	30-Sep	IV	2nd	1	E	Aco	6.5	9.5	1.6	46	7	39	F	N	-	-	-	-	1	-	-	-
192	C	B8	30-Sep	IV	2nd	7	E	Aco	7	9.5	1.6	41	8	33	M	N	-	-	-	-	-	-	-	-
182	C	B8	29-Sep	IV	1st	11	F	Aco	8	9.5	1.7	40	7	33	F	N	-	2	-	-	-	-	-	-
181	R	B8	30-Sep	IV	2nd	5	F	Aco	-	-	-	38	7	31	-	N	-	-	8	0	-	-	-	-
182	R	B8	30-Sep	IV	2nd	6	F	Aco	-	-	-	39	7	32	-	N	-	-	8	1	-	-	-	-
196	C	B8	30-Sep	IV	2nd	21	F	Aco	7	9.5	1.7	37	9	28	M	N	-	-	-	-	-	-	-	-
197	C	B8	30-Sep	IV	2nd	22	F	Aco	6.5	9	1.7	38	8	30	F	N	-	-	-	-	-	-	-	-
182	R	B8	1-Oct	IV	3rd	6	F	Aco	-	-	-	38	9	29	-	N	-	1	0	1	-	-	-	-
196	R	B8	1-Oct	IV	3rd	11	F	Aco	-	-	-	34	7	27	-	N	-	1	32	1	-	-	-	-
181	R	B8	1-Oct	IV	3rd	15	F	Aco	-	-	-	38	8	30	-	N	-	1	24	1	-	-	-	-
197	R	B8	1-Oct	IV	3rd	25	F	Aco	-	-	-	39	9	30	-	N	-	1	24	1	-	-	-	-
181	R	B8	2-Oct	IV	4th	5	F	Aco	-	-	-	39	9	30	-	N	-	2	24	1	-	-	-	-
202	C	B8	2-Oct	IV	4th	6	F	Aco	6.5	8.5	1.5	34	8	26	M	N	-	2	-	-	-	-	-	-
192	R	B8	2-Oct	IV	4th	11	F	Aco	-	-	-	40	8	32	-	N	-	2	14	2	-	-	-	-
197	R	B8	2-Oct	IV	4th	22	F	Aco	-	-	-	38	9	29	-	N	-	2	24	1	-	-	-	-
204	C	B8	3-Oct	IV	5th	3	F	Aco	4	5.5	1.3	14	9	5	F	N	-	-	-	-	-	1	-	-
192	R	B8	3-Oct	IV	5th	6	F	Aco	-	-	-	41	8	33	-	N	-	-	8	1	-	-	-	-
182	R	B8	3-Oct	IV	5th	11	F	Aco	-	-	-	37	9	28	-	N	-	-	6	1	-	-	-	-
181	R	B8	3-Oct	IV	5th	15	F	Aco	-	-	-	39	9	30	-	N	-	-	24	1	-	-	-	-
197	R	B8	3-Oct	IV	5th	22	F	Aco	-	-	-	38	8	30	-	N	-	-	0	1	-	-	-	-
181	R	B8	29-Sep	IV	1st	9	H	Aco	-	-	-	40	9	31	-	D	-	-	0	0	-	-	-	-
181	C	B8	29-Sep	IV	1st	9	H	Aco	6.5	9	1.6	37	8	29	F	N	22	2	-	-	-	-	-	-
191	R	B8	1-Oct	IV	3rd	2	H	Aco	-	-	-	47	9	38	-	N	-	1	16	1	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
178	C	B8	29-Sep	IV	1st	6	F	Ele	10	12	3.1	60	10	50	M	N	-	2	-	-	-	-	-	-
183	R	B8	3-Oct	IV	5th	7	E	Gra	-	-	-	35	7	28	-	N	-	-	20	1	-	-	-	-
177	C	B8	29-Sep	IV	1st	3	F	Gra	17	9	2.4	35	7	28	M	N	-	2	-	-	-	-	-	-
187	C	B8	29-Sep	IV	1st	21	F	Gra	15	9	2.2	34	7	27	F	N	-	2	-	-	-	-	-	-
187	R	B8	30-Sep	IV	2nd	11	F	Gra	-	-	-	33	8	25	-	N	-	-	32	1	-	-	-	-
177	R	B8	1-Oct	IV	3rd	3	F	Gra	-	-	-	40	9	31	-	N	-	1	10	1	-	-	-	-
183	R	B8	2-Oct	IV	4th	16	F	Gra	-	-	-	34	8	26	-	N	-	2	10	1	-	-	-	-
183	C	B8	29-Sep	IV	1st	12	H	Gra	16	9	2.1	35	8	27	F	N	23	2	-	-	-	-	-	-
188	C	B8	29-Sep	IV	1st	24	H	Gra	15	9	2.3	36	8	28	F	N	-	2	-	-	-	-	-	-
177	R	B8	30-Sep	IV	2nd	2	H	Gra	-	-	-	33	7	26	-	N	-	-	10	1	-	-	-	-
193	C	B8	30-Sep	IV	2nd	9	H	Gra	15	9	2.1	36	8	28	F	N	-	-	-	-	-	-	-	-
183	R	B8	30-Sep	IV	2nd	12	H	Gra	-	-	-	34	7	27	-	N	-	-	0	1	-	-	-	-
183	R	B8	1-Oct	IV	3rd	12	H	Gra	-	-	-	34	8	26	-	N	-	1	0	1	-	-	-	-
187	R	B8	1-Oct	IV	3rd	17	H	Gra	-	-	-	35	8	27	-	N	-	1	14	1	-	-	-	-
177	R	B8	2-Oct	IV	4th	2	H	Gra	-	-	-	-	-	-	-	N	-	2	10	1	-	-	-	1
193	R	B8	2-Oct	IV	4th	4	H	Gra	-	-	-	35	8	27	-	N	-	2	18	2	-	-	-	-
188	R	B8	2-Oct	IV	4th	23	H	Gra	-	-	-	37	8	29	-	N	-	2	8	3	-	-	-	-
193	R	B8	3-Oct	IV	5th	4	H	Gra	-	-	-	34	7	27	-	N	-	-	0	1	-	-	-	-
187	R	B8	3-Oct	IV	5th	12	H	Gra	-	-	-	36	7	29	-	N	-	-	14	2	-	-	-	-
188	R	B8	3-Oct	IV	5th	23	H	Gra	-	-	-	37	8	29	-	N	-	-	0	1	-	-	-	-
179	C	B8	29-Sep	IV	1st	7	E	Mas	9.5	9	2.3	32	8	24	M	N	-	2	-	-	-	-	-	-
180	C	B8	29-Sep	IV	1st	8	E	Mas	10	9	2.2	34	7	27	M	N	21	2	-	-	-	-	-	-
184	C	B8	29-Sep	IV	1st	14	E	Mas	9.5	9.5	2.1	35	7	28	F	N	-	2	-	-	-	-	-	-
185	C	B8	29-Sep	IV	1st	18	E	Mas	11	10.5	2.4	45	7	38	M	N	-	2	-	-	-	-	-	-
186	C	B8	29-Sep	IV	1st	20	E	Mas	9	9	2.1	27	7	20	F	N	-	2	-	-	-	-	1	-
185	R	B8	30-Sep	IV	2nd	14	E	Mas	-	-	-	44	7	37	-	N	-	-	12	1	-	-	-	-
195	C	B8	30-Sep	IV	2nd	18	E	Mas	10	10	2.2	33	8	25	F	N	-	-	-	-	-	-	-	-
186	R	B8	30-Sep	IV	2nd	19	E	Mas	-	-	-	28	8	20	-	N	-	-	18	1	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
195	R	B8	1-Oct	IV	3rd	13	E	Mas	-	-	-	33	7	26	-	N	-	1	14	1	-	-	-	-
185	R	B8	1-Oct	IV	3rd	18	E	Mas	-	-	-	44	8	36	-	N	-	1	12	1	-	-	-	-
201	C	B8	1-Oct	IV	3rd	20	E	Mas	9	8	2.2	27	8	19	F	N	-	1	-	-	-	-	-	-
179	R	B8	2-Oct	IV	4th	7	E	Mas	-	-	-	30	8	22	-	N	-	2	20	1	-	-	-	-
201	R	B8	2-Oct	IV	4th	20	E	Mas	-	-	-	26	7	19	-	N	-	2	0	1	-	-	-	-
205	C	B8	3-Oct	IV	5th	8	E	Mas	8.5	8.5	2.2	31	7	24	M	N	-	-	-	-	-	-	-	-
206	C	B8	3-Oct	IV	5th	13	E	Mas	10	10	2.3	32	7	25	F	N	-	-	-	-	-	-	-	-
207	C	B8	3-Oct	IV	5th	18	E	Mas	-	-	-	-	-	-	M	N	-	-	-	-	-	-	-	-
189	R	B8	3-Oct	IV	5th	20	E	Mas	-	-	-	26	8	18	-	N	-	-	14	2	-	-	-	-
189	C	B8	29-Sep	IV	1st	25	F	Mas	8	8.5	2	26	7	19	M	N	-	2	-	-	-	-	-	1
179	R	B8	30-Sep	IV	2nd	16	F	Mas	-	-	-	31	8	23	-	N	-	-	20	1	-	-	-	-
179	R	B8	1-Oct	IV	3rd	16	F	Mas	-	-	-	31	7	24	-	N	-	1	0	1	-	-	-	-
200	R	B8	3-Oct	IV	5th	16	F	Mas	-	-	-	41	8	33	-	N	-	-	20	2	-	-	-	-
194	C	B8	30-Sep	IV	2nd	17	H	Mas	8.5	9	2.2	32	9	23	M	N	-	-	-	-	-	-	-	-
189	R	B8	30-Sep	IV	2nd	24	H	Mas	-	-	-	26	8	18	-	N	-	-	12	1	-	-	-	-
180	R	B8	1-Oct	IV	3rd	4	H	Mas	-	-	-	34	7	27	-	N	-	1	22	2	-	-	-	-
189	R	B8	1-Oct	IV	3rd	24	H	Mas	8	8	2	27	7	20	M	N	-	1	0	1	-	-	-	-
195	R	B8	2-Oct	IV	4th	17	H	Mas	-	-	-	33	7	26	-	N	-	2	14	1	-	-	-	-
203	C	B8	2-Oct	IV	4th	24	H	Mas	8.5	8	2.1	27	8	19	M	N	-	2	-	-	-	-	-	-
179	R	B8	3-Oct	IV	5th	17	H	Mas	-	-	-	30	8	22	-	N	-	-	20	1	-	-	-	-
203	R	B8	3-Oct	IV	5th	24	H	Mas	-	-	-	26	7	19	-	N	-	-	0	1	-	-	-	-
5	C	C14	2-May	II	2nd	16	-	Aco	7	11	-	30	5	25	M	N	-	-	-	-	-	-	-	-
10	C	C14	4-May	II	4th	16	-	Aco	7	8	-	30	5	25	M	N	-	-	-	-	-	-	-	-
83	C	C2	16-Jul	III	3rd	12	-	Aco	4.5	8.5	1.3	34	9	25	F	D	-	-	-	-	-	-	-	-
83	R	C2	18-Jul	III	5th	12	-	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
83	R	C2	19-Jul	III	6th	12	-	Aco	-	-	-	-	-	-	-	D	-	-	8	0	-	-	-	-
85	R	C2	19-Jul	III	6th	13	-	Aco	-	-	-	-	-	-	-	D	-	-	8	0	-	-	-	-
83	R	C2	20-Jul	III	7th	12	-	Aco	-	-	-	-	-	-	-	D	-	-	9	0	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
102	R	C2	13-Sep	IV	3rd	12	-	Aco	-	-	-	26	7	19	-	D	-	-	0	0	-	-	-	-
102	R	C2	14-Sep	IV	4th	8	-	Aco	-	-	-	28	7	21	-	D	-	-	9	0	-	-	-	-
112	R	C2	14-Sep	IV	4th	14	-	Aco	-	-	-	-	-	-	-	D	-	-	8	0	-	-	-	1
42	C	C2	14-Jan	I	3rd	1	-	Aco	4	5	-	13	7	5.5	M	N	-	2	-	-	-	-	-	-
45	C	C2	15-Jan	I	4th	6	-	Aco	4.5	6	-	11	6	5	F	N	7	-	-	-	-	1	-	-
46	C	C2	15-Jan	I	4th	7	-	Aco	7	9	-	30	5	25	M	N	-	-	-	-	-	-	-	-
50	C	C2	16-Jan	I	5th	6	-	Aco	4	6	-	13	5	7.5	F	N	9	-	-	-	-	1	-	-
46	R	C2	16-Jan	I	5th	11	-	Aco	-	-	-	-	-	-	-	N	-	-	9	1	-	-	-	-
60	C	C2	17-May	II	4th	19	-	Aco	6	10	1.5	38	5	33	F	N	-	-	-	-	-	-	-	-
62	C	C2	18-May	II	5th	18	-	Aco	3	6.5	1.3	18	8	10	F	N	-	-	-	-	-	1	-	-
63	C	C2	19-May	II	6th	3	-	Aco	5	10	-	40	5	35	F	N	-	-	-	-	-	-	-	-
67	C	C2	20-May	II	7th	3	-	Aco	4	9	1.3	30	5	25	F	N	-	-	-	-	-	-	-	-
68	C	C2	20-May	II	7th	19	-	Aco	8	10.5	1.6	38	7	31	M	N	-	-	-	-	-	-	-	-
76	C	C2	15-Jul	III	2nd	11	-	Aco	3.5	8.5	1.3	26	7	19	M	N	-	1	-	-	-	-	1	-
77	C	C2	15-Jul	III	2nd	6	-	Aco	4.5	9	1.5	31	7	24	M	N	-	1	-	-	-	-	-	-
78	C	C2	16-Jul	III	3rd	2	-	Aco	4	8	1.3	27	7	20	M	N	-	2	-	-	-	-	1	-
79	C	C2	16-Jul	III	3rd	6	-	Aco	6	9	1.7	39	7	32	M	N	-	2	-	-	-	-	-	-
80	C	C2	16-Jul	III	3rd	12	-	Aco	4.5	9	1.5	28	7	21	M	N	-	2	-	-	-	-	-	-
81	C	C2	16-Jul	III	3rd	17	-	Aco	4	8	1.3	29	8	21	F	N	-	2	-	-	-	-	-	-
84	C	C2	17-Jul	III	4th	15	-	Aco	3.5	7.5	1.4	21	7	14	M	N	-	-	-	-	-	-	-	-
78	R	C2	17-Jul	III	4th	8	-	Aco	-	-	-	26	7	19	-	N	-	-	9	1	-	-	-	-
85	C	C2	17-Jul	III	4th	1	-	Aco	4	10	1.3	44	7	37	F	N	-	-	-	-	1	-	-	-
77	R	C2	17-Jul	III	4th	6	-	Aco	-	-	-	30	7	23	-	N	-	-	0	2	-	-	-	-
83	R	C2	17-Jul	III	4th	11	-	Aco	-	-	-	32	7	25	-	N	-	-	8	1	-	-	-	-
81	R	C2	17-Jul	III	4th	21	-	Aco	-	-	-	28	7	21	-	N	-	-	9	2	-	-	-	1
86	C	C2	17-Jul	III	4th	12	-	Aco	4	8	1.4	23	7	16	M	N	-	-	-	-	-	-	-	-
87	C	C2	18-Jul	III	5th	1	-	Aco	-	10	1.4	33	7	26	F	N	-	-	-	-	-	-	-	-
78	R	C2	18-Jul	III	5th	2	-	Aco	-	-	-	26	7	19	-	N	-	-	9	1	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
77	R	C2	18-Jul	III	5th	8	-	Aco	-	-	-	29	7	22	-	N	-	-	16	1	-	-	-	-
89	C	C2	18-Jul	III	5th	11	-	Aco	3	6	1.3	13	7	6	F	N	-	-	-	-	-	-	-	-
83	R	C2	18-Jul	III	5th	12	-	Aco	-	-	-	32	7	25	-	N	-	-	8	1	-	-	-	-
84	R	C2	18-Jul	III	5th	15	-	Aco	-	-	-	20	7	13	-	N	-	-	0	1	-	-	-	-
91	C	C2	18-Jul	III	5th	18	-	Aco	3	6.5	-	11	4	7	-	N	-	-	-	-	-	-	-	-
88	R	C2	19-Jul	III	6th	2	-	Aco	-	-	-	22	9	13	-	N	-	-	8	1	-	-	-	-
78	R	C2	19-Jul	III	6th	3	-	Aco	-	-	-	-	-	-	-	N	-	-	8	1	-	-	-	-
96	C	C2	19-Jul	III	6th	6	-	Aco	4	8	1.4	26	9	17	M	N	-	-	-	-	-	-	-	-
83	R	C2	19-Jul	III	6th	7	-	Aco	-	-	-	-	-	-	-	N	-	-	8	0	-	-	-	-
77	R	C2	19-Jul	III	6th	8	-	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
86	R	C2	19-Jul	III	6th	11	-	Aco	-	-	-	25	8	17	-	N	-	-	8	2	-	-	-	-
85	R	C2	19-Jul	III	6th	12	-	Aco	-	-	-	31	7	24	-	N	-	-	18	2	-	-	-	-
84	R	C2	19-Jul	III	6th	13	-	Aco	-	-	-	-	-	-	-	N	-	-	16	1	-	-	-	-
97	C	C2	19-Jul	III	6th	17	-	Aco	3.5	7	1.3	19	8	11	F	N	-	-	-	-	-	-	-	-
98	C	C2	19-Jul	III	6th	18	-	Aco	3.5	7	1.4	19	9	10	M	N	-	-	-	-	-	-	-	-
78	R	C2	20-Jul	III	7th	3	-	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
77	R	C2	20-Jul	III	7th	6	-	Aco	-	-	-	-	-	-	-	N	-	-	16	1	-	-	-	-
88	R	C2	20-Jul	III	7th	7	-	Aco	-	-	-	-	-	-	-	N	-	-	8	1	-	-	-	-
83	R	C2	20-Jul	III	7th	8	-	Aco	-	-	-	-	-	-	-	N	-	-	9	0	-	-	-	-
86	R	C2	20-Jul	III	7th	12	-	Aco	-	-	-	-	-	-	-	N	-	-	8	1	-	-	-	-
85	R	C2	20-Jul	III	7th	13	-	Aco	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
97	R	C2	20-Jul	III	7th	17	-	Aco	-	-	-	-	-	-	-	N	-	-	0	1	-	-	-	-
76	R	C2	20-Jul	III	7th	21	-	Aco	-	-	-	29	9	20	-	N	-	-	16	5	-	-	-	-
102	C	C2	11-Sep	IV	1st	9	-	Aco	4	9	1.4	28	7	21	M	N	-	-	-	-	-	-	-	-
104	C	C2	11-Sep	IV	1st	12	-	Aco	4.5	8.5	1.5	24	7	17	F	N	-	-	-	-	-	-	-	1
111	C	C2	12-Sep	IV	2nd	3	-	Aco	4	8	1.3	20	7	13	M	N	-	-	-	-	-	-	-	1
112	C	C2	12-Sep	IV	2nd	14	-	Aco	-	9	1.4	29	7	22	F	N	12	-	-	-	-	-	-	-
102	R	C2	12-Sep	IV	2nd	12	-	Aco	-	-	-	30	9	21	-	N	-	-	18	1	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
114	C	C2	12-Sep	IV	2nd	21	-	Aco	4	8	1.3	28	9	19	M	N	13	-	-	-	-	-	-	-
117	C	C2	13-Sep	IV	3rd	1	-	Aco	4.5	8	1.4	28	10	18	M	N	-	-	-	-	-	-	-	-
112	R	C2	13-Sep	IV	3rd	9	-	Aco	-	-	-	30	9	21	-	N	-	-	8	1	-	-	-	-
102	R	C2	13-Sep	IV	3rd	12	-	Aco	-	-	-	28	8	20	-	N	-	-	0	1	-	-	-	-
114	R	C2	13-Sep	IV	3rd	23	-	Aco	-	-	-	28	9	19	-	N	-	-	16	1	-	-	-	-
102	R	C2	14-Sep	IV	4th	12	-	Aco	-	-	-	29	10	19	-	N	-	-	0	0	-	-	-	-
114	R	C2	14-Sep	IV	4th	6	-	Aco	-	-	-	26	7	19	-	N	-	-	29	1	-	-	-	-
112	R	C2	14-Sep	IV	4th	9	-	Aco	-	-	-	28	8	20	-	N	-	-	0	1	-	-	-	-
117	R	C2	15-Sep	IV	5th	3	-	Aco	-	-	-	25	7	18	-	N	-	-	16	2	-	-	-	-
114	R	C2	15-Sep	IV	5th	23	-	Aco	-	-	-	27	7	20	-	N	-	-	29	1	-	-	-	-
117	R	C2	16-Sep	IV	6th	7	-	Aco	-	-	-	28	10	18	-	N	-	-	9	1	-	-	-	-
114	R	C2	16-Sep	IV	6th	21	-	Aco	-	-	-	29	10	19	-	N	-	-	16	1	-	-	-	-
117	R	C2	17-Sep	IV	7th	7	-	Aco	4.5	9	1.4	25	8	17	M	N	-	-	0	1	-	-	-	-
114	R	C2	17-Sep	IV	7th	22	-	Aco	-	-	-	26	7	19	-	N	-	-	8	1	-	-	-	-
120	C	C2	17-Sep	IV	7th	3	M	Aco	7.5	8.5	1.7	36	8	28	M	N	-	-	-	-	-	-	-	-
110	C	C2	12-Sep	IV	2nd	9	-	Ele	9	11	3	49	10	39	M	N	11	-	-	-	-	-	-	-
118	C	C2	15-Sep	IV	5th	1	-	Ele	7	9	2.9	30	7	23	M	N	15	-	-	-	-	-	1	-
69	R	C2	14-Jul	III	1st	6	-	Tera	-	-	-	68	7	61	-	D	-	-	0	0	-	-	-	-
74	R	C2	16-Jul	III	3rd	19	-	Tera	-	-	-	-	-	-	-	D	-	-	?	0	-	-	-	-
55	C	C2	14-May	II	1st	15	-	Tera	19	16	4	154	11	143	F	N	1	1	-	-	-	-	-	-
64	C	C2	19-May	II	6th	6	-	Tera	24	20	4	220	15	205	M	N	2	-	-	-	-	-	-	-
65	C	C2	19-May	II	6th	13	-	Tera	17	15	4	148	10	138	F	N	-	-	-	-	-	-	-	-
69	C	C2	14-Jul	III	1st	6	-	Tera	14	12.5	3.7	68	7	61	M	N	-	1	-	-	-	-	-	-
70	C	C2	14-Jul	III	1st	8	-	Tera	-	17	3.9	209	15	194	M	N	-	1	-	-	-	-	-	-
74	C	C2	15-Jul	III	2nd	23	-	Tera	17	14	4	140	15	125	F	N	2	1	-	-	-	-	-	-
75	C	C2	15-Jul	III	2nd	13	-	Tera	14	12.5	3.5	81	7	74	F	N	3	1	-	-	-	-	-	-
74	R	C2	16-Jul	III	3rd	13	-	Tera	-	-	-	130	7	123	-	N	-	2	?	1	-	-	-	-
69	R	C2	16-Jul	III	3rd	15	-	Tera	-	-	-	-	-	-	-	N	-	2	?	2	-	-	-	-

Individual ID	Capture/Recatpure	Site^{a}	Date	Session	Day in session	Trap no.	Trap context^{b}	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^{c}	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
90	C	C2	18-Jul	III	5th	13	-	Tera	21	18	4.1	217	15	202	M	N	4	-	-	-	-	-	-	-
69	R	C2	18-Jul	III	5th	14	-	Tera	-	-	-	66	7	59	-	N	-	-	?	1	-	-	-	-
69	R	C2	20-Jul	III	7th	14	-	Tera	-	-	-	-	-	-	-	N	-	-	0	2	-	-	-	-
103	C	C2	11-Sep	IV	1st	13	-	Tera	20	17	4.1	159	15	144	M	N	8	-	-	-	-	-	-	-
121	C	C2	17-Sep	IV	7th	23	-	Tera	21	17	4.1	173	15	158	M	N	16	-	-	-	-	-	-	-
213	R	C21`	25-Jul	III	3rd	19	-	Aco	-	-	-	-	-	-	-	D	-	-	0	0	-	-	-	-
224	R	C21`	23-Sep	IV	4th	22	-	Aco	-	-	-	29	7	22	-	D	-	1	0	0	-	-	-	-
213	C	C21`	23-Jul	III	1st	19	-	Aco	4	8	1.4	24	9	15	M	N	-	-	-	-	-	-	-	-
213	R	C21`	24-Jul	III	2nd	19	-	Aco	-	-	-	23	8	15	-	N	-	-	0	1	-	-	-	-
213	R	C21`	25-Jul	III	3rd	19	-	Aco	-	-	-	-	-	-	-	N	-	1	0	1	-	-	-	-
213	R	C21`	26-Jul	III	4th	19	-	Aco	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
213	R	C21`	27-Jul	III	5th	25	-	Aco	-	-	-	-	-	-	-	N	-	-	9	1	-	-	-	-
221	C	C21`	28-Jul	III	6th	22	-	Aco	6	9	1.5	31	8	23	F	N	-	-	-	-	1	-	-	-
221	R	C21`	29-Jul	III	7th	21	-	Aco	-	-	-	30	8	22	-	N	-	-	8	1	-	-	-	-
224	C	C21`	20-Sep	IV	1st	17	-	Aco	7	9	1.5	35	10	25	M	N	-	-	-	-	-	-	-	-
227	C	C21`	21-Sep	IV	2nd	22	-	Aco	7.5	9	1.5	30	7	23	F	N	17	-	-	-	-	-	-	-
224	R	C21`	21-Sep	IV	2nd	22	-	Aco	-	-	-	30	8	22	-	N	17	-	8	1	-	-	-	-
224	R	C21`	22-Sep	IV	3rd	22	-	Aco	-	-	-	30	8	22	-	N	-	-	0	1	-	-	-	-
224	R	C21`	23-Sep	IV	4th	22	-	Aco	-	-	-	28	7	21	-	N	-	-	0	1	-	-	-	-
224	R	C21`	25-Sep	IV	6th	22	-	Aco	-	-	-	30	8	22	-	N	-	-	0	2	-	-	-	-
232	C	C21`	25-Sep	IV	6th	25	-	Aco	4	8	1.5	26	8	18	M	N	-	-	-	-	-	-	-	-
232	R	C21`	26-Sep	IV	7th	25	-	Aco	-	-	-	26	10	16	-	N	-	1	0	1	-	-	-	-
219	R	C21`	25-Jul	III	3rd	25	-	Lem	7.5	6.5	2.2	20	10	10	F	D	-	-	-	-	-	-	1	-
219	R	C21`	26-Jul	III	4th	21	-	Lem	-	-	-	19	9	10	-	D	-	1	?	0	-	-	-	-
219	R	C21`	27-Jul	III	5th	21	-	Lem	-	-	-	-	-	-	-	D	-	-	0	1	-	-	-	-
220	R	C21`	27-Jul	III	5th	19	-	Lem	8	7	2	21	10	11	F	D	-	-	-	-	-	-	-	-
219	R	C21`	26-Jul	III	4th	23	-	Lem	-	-	-	-	-	-	-	N	-	-	?	0	-	-	-	-
273	C	C43	10-Feb	I	2nd	6	-	Aco	8	9	-	35	5	30	M	N	-	-	-	-	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
281	C	C43	11-Feb	I	3rd	18	-	Aco	7.5	8	-	23	5	18	F	N	-	-	-	-	-	-	-	-
281	R	C43	12-Feb	I	4th	19	-	Aco	-	-	-	-	-	-	-	N	-	-	8	1	-	-	-	-
273	R	C43	12-Feb	I	4th	6	-	Aco	-	-	-	-	-	-	-	N	-	-	0	2	-	-	-	-
282	C	C43	12-Feb	I	4th	25	-	Aco	7	8	-	21	5	16	F	N	-	-	-	-	-	-	-	-
285	C	C43	13-Feb	I	5th	5	-	Aco	8	10	-	32	5	27	M	N	-	-	-	-	-	-	-	-
293	C	C43	17-Jun	II	1st	18	-	Aco	7	9	1.5	35	7	28	M	N	-	-	-	-	-	-	-	-
296	C	C43	18-Jun	II	2nd	7	-	Aco	8	10	1.7	51	7	44	F	N	-	-	-	-	1	-	-	-
303	C	C43	19-Jun	II	3rd	2	-	Aco	7	10	1.6	33	7	26	M	N	-	-	-	-	-	-	-	-
296	R	C43	19-Jun	II	3rd	5	-	Aco	-	-	-	53	8	45	-	N	-	-	25	1	-	-	-	-
304	C	C43	19-Jun	II	3rd	7	-	Aco	6	8	1.5	29	7	22	M	N	-	-	-	-	-	-	-	-
305	C	C43	19-Jun	II	3rd	10	-	Aco	7.5	9	1.6	34	7	27	F	N	-	-	-	-	-	-	-	-
306	C	C43	19-Jun	II	3rd	19	-	Aco	8	11	1.5	52	7	45	F	N	-	-	-	-	-	-	-	-
304	R	C43	20-Jun	II	4th	2	-	Aco	-	-	-	33	7	26	-	N	-	-	8	1	-	-	-	-
311	C	C43	20-Jun	II	4th	7	-	Aco	6	8	1.6	28	7	21	F	N	-	-	-	-	-	-	-	-
305	R	C43	20-Jun	II	4th	8	-	Aco	-	-	-	34	7	27	-	N	-	-	16	1	-	-	-	-
312	C	C43	20-Jun	II	4th	10	-	Aco	6	9.5	1.6	37	8	29	F	N	-	-	-	-	-	-	-	-
311	R	C43	21-Jun	II	5th	2	-	Aco	-	-	-	29	7	22	-	N	-	-	8	1	-	-	-	-
304	R	C43	21-Jun	II	5th	7	-	Aco	-	-	-	32	7	25	-	N	-	-	8	1	-	-	-	-
305	R	C43	21-Jun	II	5th	8	-	Aco	-	-	-	34	7	27	-	N	-	-	0	1	-	-	-	-
312	R	C43	21-Jun	II	5th	10	-	Aco	-	-	-	35	7	28	-	N	-	-	0	1	-	-	-	-
293	R	C43	21-Jun	II	5th	18	-	Aco	-	-	-	36	7	29	-	N	-	-	0	4	-	-	-	-
325	C	C43	16-Aug	III	2nd	7	-	Aco	7.5	9	1.6	33	7	26	M	N	-	-	-	-	-	-	-	-
325	R	C43	17-Aug	III	3rd	16	-	Aco	-	-	-	35	7	28	-	N	-	-	18	1	-	-	-	-
325	R	C43	19-Aug	III	5th	7	-	Aco	-	-	-	35	9	26	-	N	-	-	18	2	-	-	-	-
344	C	C43	12-Oct	IV	2nd	22	-	Aco	7	9	1.5	37	9	28	M	N	-	-	-	-	-	-	-	-
345	C	C43	13-Oct	IV	3rd	11	-	Aco	7	9	1.6	35	8	27	F	N	-	-	-	-	-	-	-	-
344	R	C43	13-Oct	IV	3rd	12	-	Aco	-	-	-	37	11	26	-	N	-	-	16	1	-	-	-	-
350	C	C43	15-Oct	IV	5th	4	-	Aco	8	8.5	1.6	31	8	23	M	N	-	-	-	-	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
340	C	C43	11-Oct	IV	1st	7	-	Ele	9.5	11.5	3.1	-	-	-	M	N	-	-	-	-	-	-	-	-
340	R	C43	13-Oct	IV	3rd	4	-	Ele	-	-	-	60	13	47	-	N	-	-	?	1	-	-	-	-
340	R	C43	14-Oct	IV	4th	3	-	Ele	-	-	-	55	10	45	-	N	-	-	?	1	-	-	-	-
339	C	C43	11-Oct	IV	1st	3	-	Ger	9.5	7	2	24	8	16	F	N	-	-	-	-	-	-	-	-
351	C	C43	15-Oct	IV	5th	16	-	Ger	9	7	2	24	10	14	F	N	-	-	-	-	-	-	-	-
346	R	C43	14-Oct	IV	4th	8	-	Lem	-	-	-	40	9	31	-	D	-	-	5	0	-	-	-	-
347	R	C43	14-Oct	IV	4th	23	-	Lem	-	-	-	39	9	30	-	D	-	-	?	0	-	-	-	-
322	C	C43	15-Aug	III	1st	19	-	Lem	10	10	2.6	46	10	36	F	N	-	-	-	-	-	-	-	-
322	R	C43	16-Aug	III	2nd	18	-	Lem	-	-	-	45	9	36	-	N	-	-	?	1	-	-	-	-
346	C	C43	14-Oct	IV	4th	7	-	Lem	10	9	2.3	39	8	31	M	N	3-	-	-	-	-	-	-	-
347	C	C43	14-Oct	IV	4th	11	-	Lem	11	10	2.3	39	7	32	M	N	31	-	-	-	-	-	-	-
346	R	C43	15-Oct	IV	5th	8	-	Lem	-	-	-	39	8	31	-	N	-	-	0	0	-	-	-	-
347	R	C43	15-Oct	IV	5th	11	-	Lem	-	-	-	41	10	31	-	N	-	-	?	0	-	-	-	-
274	C	C43	10-Feb	I	2nd	20	-	Tera	19	14	3.5	110	12	98	-	N	-	-	-	-	-	-	-	-
280	C	C43	11-Feb	I	3rd	11	-	Tera	17	12	3.8	65	5	60	F	N	21	-	-	-	-	-	-	-
331	C	C43	18-Aug	III	4th	11	-	Tera	15	12	3.8	66	7	59	F	N	-	-	-	-	-	-	-	-
332	C	C43	19-Aug	III	5th	3	-	Tera	14	11	3.5	57	7	50	F	N	-	-	-	-	-	-	-	-
237	C	C45	9-Jun	II	1st	5	-	Aco	7	10	1.5	34	7	27	M	N	-	1	-	-	-	-	-	-
245	C	C45	12-Jun	II	4th	25	-	Aco	7	8	1.5	37	9	28	F	N	-	-	-	-	-	-	-	-
245	R	C45	14-Jun	II	6th	20	-	Aco	-	-	-	36	8	28	-	N	-	-	10	2	-	-	-	-
249	C	C45	14-Jun	II	6th	25	-	Aco	7.5	9	1.5	35	7	28	M	N	-	-	-	-	-	-	-	-
247	C	C45	13-Jun	II	5th	22	-	Gra	11	8	1.8	18	7	11	F	N	-	-	-	-	-	1	-	-
252	C	C45	15-Jun	II	7th	25	-	Gra	16	11	2.2	37	7	30	F	N	-	-	-	-	-	-	-	-
253	C	C45	15-Jun	II	7th	22	-	Gra	16	10	2.1	36	7	29	M	N	-	-	-	-	-	-	-	-
242	C	C45	10-Jun	II	2nd	25	-	Lem	10	8	2.2	33	10	23	M	D	-	-	-	-	-	-	-	-
244	C	C45	11-Jun	II	3rd	24	-	Lem	11	10	2.4	39	9	30	M	D	-	-	-	-	-	-	-	-
242	R	C45	11-Jun	II	3rd	25	-	Lem	-	-	-	32	9	23	-	D	-	-	0	1	-	-	-	-
246	R	C45	12-Jun	II	4th	13	-	Lem	-	-	-	34	10	24	-	D	-	-	?	0	-	-	-	-

Individual ID	Capture/Recatpure	Site^a	Date	Session	Day in session	Trap no.	Trap context^b	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term^c	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
244	R	C45	13-Jun	II	5th	9	-	Lem	-	-	-	40	8	32	-	D	-	-	?	2	-	-	-	-
246	R	C45	13-Jun	II	5th	13	-	Lem	-	-	-	-	-	-	-	D	-	-	?	0	-	-	-	-
242	R	C45	13-Jun	II	5th	25	-	Lem	-	-	-	-	-	-	-	D	-	-	?	0	-	-	-	-
241	C	C45	10-Jun	II	2nd	13	-	Lem	9	11	2.3	29	7	22	F	N	1-	-	-	-	-	-	-	-
241	R	C45	11-Jun	II	3rd	24	-	Lem	-	-	-	31	8	23	-	N	-	-	?	1	-	-	-	-
242	R	C45	12-Jun	II	4th	17	-	Lem	-	-	-	33	10	23	-	N	-	-	?	0	-	-	-	-
246	C	C45	12-Jun	II	4th	24	-	Lem	10	8	2.4	30	7	23	F	N	-	-	-	-	-	-	-	-
242	R	C45	13-Jun	II	5th	17	-	Lem	-	-	-	-	-	-	-	N	-	-	9	0	-	-	-	-
246	R	C45	13-Jun	II	5th	24	-	Lem	-	-	-	-	-	-	-	N	-	-	?	0	-	-	-	-
246	R	C45	14-Jun	II	6th	13	-	Lem	-	-	-	-	-	-	-	N	-	-	0	0	-	-	-	-
242	R	C45	14-Jun	II	6th	23	-	Lem	-	-	-	-	-	-	-	N	-	-	16	0	-	-	-	-
246	R	C45	15-Jun	II	7th	24	-	Lem	-	-	-	-	-	-	-	N	-	-	?	1	-	-	-	-
257	R	C45'	9-Oct	IV	6th	23	-	Aco	-	-	-	21	8	13	-	D	-	-	0	0	-	-	-	-
257	C	C45'	4-Oct	IV	1st	23	-	Aco	3.5	8	1.3	22	8	14	M	N	-	-	-	-	-	-	-	-
258	C	C45'	5-Oct	IV	2nd	23	-	Aco	4.5	7.5	1.3	23	8	15	F	N	24	-	-	-	-	-	-	-
257	R	C45'	5-Oct	IV	2nd	25	-	Aco	-	-	-	22	8	14	-	N	-	-	18	1	-	-	-	-
258	R	C45'	6-Oct	IV	3rd	10	-	Aco	-	-	-	23	8	15	-	N	-	-	13	1	-	-	-	-
257	R	C45'	6-Oct	IV	3rd	18	-	Aco	-	-	-	22	8	14	-	N	-	-	25	1	-	-	-	-
260	C	C45'	6-Oct	IV	3rd	23	-	Aco	4	8.5	1.4	28	8	20	F	N	-	-	-	-	-	-	-	-
261	C	C45'	6-Oct	IV	3rd	25	-	Aco	5	7.5	1.5	25	7	18	F	N	-	-	-	-	-	-	-	-
257	R	C45'	7-Oct	IV	4th	18	-	Aco	-	-	-	22	9	13	-	N	-	-	0	1	-	-	-	-
258	R	C45'	7-Oct	IV	4th	23	-	Aco	-	-	-	22	8	14	-	N	-	-	13	1	-	-	-	-
260	R	C45'	7-Oct	IV	4th	25	-	Aco	-	-	-	27	8	19	-	N	-	-	18	1	-	-	-	-
258	R	C45'	8-Oct	IV	5th	2	-	Aco	-	-	-	23	9	14	-	N	-	-	29	1	-	-	-	-
257	R	C45'	8-Oct	IV	5th	23	-	Aco	-	-	-	22	8	14	-	N	-	-	5	1	-	-	-	-
260	R	C45'	8-Oct	IV	5th	24	-	Aco	-	-	-	28	8	20	-	N	-	-	5	1	-	-	-	-
261	R	C45'	8-Oct	IV	5th	25	-	Aco	-	-	-	26	8	18	-	N	-	-	0	2	-	-	-	-
258	R	C45'	9-Oct	IV	6th	6	-	Aco	-	-	-	21	7	14	-	N	-	-	7	1	-	-	-	-

Individual ID	Capture/Recatpure	Site[a]	Date	Session	Day in session	Trap no.	Trap context[b]	Genus	Tail length (cm)	Head&body length (cm)	Hindfoot length (cm)	Weight with bag (g)	Bag weight (g)	Net weight (g)	Sex	Term[c]	Feces sample #	No. traps disturbed	Movement distance (m)	Movement duration (days)	Lactating female	Juvenile	Sub-adult	Trap death
257	R	C45'	9-Oct	IV	6th	23	-	Aco	-	-	-	21	7	14	-	N	-	-	0	1	-	-	-	-
264	C	C45'	9-Oct	IV	6th	24	-	Aco	4	5.5	1.3	13	8	5	M	N	27	-	-	-	-	-	-	-
261	R	C45'	9-Oct	IV	6th	25	-	Aco	-	-	-	24	7	17	-	N	-	-	0	1	-	-	-	-
266	C	C45'	10-Oct	IV	7th	1	-	Aco	5	6	1.3	16	9	7	M	N	-	-	-	-	-	-	1	-
258	R	C45'	10-Oct	IV	7th	13	-	Aco	-	-	-	23	9	14	-	N	-	-	24	1	-	-	-	-
257	R	C45'	10-Oct	IV	7th	23	-	Aco	-	-	-	22	9	13	-	N	-	-	0	0	-	-	-	-
260	R	C45'	10-Oct	IV	7th	24	-	Aco	-	-	-	27	8	19	-	N	-	-	15	1	-	-	-	-
261	R	C45'	10-Oct	IV	7th	25	-	Aco	-	-	-	24	7	17	-	N	-	-	0	1	-	-	-	-
199	R	C8	30-Sep	IV	2nd	21	-	Aco	-	-	-	28	9	19	-	D	-	-	0	0	-	-	-	-
199	R	C8	1-Oct	IV	3rd	21	-	Aco	-	-	-	26	7	19	-	D	-	2	0	0	-	-	-	-
126	C	C8	26-Jan	I	2nd	11	-	Aco	4.5	8	-	27	8	19	F	N	-	1	-	-	-	-	-	1
147	C	C8	3-Jun	II	3rd	12	-	Aco	4	9	1.4	25	4	21	F	N	-	-	-	-	-	-	-	-
152	C	C8	4-Jun	II	4th	14	-	Aco	7	9	1.5	34	6	28	M	N	-	-	-	-	-	-	-	-
152	R	C8	5-Jun	II	5th	9	-	Aco	-	-	-	33	6	27	-	N	-	-	8	1	-	-	-	-
154	C	C8	5-Jun	II	5th	10	-	Aco	6.5	10	1.5	35	8	27	M	N	-	-	-	-	-	-	-	-
152	R	C8	6-Jun	II	6th	10	-	Aco	-	-	-	-	-	-	-	N	-	-	8	1	-	-	-	-
152	R	C8	7-Jun	II	7th	9	-	Aco	-	-	-	-	-	-	-	N	-	-	8	1	-	-	-	-
176	C	C8	3-Aug	III	4th	19	-	Aco	4	6.5	1.3	22	9	13	F	N	-	-	-	-	-	-	-	-
176	R	C8	4-Aug	III	5th	15	-	Aco	-	-	-	20	8	12	-	N	-	-	9	1	-	-	-	-
190	C	C8	29-Sep	IV	1st	25	-	Aco	6.5	8.5	1.6	36	9	27	M	N	-	-	-	-	-	-	-	-
198	C	C8	30-Sep	IV	2nd	8	-	Aco	3.5	7.5	1.4	25	9	16	M	N	-	-	-	-	-	-	-	-
199	C	C8	30-Sep	IV	2nd	21	-	Aco	4.5	8.5	1.3	28	8	20	M	N	-	-	-	-	-	-	-	-
153	C	C8	4-Jun	II	4th	18	-	Croc	5	9	1.3	24	7	17	F	N	-	-	-	-	-	-	-	-
208	C	C8	3-Oct	IV	5th	11	-	Mas	9	9.5	2	32	8	24	F	N	-	-	-	-	-	-	-	-
136	C	C8	1-Jun	II	1st	24	-	Tera	15	12	3	71	6	65	M	N	-	-	-	-	-	-	-	-

[a] Tag designates a change in location of control site during the 3rd or 4th trapping session as explained in text.

[b] Abbreviations: F=Circumference fence; E=Enclosure fence; H=House.

[c] Abbreviations: N=Nocturnal; D=Diurnal.

Appendix 2. Communitiy similarities among trapping sites based on Morisita's Index.

	B2-I	**B2-II**	**B2-III**	**B2-IV**	**B8-I**	**B8-II**	**B8-III**	**B8-IV**	**B14-I**	**B14-II**	**B14-III**	**B14-IV**	**B21-I**
B2-I	1.00	0.97	0.67	0.96	0.99	0.95	0.80	0.51	0.97	0.65	0.94	0.92	0.97
B2-II	0.97	1.00	0.54	0.89	0.99	0.92	0.78	0.42	1.00	0.51	0.86	0.80	1.00
B2-III	0.67	0.54	1.00	0.77	0.63	0.58	0.50	0.33	0.54	0.85	0.81	0.78	0.54
B2-IV	0.96	0.89	0.77	1.00	0.94	0.90	0.77	0.46	0.89	0.79	0.98	0.94	0.89
B8-I	0.99	0.99	0.63	0.94	1.00	0.94	0.79	0.44	0.99	0.61	0.92	0.87	0.99
B8-II	0.95	0.92	0.58	0.90	0.94	1.00	0.93	0.57	0.92	0.53	0.86	0.91	0.92
B8-III	0.80	0.78	0.50	0.77	0.79	0.93	1.00	0.55	0.78	0.45	0.73	0.83	0.78
B8-IV	0.51	0.42	0.33	0.46	0.44	0.57	0.55	1.00	0.42	0.31	0.44	0.65	0.42
B14-I	0.97	1.00	0.54	0.89	0.99	0.92	0.78	0.42	1.00	0.51	0.86	0.80	1.00
B14-II	0.65	0.51	0.85	0.79	0.61	0.53	0.45	0.31	0.51	1.00	0.85	0.79	0.51
B14-III	0.94	0.86	0.81	0.98	0.92	0.86	0.73	0.44	0.86	0.85	1.00	0.95	0.86
B14-IV	0.92	0.80	0.78	0.94	0.87	0.91	0.83	0.65	0.80	0.79	0.95	1.00	0.80
B21-I	0.97	1.00	0.54	0.89	0.99	0.92	0.78	0.42	1.00	0.51	0.86	0.80	1.00
B21-II	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B21-III	0.77	0.62	0.86	0.85	0.71	0.67	0.56	0.56	0.62	0.94	0.91	0.91	0.62
B21-IV	0.57	0.42	0.61	0.60	0.49	0.50	0.39	0.86	0.42	0.66	0.63	0.74	0.42
E43-I	0.31	0.31	0.19	0.29	0.31	0.30	0.26	0.14	0.31	0.17	0.28	0.28	0.31
E43-II	0.40	0.38	0.42	0.39	0.39	0.40	0.34	0.20	0.38	0.23	0.37	0.38	0.38
E43-III	0.53	0.49	0.40	0.55	0.51	0.53	0.45	0.27	0.49	0.34	0.49	0.50	0.49
E43-IV	0.92	0.88	0.58	0.90	0.90	0.91	0.77	0.55	0.88	0.54	0.84	0.87	0.88
B45-I	0.91	0.86	0.54	0.84	0.87	0.89	0.73	0.78	0.86	0.49	0.80	0.87	0.86
B45-II	0.00	0.00	0.00	0.03	0.00	0.06	0.00	0.00	0.00	0.02	0.00	0.00	0.00
B45-III	0.44	0.43	0.27	0.42	0.44	0.43	0.37	0.21	0.43	0.24	0.40	0.39	0.43
B45-IV	0.06	0.00	0.00	0.06	0.00	0.05	0.00	0.68	0.00	0.06	0.00	0.15	0.00
C2-I	0.97	1.00	0.54	0.89	0.99	0.92	0.78	0.42	1.00	0.51	0.86	0.80	1.00
C2-II	0.84	0.82	0.52	0.88	0.83	0.82	0.70	0.40	0.82	0.54	0.77	0.76	0.82
C2-III	0.95	0.94	0.57	0.94	0.95	0.92	0.78	0.44	0.94	0.56	0.86	0.83	0.94
C2-IV	0.95	0.89	0.72	0.99	0.93	0.91	0.77	0.45	0.89	0.74	0.95	0.92	0.89
C8-I	0.97	1.00	0.54	0.89	0.99	0.92	0.78	0.42	1.00	0.51	0.86	0.80	1.00
C8-II	0.87	0.83	0.70	0.89	0.86	0.86	0.74	0.43	0.83	0.54	0.80	0.81	0.83
C8-III	0.97	1.00	0.54	0.89	0.99	0.92	0.78	0.42	1.00	0.51	0.86	0.80	1.00
C8-IV	0.96	0.92	0.57	0.88	0.93	0.93	0.77	0.69	0.92	0.51	0.85	0.88	0.92
C14-II	0.97	1.00	0.54	0.89	0.99	0.92	0.78	0.42	1.00	0.51	0.86	0.80	1.00
C21`-III	0.69	0.67	0.43	0.66	0.68	0.68	0.58	0.33	0.67	0.39	0.63	0.63	0.67
C21`-IV	0.97	1.00	0.54	0.89	0.99	0.92	0.78	0.42	1.00	0.51	0.86	0.80	1.00
C43-I	0.91	0.90	0.56	0.93	0.91	0.89	0.76	0.43	0.90	0.55	0.83	0.81	0.90
C43-II	0.97	0.99	0.57	0.91	0.99	0.94	0.79	0.44	0.99	0.52	0.87	0.83	0.99
C43-III	0.39	0.36	0.25	0.50	0.38	0.39	0.33	0.19	0.36	0.34	0.36	0.37	0.36
C43-IV	0.67	0.59	0.59	0.71	0.64	0.64	0.55	0.35	0.59	0.57	0.70	0.71	0.59
C45-II	0.48	0.45	0.32	0.47	0.47	0.61	0.70	0.40	0.45	0.28	0.45	0.55	0.45
C45`-IV	0.97	1.00	0.54	0.89	0.99	0.92	0.78	0.42	1.00	0.51	0.86	0.80	1.00

	B21-II	B21-III	B21-IV	E43-I	E43-II	E43-III	E43-IV	B45-I	B45-II	B45-III	B45-IV	C2-I	C2-II	C2-III
B2-I	0.00	0.77	0.57	0.31	0.40	0.53	0.92	0.91	0.00	0.44	0.06	0.97	0.84	0.95
B2-II	0.00	0.62	0.42	0.31	0.38	0.49	0.88	0.86	0.00	0.43	0.00	1.00	0.82	0.94
B2-III	0.41	0.86	0.61	0.19	0.42	0.40	0.58	0.54	0.00	0.27	0.00	0.54	0.52	0.57
B2-IV	0.00	0.85	0.60	0.29	0.39	0.55	0.90	0.84	0.03	0.42	0.06	0.89	0.88	0.94
B8-I	0.00	0.71	0.49	0.31	0.39	0.51	0.90	0.87	0.00	0.44	0.00	0.99	0.83	0.95
B8-II	0.00	0.67	0.50	0.30	0.40	0.53	0.91	0.89	0.06	0.43	0.05	0.92	0.82	0.92
B8-III	0.00	0.56	0.39	0.26	0.34	0.45	0.77	0.73	0.00	0.37	0.00	0.78	0.70	0.78
B8-IV	0.00	0.56	0.86	0.14	0.20	0.27	0.55	0.78	0.00	0.21	0.68	0.42	0.40	0.44
B14-I	0.00	0.62	0.42	0.31	0.38	0.49	0.88	0.86	0.00	0.43	0.00	1.00	0.82	0.94
B14-II	0.00	0.94	0.66	0.17	0.23	0.34	0.54	0.49	0.02	0.24	0.06	0.51	0.54	0.56
B14-III	0.00	0.91	0.63	0.28	0.37	0.49	0.84	0.80	0.00	0.40	0.00	0.86	0.77	0.86
B14-IV	0.00	0.91	0.74	0.28	0.38	0.50	0.87	0.87	0.00	0.39	0.15	0.80	0.76	0.83
B21-I	0.00	0.62	0.42	0.31	0.38	0.49	0.88	0.86	0.00	0.43	0.00	1.00	0.82	0.94
B21-II	1.00	0.00	0.00	0.00	0.30	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B21-III	0.00	1.00	0.83	0.21	0.29	0.39	0.68	0.71	0.00	0.30	0.19	0.62	0.58	0.64
B21-IV	0.00	0.83	1.00	0.15	0.20	0.27	0.55	0.74	0.00	0.21	0.59	0.42	0.41	0.44
E43-I	0.00	0.21	0.15	1.00	0.91	0.89	0.55	0.28	0.00	0.99	0.38	0.31	0.27	0.30
E43-II	0.30	0.29	0.20	0.91	1.00	0.94	0.62	0.37	0.00	0.93	0.34	0.38	0.36	0.39
E43-III	0.10	0.39	0.27	0.89	0.94	1.00	0.77	0.49	0.03	0.93	0.41	0.49	0.59	0.58
E43-IV	0.00	0.68	0.55	0.55	0.62	0.77	1.00	0.90	0.02	0.66	0.27	0.88	0.88	0.93
B45-I	0.00	0.71	0.74	0.28	0.37	0.49	0.90	1.00	0.00	0.40	0.36	0.86	0.77	0.86
B45-II	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.00	1.00	0.00	0.06	0.00	0.08	0.05
B45-III	0.00	0.30	0.21	0.99	0.93	0.93	0.66	0.40	0.00	1.00	0.36	0.43	0.38	0.43
B45-IV	0.00	0.19	0.59	0.38	0.34	0.41	0.27	0.36	0.06	0.36	1.00	0.00	0.21	0.11
C2-I	0.00	0.62	0.42	0.31	0.38	0.49	0.88	0.86	0.00	0.43	0.00	1.00	0.82	0.94
C2-II	0.00	0.58	0.41	0.27	0.36	0.59	0.88	0.77	0.08	0.38	0.21	0.82	1.00	0.96
C2-III	0.00	0.64	0.44	0.30	0.39	0.58	0.93	0.86	0.05	0.43	0.11	0.94	0.96	1.00
C2-IV	0.00	0.80	0.56	0.30	0.39	0.57	0.92	0.84	0.04	0.42	0.10	0.89	0.93	0.96
C8-I	0.00	0.62	0.42	0.31	0.38	0.49	0.88	0.86	0.00	0.43	0.00	1.00	0.82	0.94
C8-II	0.28	0.62	0.44	0.28	0.48	0.61	0.89	0.80	0.05	0.40	0.12	0.83	0.93	0.94
C8-III	0.00	0.62	0.42	0.31	0.38	0.49	0.88	0.86	0.00	0.43	0.00	1.00	0.82	0.94
C8-IV	0.00	0.71	0.66	0.30	0.39	0.51	0.93	0.99	0.00	0.42	0.25	0.92	0.81	0.91
C14-II	0.00	0.62	0.42	0.31	0.38	0.49	0.88	0.86	0.00	0.43	0.00	1.00	0.82	0.94
C21`-III	0.00	0.48	0.34	0.22	0.30	0.39	0.67	0.63	0.00	0.32	0.00	0.67	0.61	0.67
C21`-IV	0.00	0.62	0.42	0.31	0.38	0.49	0.88	0.86	0.00	0.43	0.00	1.00	0.82	0.94
C43-I	0.00	0.63	0.43	0.29	0.38	0.59	0.92	0.83	0.06	0.42	0.15	0.90	0.99	0.99
C43-II	0.00	0.64	0.44	0.43	0.49	0.60	0.93	0.87	0.00	0.55	0.05	0.99	0.83	0.95
C43-III	0.00	0.28	0.20	0.13	0.17	0.41	0.49	0.36	0.13	0.18	0.33	0.36	0.76	0.60
C43-IV	0.00	0.64	0.45	0.62	0.69	0.76	0.77	0.60	0.00	0.70	0.19	0.59	0.58	0.62
C45-II	0.00	0.35	0.25	0.16	0.22	0.29	0.48	0.45	0.00	0.22	0.00	0.45	0.43	0.47
C45`-IV	0.00	0.62	0.42	0.31	0.38	0.49	0.88	0.86	0.00	0.43	0.00	1.00	0.82	0.94

	C2-IV	C8-I	C8-II	C8-III	C8-IV	C14-II	C21`-III	C21`-IV	C43-I	C43-II	C43-III	C43-IV	C45-II	C45`-IV
B2-I	0.95	0.97	0.87	0.97	0.96	0.97	0.69	0.97	0.91	0.97	0.39	0.67	0.48	0.97
B2-II	0.89	1.00	0.83	1.00	0.92	1.00	0.67	1.00	0.90	0.99	0.36	0.59	0.45	1.00
B2-III	0.72	0.54	0.70	0.54	0.57	0.54	0.43	0.54	0.56	0.57	0.25	0.59	0.32	0.54
B2-IV	0.99	0.89	0.89	0.89	0.88	0.89	0.66	0.89	0.93	0.91	0.50	0.71	0.47	0.89
B8-I	0.93	0.99	0.86	0.99	0.93	0.99	0.68	0.99	0.91	0.99	0.38	0.64	0.47	0.99
B8-II	0.91	0.92	0.86	0.92	0.93	0.92	0.68	0.92	0.89	0.94	0.39	0.64	0.61	0.92
B8-III	0.77	0.78	0.74	0.78	0.77	0.78	0.58	0.78	0.76	0.79	0.33	0.55	0.70	0.78
B8-IV	0.45	0.42	0.43	0.42	0.69	0.42	0.33	0.42	0.43	0.44	0.19	0.35	0.40	0.42
B14-I	0.89	1.00	0.83	1.00	0.92	1.00	0.67	1.00	0.90	0.99	0.36	0.59	0.45	1.00
B14-II	0.74	0.51	0.54	0.51	0.51	0.51	0.39	0.51	0.55	0.52	0.34	0.57	0.28	0.51
B14-III	0.95	0.86	0.80	0.86	0.85	0.86	0.63	0.86	0.83	0.87	0.36	0.70	0.45	0.86
B14-IV	0.92	0.80	0.81	0.80	0.88	0.80	0.63	0.80	0.81	0.83	0.37	0.71	0.55	0.80
B21-I	0.89	1.00	0.83	1.00	0.92	1.00	0.67	1.00	0.90	0.99	0.36	0.59	0.45	1.00
B21-II	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B21-III	0.80	0.62	0.62	0.62	0.71	0.62	0.48	0.62	0.63	0.64	0.28	0.64	0.35	0.62
B21-IV	0.56	0.42	0.44	0.42	0.66	0.42	0.34	0.42	0.43	0.44	0.20	0.45	0.25	0.42
E43-I	0.30	0.31	0.28	0.31	0.30	0.31	0.22	0.31	0.29	0.43	0.13	0.62	0.16	0.31
E43-II	0.39	0.38	0.48	0.38	0.39	0.38	0.30	0.38	0.38	0.49	0.17	0.69	0.22	0.38
E43-III	0.57	0.49	0.61	0.49	0.51	0.49	0.39	0.49	0.59	0.60	0.41	0.76	0.29	0.49
E43-IV	0.92	0.88	0.89	0.88	0.93	0.88	0.67	0.88	0.92	0.93	0.49	0.77	0.48	0.88
B45-I	0.84	0.86	0.80	0.86	0.99	0.86	0.63	0.86	0.83	0.87	0.36	0.60	0.45	0.86
B45-II	0.04	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.13	0.00	0.00	0.00
B45-III	0.42	0.43	0.40	0.43	0.42	0.43	0.32	0.43	0.42	0.55	0.18	0.70	0.22	0.43
B45-IV	0.10	0.00	0.12	0.00	0.25	0.00	0.00	0.00	0.15	0.05	0.33	0.19	0.00	0.00
C2-I	0.89	1.00	0.83	1.00	0.92	1.00	0.67	1.00	0.90	0.99	0.36	0.59	0.45	1.00
C2-II	0.93	0.82	0.93	0.82	0.81	0.82	0.61	0.82	0.99	0.83	0.76	0.58	0.43	0.82
C2-III	0.96	0.94	0.94	0.94	0.91	0.94	0.67	0.94	0.99	0.95	0.60	0.62	0.47	0.94
C2-IV	1.00	0.89	0.92	0.89	0.89	0.89	0.67	0.89	0.96	0.91	0.57	0.69	0.48	0.89
C8-I	0.89	1.00	0.83	1.00	0.92	1.00	0.67	1.00	0.90	0.99	0.36	0.59	0.45	1.00
C8-II	0.92	0.83	1.00	0.83	0.85	0.83	0.64	0.83	0.94	0.86	0.61	0.62	0.46	0.83
C8-III	0.89	1.00	0.83	1.00	0.92	1.00	0.67	1.00	0.90	0.99	0.36	0.59	0.45	1.00
C8-IV	0.89	0.92	0.85	0.92	1.00	0.92	0.67	0.92	0.88	0.93	0.38	0.62	0.47	0.92
C14-II	0.89	1.00	0.83	1.00	0.92	1.00	0.67	1.00	0.90	0.99	0.36	0.59	0.45	1.00
C21`-III	0.67	0.67	0.64	0.67	0.67	0.67	1.00	0.67	0.65	0.68	0.57	0.80	0.83	0.67
C21`-IV	0.89	1.00	0.83	1.00	0.92	1.00	0.67	1.00	0.90	0.99	0.36	0.59	0.45	1.00
C43-I	0.96	0.90	0.94	0.90	0.88	0.90	0.65	0.90	1.00	0.91	0.66	0.61	0.46	0.90
C43-II	0.91	0.99	0.86	0.99	0.93	0.99	0.68	0.99	0.91	1.00	0.38	0.67	0.47	0.99
C43-III	0.57	0.36	0.61	0.36	0.38	0.36	0.57	0.36	0.66	0.38	1.00	0.48	0.49	0.36
C43-IV	0.69	0.59	0.62	0.59	0.62	0.59	0.80	0.59	0.61	0.67	0.48	1.00	0.68	0.59
C45-II	0.48	0.45	0.46	0.45	0.47	0.45	0.83	0.45	0.46	0.47	0.49	0.68	1.00	0.45
C45`-IV	0.89	1.00	0.83	1.00	0.92	1.00	0.67	1.00	0.90	0.99	0.36	0.59	0.45	1.00

Appendix 3. Day-to-day records of captures and recaptures of *Acomys* sp. for computing Schumacher & Eschmeyer population size estimates (see Krebs 1999: 38-39).

B2-I

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
1st	1	0	1	0
2nd	2	0	2	1
3rd	3	0	3	3
4th	1	0	1	6
5th	4	1	3	7
6th	5	2	3	10
7th	-	-	-	-

C2-I

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
1st	0	0	0	0
2nd	0	0	0	0
3rd	1	0	1	0
4th	2	0	2	1
5th	2	1	1	3
6th	-	-	-	-
7th	-	-	-	-

B2-III

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
1st	1	0	1	0
2nd	0	0	0	1
3rd	2	1	1	1
4th	2	2	0	2
5th	2	1	1	2
6th	2	1	1	3
7th	0	0	0	3

C2-III

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
1st	0	0	0	0
2nd	2	0	2	0
3rd	5	0	5	2
4th	7	4	2	7
5th	8	4	4	10
6th	10	7	3	14
7th	8	8	0	17

B2-II

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
1st	2	0	2	0
2nd	2	0	2	2
3rd	1	1	0	4
4th	1	1	1	4
5th	1	0	1	5
6th	1	1	0	5
7th	-	-	-	-

C2-II

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
1st	0	0	0	0
2nd	0	0	0	0
3rd	0	0	0	0
4th	1	0	1	0
5th	1	0	1	1
6th	1	0	1	2
7th	2	0	2	3

B2-IV

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
1st	4	0	4	0
2nd	1	2	1	4
3rd	5	5	0	5
4th	3	3	0	5
5th	4	4	0	5
6th	3	3	0	5
7th	4	3	1	5

C2-IV

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
1st	2	0	1	0
2nd	5	1	3	2
3rd	5	4	1	6
4th	5	5	0	7
5th	2	2	0	7
6th	2	2	0	7
7th	3	2	1	7

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
	B8-I				**B8-II**			
1st	2	0	2	0	2	0	2	0
2nd	2	1	1	2	4	1	3	2
3rd	2	0	2	3	4	1	3	5
4th	2	0	2	5	6	3	3	8
5th	3	2	1	7	5	5	0	11
6th	-	-	-	-	6	3	3	11
7th	-	-	-	-	3	2	1	14
	C8-I				**C8-II**			
1st	0	0	0	0	0	0	0	0
2nd	1	0	1	0	0	0	0	0
3rd	0	0	0	1	1	0	1	0
4th	0	0	0	1	1	0	1	1
5th	0	0	0	1	2	1	1	2
6th	-	-	-	-	1	1	0	3
7th	-	-	-	-	1	1	0	3
	B8-III				**B8-IV**			
1st	7	0	7	0	2	0	2	0
2nd	9	7	2	7	6	2	4	2
3rd	8	7	1	9	5	5	0	6
4th	7	7	0	10	5	4	1	6
5th	7	7	0	10	5	4	1	7
6th	-	-	-	-	-	-	-	-
7th	-	-	-	-	-	-	-	-
	C8-III				**C8-IV**			
1st	0	0	0	0	1	0	1	0
2nd	0	0	0	0	3	1	2	1
3rd	0	0	0	0	1	1	0	3
4th	1	0	1	0	0	0	0	3
5th	1	1	0	1	0	0	0	3
6th	-	-	-	-	-	-	-	-
7th	-	-	-	-	-	-	-	-

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
		B14-I				**B14-II**		
1st	0	0	0	0	0	0	0	0
2nd	1	0	1	0	0	0	0	0
3rd	0	0	0	1	0	0	0	0
4th	0	0	0	1	1	0	1	0
5th	1	0	1	1	1	0	1	1
6th	-	-	-	-	0	0	0	2
7th	-	-	-	-	2	0	2	2
		C14-I				**C14-II**		
1st	0	0	0	0	0	0	0	0
2nd	0	0	0	0	1	0	1	0
3rd	0	0	0	0	0	0	0	1
4th	0	0	0	0	1	0	1	1
5th	0	0	0	0	0	0	0	2
6th	-	-	-	-	0	0	0	2
7th	-	-	-	-	0	0	0	2
		B14-III				**B14-IV**		
1st	4	0	4	0	1	0	1	0
2nd	3	2	1	4	1	1	0	1
3rd	2	2	0	5	1	1	0	1
4th	5	5	0	5	2	1	1	1
5th	3	3	0	5	1	1	0	2
6th	4	4	0	5	3	2	1	2
7th	3	2	1	5	3	1	2	3
		C14-III				**C14`-IV**[a]		
1st	0	0	0	0	0	0	0	0
2nd	0	0	0	0	0	0	0	0
3rd	0	0	0	0	0	0	0	0
4th	0	0	0	0	0	0	0	0
5th	0	0	0	0	0	0	0	0
6th	0	0	0	0	0	0	0	0
7th	0	0	0	0	0	0	0	0

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
	B21-I				**B21-II**			
1st	0	0	0	0	0	0	0	0
2nd	1	0	1	0	0	0	0	0
3rd	0	0	0	1	0	0	0	0
4th	0	0	0	1	0	0	0	0
5th	2	1	1	1	0	0	0	0
6th	2	1	1	2	0	0	0	0
7th	-	-	-	-	0	0	0	0
	C21-I				**C21-II**			
1st	0	0	0	0	0	0	0	0
2nd	0	0	0	0	0	0	0	0
3rd	0	0	0	0	0	0	0	0
4th	0	0	0	0	0	0	0	0
5th	0	0	0	0	0	0	0	0
6th	0	0	0	0	0	0	0	0
7th	-	-	-	-	0	0	0	0
	B21-III				**B21-IV**			
1st	1	0	1	0	1	0	1	0
2nd	3	1	2	1	0	0	0	1
3rd	1	1	0	3	1	1	0	1
4th	2	2	0	3	0	0	0	1
5th	2	2	0	3	0	0	0	1
6th	2	2	0	3	2	1	1	1
7th	1	1	0	3	1	1	0	2
	C21`-III				**C21`-IV**			
1st	1	0	1	0	1	0	1	0
2nd	1	1	0	1	2	1	1	1
3rd	1	1	0	1	1	1	0	2
4th	1	1	0	1	2	2	0	2
5th	1	1	0	1	0	0	0	2
6th	1	0	1	1	2	1	1	2
7th	1	1	0	2	1	1	0	3

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
	E43-I				**E43-II**			
1st	1	0	1	0	4	0	4	0
2nd	3	1	2	1	4	4	0	4
3rd	2	2	0	3	5	4	1	4
4th	3	3	0	3	5	5	0	5
5th	2	2	0	3	5	5	0	5
6th	-	-	-	-	-	-	-	-
7th	-	-	-	-	-	-	-	-
	C43-I				**C4-II**			
1st	0	0	0	0	1	0	1	0
2nd	1	0	1	0	1	0	1	1
3rd	2	0	2	1	5	1	4	2
4th	3	2	1	3	4	2	2	6
5th	1	0	1	3	5	5	0	6
6th	-	-	-	-	-	-	-	-
7th	-	-	-	-	-	-	-	-
	E43-III				**E43-IV**			
1st	5	0	5	0	4	0	4	0
2nd	3	3	0	5	6	3	3	4
3rd	5	5	0	5	4	4	0	7
4th	5	5	0	5	3	3	0	7
5th	3	3	0	5	3	3	0	7
6th	-	-	-	-	-	-	-	-
7th	-	-	-	-	-	-	-	-
	C43-III				**C43-IV**			
1st	0	0	0	0	0	0	0	0
2nd	1	0	1	0	1	0	1	0
3rd	1	1	0	1	2	1	1	1
4th	0	0	0	1	0	0	0	2
5th	1	1	0	1	1	0	1	2
6th	-	-	-	-	-	-	-	-
7th	-	-	-	-	-	-	-	-

Trap day	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)	No. cought (C_t)	No. recaptures (R_t)	No. newly marked (less deaths)	No. marked at large (M_t)
	B45-I				**B45-II**			
1st	0	0	0	0	0	0	0	0
2nd	0	0	0	0	0	0	0	0
3rd	0	0	0	0	0	0	0	0
4th	1	0	1	0	0	0	0	0
5th	1	0	1	1	0	0	0	0
6th	-	-	-	-	0	0	0	0
7th	-	-	-	-	0	0	0	0
	C45-I				**C45-II**			
1st	0	0	0	0	1	0	1	0
2nd	0	0	0	0	0	0	0	1
3rd	0	0	0	0	0	0	0	1
4th	0	0	0	0	1	0	1	1
5th	0	0	0	0	0	0	0	2
6th	-	-	-	-	2	1	1	2
7th	-	-	-	-	0	0	0	3
	B45-III				**B45-IV**			
1st	0	0	0	0	0	0	0	0
2nd	0	0	0	0	0	0	0	0
3rd	1	0	1	0	0	0	0	0
4th	1	1	0	1	0	0	0	0
5th	0	0	0	1	0	0	0	0
6th	0	0	0	1	0	0	0	0
7th	0	0	0	1	0	0	0	0
	C45-III				**C45[a]-IV**			
1st	0	0	0	0	1	0	1	0
2nd	0	0	0	0	2	1	1	1
3rd	0	0	0	0	4	2	2	2
4th	0	0	0	0	3	3	0	4
5th	0	0	0	0	4	4	0	4
6th	0	0	0	0	5	4	1	4
7th	0	0	0	0	5	4	1	5

[a] Tag designates a change in location of control site during the 3rd or 4th trapping session as explained in text.

Appendix 4. Vegetation data according to study sites and trapping stations.

	C2[b]																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat[a]																									
Eiiti	1	1	1										1						1		1	1	1		
Enchani osinkon																									
Engamoloki						1			1											1		1			
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai	1	1						1									1					1			
Oltangoringoroi																									
Oloireroi																									
Oltepesi									1	1				1			1		1		1				1
Orngoswa	1	1					1				1	1	1					1		1					
Orkiheli	1			1	1		1			1	1	1	1	1	1		1	1			1		1		
Osaragi																									
Olchilishili		1		1	1						1														
Osilalei	1	1		1	1	1	1			1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
Shrubs																									
Engaibor ikunya																									1
Entorboni																									1
Engairrab																									
Eirri		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1
Enkokii																									
Emangulai (Ormangulai)																									
Engoyiangalani																									
Empere epapa	1				1			1		1	1		1		1			1		1	1			1	
Esukari onkishu					1														1						
Esiuwantet	1	1	1			1	1	1			1	1		1	1			1	1		1			1	1
Esenetoi																									
Entulelei		1	1		1	1	1		1		1	1					1				1		1		
Entemelwa	1	1		1													1	1		1			1		
Esiteti				1																					
Olkilenyei																									
Lebornot																									
Enaingongu ndero																									
Orbibiai																									
Oloibor benek				1	1		1						1	1	1				1						
Orkurishashi																									
Olkirgirii																									
Oloikororomi (Engoikororomi)																							1		1
Oltiameleteki		1		1					1					1										1	
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)	1			1	1	1					1				1					1					1
Orporokwai					1	1		1	1				1	1			1	1							
Ormagirigiriani	1	1	1		1	1		1	1	1					1	1	1		1		1	1		1	1
Olairairai						1																			
Beans																									
Maize																									
OPK																									

[a] See partial key of scientific names at end of appendix 4.

[b] Crossed trapping stations in settlement sites represent stations located inside houses without recording of vegetation.

	B2																								
Trees	1	2	3	4	~~5~~	6	7	8	9	10	11	12	13	14	~~15~~	16	17	18	19	20	21	22	~~23~~	24	~~25~~
Entaikaikat																									
Eiiti																									
Enchani osinkon																									
Engamoloki																									
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai	22																								
Oltangoringoroi																									
Oloireroi																									
Oltepesi	7																								
Orngoswa																									
Orkiheli	1																								
Osaragi																									
Olchilishili	1																								
Osilalei	20																								
Shrubs																									
Engaibor ikunya							1							1											
Entorboni																									
Engairrab																									
Eirri							1							1											
Enkokii																									
Emangulai (Ormangulai)																									
Engoyiangalani																									
Empere epapa									1	1															
Esukari onkishu																									
Esiuwantet																									
Esenetoi																									
Entulelei			1	1		1	1	1	1		1	1	1			1	1	1	1	1		1			
Entemelwa		1												1											
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero	1								1	1		1	1			1			1	1				1	
Orbibiai						1			1					1			1			1	1			1	
Oloibor benek																									
Orkurishashi																									
Olkirgirii																									
Oloikororomi (Engoikororomi)		1				1			1		1		1	1		1			1						
Oltiameleteki	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1		1	
Olemurran																									
Oloibor lukunya																									
Olaisikirai																								1	
Ormame (Emame)																									
Orporokwai																					1			1	
Ormagirigiriani																									
Olairairai																									
Beans																				1					
Maize																									
OPK																									

	C8																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat																									
Eiiti					1																				1
Enchani osinkon																									
Engamoloki																									
Empararuai																									
Emaputet																1									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai				1																					
Oltangoringoroi																									
Oloireroi																									
Oltepesi				1											1				1				1		
Orngoswa		1		1	1	1		1					1			1							1		1
Orkiheli	1	1					1	1	1		1			1									1		1
Osaragi																									
Olchilishili			1																						
Osilalei	1	1	1		1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1
Shrubs																									
Engaibor ikunya				1					1											1					
Entorboni					1																				
Engairrab																									
Eirri	1		1			1	1	1		1			1	1	1		1	1	1				1	1	
Enkokii													1												
Emangulai (Ormangulai)																									
Engoyiangalani																									
Empere epapa		1		1	1		1	1							1								1		1
Esukari onkishu																									
Esiuwantet	1	1	1	1		1	1		1	1	1	1					1		1		1		1	1	1
Esenetoi																									
Entulelei	1		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1
Entemelwa	1	1						1	1	1			1			1				1		1	?	1	
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero																									
Orbibiai																									
Oloibor benek																									
Orkurishashi																									
Olkirgirii																									
Oloikororomi (Engoikororomi)						1	1	1	1	1		1	1	1	1		1	1	1	1	1	1	1	1	1
Oltiameleteki	1		1	1	1	1	1	1					1		1				1	1		1	1		1
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)																									
Orporokwai																									
Ormagirigiriani	1	1	1	1	1					1	1	1	1		1	1		1		1	?			1	1
Olairairai																									
Beans																									
Maize																									
OPK														1											

	B8																								
Trees	1	~~2~~	3	4	5	6	7	8	~~9~~	10	11	~~12~~	13	14	15	16	~~17~~	18	19	20	21	22	~~23~~	~~24~~	25
Entaikaikat																									
Eiiti	3																								
Enchani osinkon																									
Engamoloki	3																								
Empararuai																									
Emaputet	1																								
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai																									
Oltangoringoroi																									
Oloireroi																									
Oltepesi	3																								
Orngoswa	7																								
Orkiheli																									
Osaragi																									
Olchilishili																									
Osilalei																									
Shrubs																									
Engaibor ikunya															1										
Entorboni																									
Engairrab																									
Eirri																1						1			
Enkokii						1		1																	
Emangulai (Ormangulai)																									
Engoyiangalani																									
Empere epapa																									
Esukari onkishu																									
Esiuwantet																						1			
Esenetoi																									
Entulelei	1					1	1				1		1					1			1				
Entemelwa					1						1				1						1				
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero																									
Orbibiai	1															1									
Oloibor benek																									
Orkurishashi																									
Olkirgirii																									
Oloikororomi (Engoikororomi)	1		1							1			1									1			
Oltiameleteki	1				1	1																			1
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)																									
Orporokwai																									
Ormagirigiriani																									
Olairairai																									
Beans																									
Maize																									
OPK																									

	C14																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat																									
Eiiti				1				1			1		1							1					
Enchani osinkon																									
Engamoloki						1										1									
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai		1					1		1				1	1											1
Oltangoringoroi																									
Oloireroi																									
Oltepesi			1												1				1		1				
Orngoswa											1					1	1								
Orkiheli	1			1	1				1	1				1		1									
Osaragi																									
Olchilishili				1				1			1				1						1				
Osilalei	1	1	1	1	1	1	1	1	1			1	1	1	1		1	1	1	1	1	1	1	1	1
Shrubs																									
Engaibor ikunya	1	1					1	1					1					1	1						
Entorboni																									
Engairrab										1															
Eirri			1	1		1		1			1		1			1	1		1	1	1			1	1
Enkokii																									
Emangulai (Ormangulai)																				1				1	
Engoyiangalani																									
Empere epapa	1		1		1	1	1	1		1		1				1	1	1	1			1	1		1
Esukari onkishu																									
Esiuwantet	1	1	1	1	1	1	1		1			1	1	1		1	1		1				1		1
Esenetoi																									
Entulelei															1						1		1	1	1
Entemelwa						1						1	1	1			1							1	
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero																									
Orbibiai																									
Oloibor benek																									
Orkurishashi	1																								
Olkirgirii																									
Oloikororomi (Engoikororomi)														1										1	
Oltiameleteki	1	1		1	1	1	1	1		1		1	1				1	1		1		?	1		1
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)		1	1	1				1				1	1		1	1		1	1						
Orporokwai			1	1																					
Ormagirigiriani	1	1	1	1	1	1	1		1		1		1	1	1	1	1	1	1	1		1	1	1	1
Olairairai																									
Beans																									
Maize																									
OPK																									

	B14																								
Trees	1	2	3	4	5	~~6~~	~~7~~	8	~~9~~	10	11	12	13	14	15	16	17	18	19	20	21	22	~~23~~	24	25
Entaikaikat																									
Eiiti																									
Enchani osinkon																									
Engamoloki	1																								
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai	2																								
Oltangoringoroi																									
Oloireroi																									
Oltepesi	6																								
Orngoswa	4																								
Orkiheli																									
Osaragi																									
Olchilishili	2																								
Osilalei	1																								
Shrubs																									
Engaibor ikunya																									
Entorboni																									
Engairrab																									
Eirri																									
Enkokii																									
Emangulai (Ormangulai)																									
Engoyiangalani																1									
Empere epapa																									
Esukari onkishu																									
Esiuwantet										1					1	1									
Esenetoi																									
Entulelei		1			1					1	1				1	1			1	1	1				1
Entemelwa	1		1	1	1																1				1
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero	1	1																							
Orbibiai											1								1						
Oloibor benek																									
Orkurishashi																									
Olkirgirii																									
Oloikororomi (Engoikororomi)	1			1									1	1				1	1	1		1		1	
Oltiameleteki	1									1															
Olemurran		1																							
Oloibor lukunya																									
Olaisikirai		1																							
Ormame (Emame)																									
Orporokwai																									
Ormagirigiriani																				1					
Olairairai																									
Beans											1														
Maize			1																						
OPK																									

	C21																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat																									
Eiiti	1					1								1						1			1		
Enchani osinkon																									
Engamoloki																									
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai				1	1					1					1	1				1	1	1	1	1	
Oltangoringoroi																									
Oloireroi																									
Oltepesi									1	1					1					1					
Orngoswa	1	1	1			1		1	1	1	1			1	1				1		1				
Orkiheli				1	1		1																		
Osaragi																									
Olchilishili	1																								
Osilalei	1			1		1	1				1	1	1		1	1	1	1	1		1	1	1	1	1
Shrubs																									
Engaibor ikunya	1	1	1	1	1	1	1	1		1	1		1			1	1								
Entorboni																									
Engairrab																									
Eirri		1	1			1		1				1	1	1		1		1		1					1
Enkokii			1	1										1											
Emangulai (Ormangulai)																									
Engoyiangalani																									
Empere epapa	1	1	1	1		1	1	1	1			1				1	1	1	1		1	1	1		
Esukari onkishu																									
Esiuwantet	1											1	1	1		1	1	1		1			1		1
Esenetoi																									
Entulelei	1				1				1	1	1		1	1	1		1	1	1	1		1	1	1	1
Entemelwa	1	1	1			1			1		1	1		1					1	1					1
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero																									
Orbibiai																									
Oloibor benek																									
Orkurishashi																									
Olkirgirii																									
Oloikororomi (Engoikororomi)					1				1												1	1	1		
Oltiameleteki	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)																			1					1	
Orporokwai																									
Ormagirigiriani	1	1			1				1	1		1						1	1	1	1	1			
Olairairai																									
Beans																									
Maize																									
OPK													1		1										

	B21																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat																									
Eiiti																									
Enchani osinkon																									
Engamoloki	18																								
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan	1																								
Enchurrai																									
Oltangoringoroi																									
Oloireroi																									
Oltepesi	7																								
Orngoswa																									
Orkiheli	25																								
Osaragi																									
Olchilishili	10																								
Osilalei	15																								
Shrubs																									
Engaibor ikunya																									
Entorboni																									
Engairrab																									
Eirri									1																
Enkokii																									
Emangulai (Ormangulai)																									
Engoyiangalani																									
Empere epapa																									
Esukari onkishu																									
Esiuwantet																									
Esenetoi															1										
Entulelei		1	1					1	1				1			1			1	1		1		1	1
Entemelwa																									
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero				1	1																				
Orbibiai		1		1	1										1				1		1				
Oloibor benek																									
Orkurishashi																									
Olkirgirii																									
Oloikororomi (Engoikororomi)	1	1	1					1	1			1		1	1	1	1		1	1	1	1			1
Oltiameleteki		1	1	1	1																1				
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)																									
Orporokwai																									
Ormagirigiriani																									
Olairairai				1																					
Beans																									
Maize																									
OPK																									

	C43																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat	1		1						1	1	1		1	1	1	1	1	1	1	1		1	1	1	1
Eiiti																									
Enchani osinkon																									
Engamoloki	1			1	1	1	1															1			
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																						1			
Ormukutan																									
Enchurrai	1	1	1	1	1	1	1	1	1	1			1		1			1	1	1	1	1	1	1	1
Oltangoringoroi																									
Oloireroi																									
Oltepesi				1	1											1	1				1				
Orngoswa																									
Orkiheli																									
Osaragi																									
Olchilishili																									
Osilalei	1	1													1									1	1
Shrubs																									
Engaibor ikunya	1			1	1	1		1	1	1	1			1		1	1		1	1	1	1	1	1	1
Entorboni														1											
Engairrab						1																			
Eirri	1	1	1	1	1	1		1	1		1	1	1	1	1	1	1	1	1						
Enkokii																									
Emangulai (Ormangulai)																									
Engoyiangalani																									
Empere epapa																									
Esukari onkishu																									
Esiuwantet	1		1	1						1					1	1	1	1	1			1	1		
Esenetoi																									
Entulelei	1	1			1	1	1	1	1	1		1	1		1					1	1		1		
Entemelwa			1				1	1							1										
Esiteti	1																								
Olkilenyei																									
Lebornot							1																		
Enaingongu ndero																									
Orbibiai																									
Oloibor benek																									
Orkurishashi									1						1	1	1			1	1	1	1	1	1
Olkirgirii																									
Oloikororomi (Engoikororomi)	1		1	1				1	1	1		1				1	1			1					
Oltiameleteki																									
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)	1									1														1	
Orporokwai																									
Ormagirigiriani							1																	1	
Olairairai																									
Beans																									
Maize																									
OPK																									

	E43																								
Trees	1	~~2~~	3	4	5	~~6~~	7	8	9	10	~~11~~	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat	5																								
Eiiti																									
Enchani osinkon																									
Engamoloki																									
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai																									
Oltangoringoroi																									
Oloireroi																									
Oltepesi	2																								
Orngoswa																									
Orkiheli																									
Osaragi																									
Olchilishili																									
Osilalei																									
Shrubs																									
Engaibor ikunya																									
Entorboni																									
Engairrab																									
Eirri																									
Enkokii																									
Emangulai (Ormangulai)																									
Engoyiangalani			1																						
Empere epapa																									
Esukari onkishu																									
Esiuwantet																									
Esenetoi																									
Entulelei																					1				
Entemelwa				1																					
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero																									
Orbibiai	1		1	1	1		1									1					1	1	1		
Oloibor benek																									
Orkurishashi	1																								
Olkirgirii																									
Oloikororomi (Engoikororomi)																1									
Oltiameleteki																									
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)																									
Orporokwai																									
Ormagirigiriani																									
Olairairai																									
Beans																									
Maize																									
OPK																									

	C45																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat																									
Eiiti							1										1								
Enchani osinkon																									
Engamoloki		1	1				1				1			1				1	1				1		1
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai																									
Oltangoringoroi																									
Oloireroi																									
Oltepesi						1								1						1	1				
Orngoswa						1																			
Orkiheli																									
Osaragi																									
Olchilishili																									
Osilalei	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Shrubs																									
Engaibor ikunya	1	1		1	1	1	1		1		1			1	1	1	1	1		1	1	1		1	1
Entorboni																									
Engairrab														1		1									
Eirri												1		1		1			1			1			
Enkokii																									
Emangulai (Ormangulai)								1																	
Engoyiangalani																									
Empere epapa																									
Esukari onkishu																									
Esiuwantet	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1		1		1	1	1	1	1
Esenetoi																									
Entulelei			1	1	1		1	1		1	1	1	1	1	1			1	1		1		1		
Entemelwa	1				1	1				1	1					1		1		1	1		1	1	1
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero																									
Orbibiai																	1								
Oloibor benek																									
Orkurishashi	1	1	1	1	1		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
Olkirgirii																									
Oloikororomi (Engoikororomi)		1	1	1	1	1			1		1		1		1	1	1	1				1	1		1
Oltiameleteki																									
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)	1			1																			1	1	
Orporokwai																									
Ormagirigiriani							1			1									1	1				1	
Olairairai																									
Beans																									
Maize																									
OPK																									

	B45																								
Trees	1	~~2~~	3	4	5	6	~~7~~	~~8~~	~~9~~	~~10~~	11	12	~~13~~	~~14~~	15	16	~~17~~	18	19	20	21	22	~~23~~	24	~~25~~
Entaikaikat																									
Eiiti																									
Enchani osinkon																									
Engamoloki	7																								
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai																									
Oltangoringoroi																									
Oloireroi	2																								
Oltepesi																									
Orngoswa																									
Orkiheli																									
Osaragi																									
Olchilishili																									
Osilalei																									
Shrubs																									
Engaibor ikunya																									
Entorboni																									
Engairrab																									
Eirri																									
Enkokii																						1			
Emangulai (Ormangulai)																									
Engoyiangalani																									
Empere epapa																									
Esukari onkishu																									
Esiuwantet																									
Esenetoi																									
Entulelei						1					1										1				
Entemelwa	1															1									
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero					1																				
Orbibiai																									
Oloibor benek																									
Orkurishashi																									
Olkirgirii																									
Oloikororomi (Engoikororomi)	1										1														
Oltiameleteki																									
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)																									
Orporokwai																									
Ormagirigiriani																									
Olairairai																									
Beans																									
Maize																									
OPK																									

	C14'																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat																									
Eiiti					1		1	1					1		1	1	1	1	1	1	1			1	1
Enchani osinkon																									
Engamoloki																1					1	1			
Empararuai																									
Emaputet													1												
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai																1									
Oltangoringoroi																									
Oloireroi																									
Oltepesi				1	1				1								1	1	1						
Orngoswa							1	1		1	1	1		1						1	1			1	1
Orkiheli												1		1											
Osaragi																									
Olchilishili				1							1														
Osilalei	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1		1	1	1	1	1	1	1	1
Shrubs																									
Engaibor ikunya	1																								
Entorboni																									
Engairrab			1				1	1	1	1															
Eirri	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Enkokii															1			1	1		1	1	1	1	
Emangulai (Ormangulai)																			1	1	1			1	
Engoyiangalani																									
Empere epapa		1												1											
Esukari onkishu																									
Esiuwantet																									
Esenetoi																									
Entulelei			1			1				1			1			1	1			1					1
Entemelwa																									
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero	1					1	1	1																	
Orbibiai																									
Oloibor benek																									
Orkurishashi											1														
Olkirgirii																									
Oloikororomi (Engoikororomi)																									
Oltiameleteki			1		1					1			1					1	1						
Olemurran																									
Oloibor lukunya						1															1	1			
Olaisikirai																									
Ormame (Emame)	1	1		1	1	1																			
Orporokwai	1	1		1		1			1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1
Ormagirigiriani			1										1	1							1				
Olairairai																									
Beans																									
Maize																									
OPK																									

	C21'																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat																									
Eiiti	1	1							1		1	1			1			1	1		1	1		1	1
Enchani osinkon																									
Engamoloki		1										1													
Empararuai																									
Emaputet																				1					
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai	1	1										1		1		1	1								
Oltangoringoroi																									
Oloireroi																									
Oltepesi						1				1			1			1			1				1		
Orngoswa																									
Orkiheli					1		1										1								
Osaragi																									
Olchilishili	1	1																							
Osilalei			1	1		1		1			1	1				1			1		1				
Shrubs																									
Engaibor ikunya																									
Entorboni																									
Engairrab																									
Eirri	1	1	1		1	1	1	1			1		1	1	1	1	1	1	1		1	1		1	1
Enkokii																									
Emangulai (Ormangulai)							1	1			1						1								
Engoyiangalani																									
Empere epapa					1		1																1		
Esukari onkishu																									
Esiuwantet				1	1		1	1	1		1				1										
Esenetoi																									
Entulelei	1	1	1	1	1	1		1	1	1	1	1				1		1	1	1	1	1		1	1
Entemelwa	1	1												1		1									
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero	1	1		1		1		1	1	1	1	1	1		1	1				1				1	
Orbibiai									1						1										
Oloibor benek																									
Orkurishashi	1	1			1	1	1	1			1	1	1									1			1
Olkirgirii																									
Oloikororomi (Engoikororomi)	1	1						1	1	1		1	1	1	1	1		1	1		1	1	1	1	
Oltiameleteki																									
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)																									
Orporokwai		1																							
Ormagirigiriani											1	1						1			1				
Olairairai																									
Beans																									
Maize																									
OPK																									

	C45'																								
Trees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Entaikaikat																									
Eiiti	1												1		1	1	1		1			1			
Enchani osinkon																									
Engamoloki																									
Empararuai																									
Emaputet																									
Eremit																									
Engonerei																									
Orbili																									
Ormukutan																									
Enchurrai							1																		1
Oltangoringoroi																									
Oloireroi															1										
Oltepesi		1			1			1		1				1					1			1	1	1	1
Orngoswa																									
Orkiheli																									
Osaragi																									
Olchilishili																									
Osilalei			1	1	1	1			1		1	1	1			1	1	1	1	1	1		1	1	1
Shrubs																									
Engaibor ikunya		1	1				1	1	1	1			1												
Entorboni																									
Engairrab					1					1				1	1				1						
Eirri				1			1			1					1		1	1	1	1			1		
Enkokii																									
Emangulai (Ormangulai)								1		1															
Engoyiangalani																									
Empere epapa																									
Esukari onkishu																									
Esiuwantet		1	1					1	1				1								1			1	1
Esenetoi																									
Entulelei	1	1		1		1	1					1		1	1		1		1					1	
Entemelwa																									
Esiteti																									
Olkilenyei																									
Lebornot																									
Enaingongu ndero						1																			
Orbibiai																									
Oloibor benek																									
Orkurishashi																									
Olkirgirii																									
Oloikororomi (Engoikororomi)																									
Oltiameleteki		1										1													
Olemurran																									
Oloibor lukunya																									
Olaisikirai																									
Ormame (Emame)	1					1					1	1		1		1				1	1	1			
Orporokwai																									
Ormagirigiriani																									
Olairairai																									
Beans																									
Maize																									
OPK																									

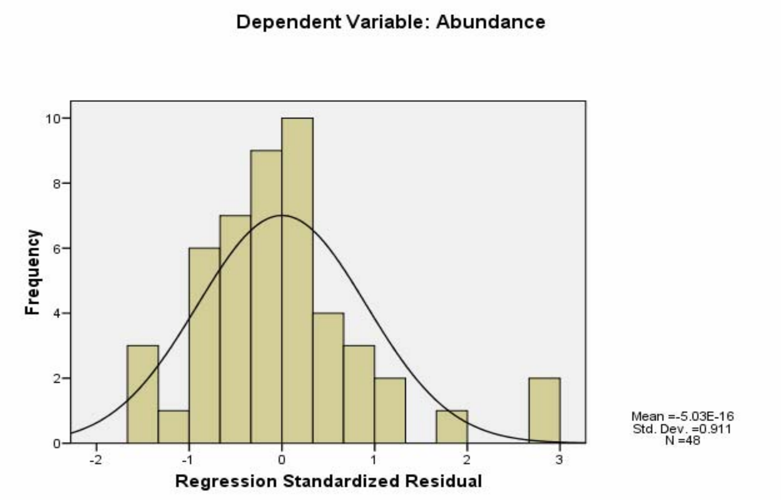
Partial key of scientific names:

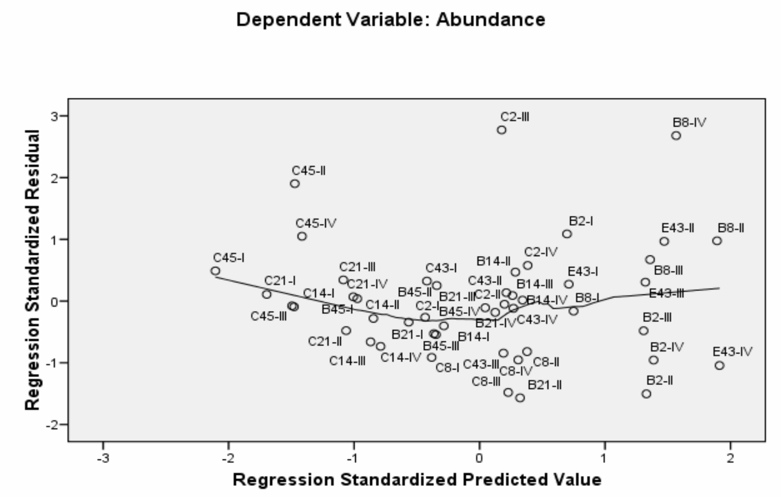
Maa name	Scientific name	Source
Trees		
Entaikaikat	*Acacia thomasii*	Dale and Greenway 1961
Eiiti	*Acacia mellifera*	Dale and Greenway 1961
Enchani osinkon	*Boscia mossambicensis*	Dale and Greenway 1961
Engamoloki	*Boscia coriacea/Maerua triphylia*	Dale and Greenway 1961
Empararuai	*Acacia siebenana*	Research assistant - personal knowledge
Emaputet	*?*	
Eremit	*Salvadora persica*	Dale and Greenway 1961
Engonerei	*Commiphora campestris*	Dale and Greenway 1961
Orbili	*Commiphora baluensis [specialis?]*	Dale and Greenway 1961
Ormukutan	*Albizia anthelmintica*	Dale and Greenway 1961
Enchurrai	*Acacia seyal*	Research assistant - personal knowledge
Oltangoringoroi	*Delonix elata*	Dale and Greenway 1961
Oloireroi	*Boscia angustifolia/Maerua endlichii*	Dale and Greenway 1961
Oltepesi	*Acacia tortilis*	Dale and Greenway 1961
Orngoswa	*Balanites glabra*	Dale and Greenway 1961
Orkiheli	*?*	
Osaragi	*Balanites aegyptiaca*	Dale and Greenway 1961
Olchilishili	*Commiphora sp.*	
Osilalei	*Commiphora africana*	Mol 1996
Shrubs		
Engaibor ikunya	*Sericocomosis hildebrandtii*	Research assistant - personal knowledge
Entorboni	*Syzygium cordatum*	Dale and Greenway 1961
Engairrab	*Grewia similis*	Dale and Greenway 1961
Eirri	*Grewia tenax*	Research assistant - personal knowledge
Enkokii	*Lycium europaeum*	Dale and Greenway 1961
Emangulai (Ormangulai)	*Grewia villosa*	Dale and Greenway 1961
Engoyiangalani	*?*	
Empere epapa	*Asparagus africanus*	Mol 1996
Esukari onkishu	*Melhania* sp.	Research assistant - personal knowledge
Esiuwantet	*Hibiscus/Urtica*	Mol 1996
Esenetoi	*Senna septemtrionalis*	Dale and Greenway 1961
Entulelei	*Solanum incanum*	Dale and Greenway 1961
Entemelwa	*Solanum taitense*	Dale and Greenway 1961
Esiteti	*Grewia bicolor*	Research assistant - personal knowledge
Olkilenyei	*Rhoicissus tridentata*	Dale and Greenway 1961
Lebornot	*Grewia tembensis*	Dale and Greenway 1961
Enaingongu ndero	*?*	
Orbibiai	*Leonotis mollissima/nepetifolia*	Dale and Greenway 1961
Oloibor benek	*Croton megalocarpus*	Mol 1996
Orkurishashi	*Barleria ramulasa*	Mol 1996
Olkirgirii	*Acasia brevispica*	Dale and Greenway 1961
Oloikororomi (Engoikororomi)	*Abutilon grandiflorum*	Research assistant - personal knowledge
Oltiameleteki	*Ipomoea hildebrandtii*	Dale and Greenway 1961
Olemurran	*Hoslundia opposita*	Dale and Greenway 1961
Oloibor lukunya	*Combertum* sp.	Research assistant - personal knowledge
Olaisikirai	*Heliotropium undulatitulia*	Research assistant - personal knowledge
Ormame (Emame)	*Euphorbia* sp.	Mol 1996
Orporokwai	*Lipia javanica*	Mol 1996
Ormagirigiriani	*Lantana trifolia*	Dale and Greenway 1961
Olairairai	*Crotalana agatiflora*	Dale and Greenway 1961
Beans	*?*	
Maize	*?*	
OPK	*?*	

Appendix 5. Post-hoc statistics and visual aids for evaluating whether the multiple regression models uphold the basic assumptions of regression analysis.

The following pages include evauation of assumptions of:
1. Homoscedasticity (constant variance of residuals) - scatterplots of standardized residuals on standardized predicted values fitted with lowess lines.
2. Autocorrelation (independence of residuals) - Durbin-Watson statistic.
3. Normality of residuals - histogram of residuals with normal curve overlay.
4. Power (probability of type II error) - established from tables in Cohen et al. 2003: 650.
5. Precision - confidence intervals.

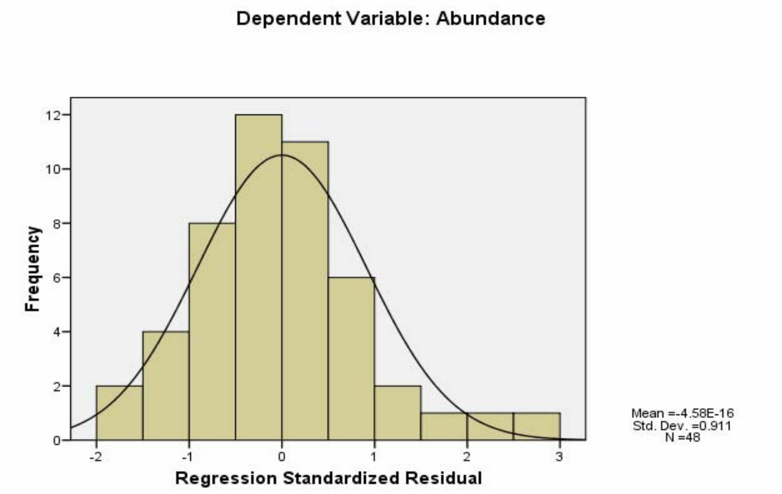
Abundance - Model I: Age-Int2Cat	R^2	*p*	Durbin-Watson[a]	95% Confidence Interval[b] Lower bound	95% Confidence Interval[b] Upper bound	Tolerance	Power (α=.01)
	.510	.000	1.586				.99
HOLevel							
Age				-9.320	-2.159	.767	
Int2Cat						.473	
SiteType				2.221	8.285	.925	
Seasonality							
S1						.604	
S2						.667	
S3						.630	
Abandonment						.528	
TrapDeaths						.717	

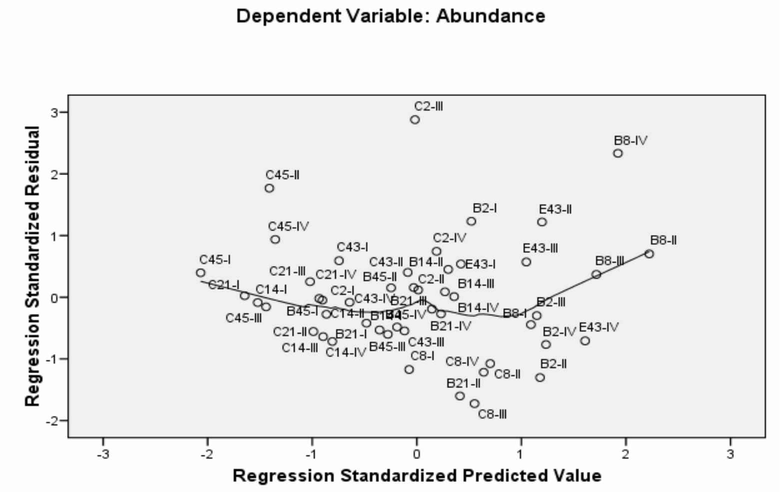




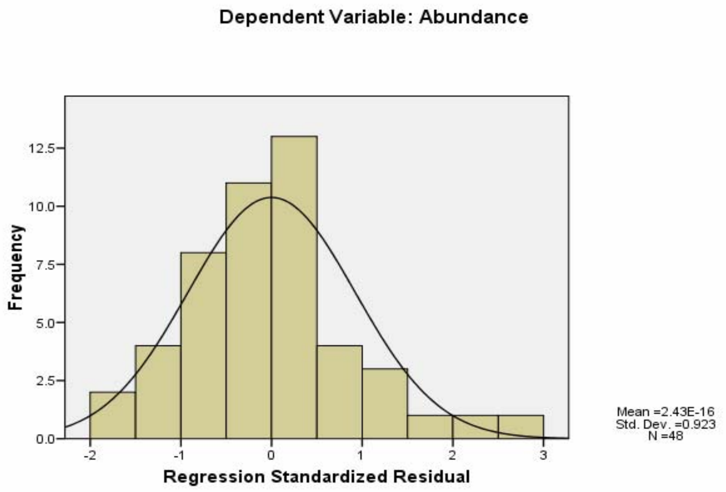
[a] Underline indicates rejection of hypothesis of autocorrelation is inconclusive. Bold indicates hypothesis of autocorrelation can be rejected.
[b] CI presented only for variables that had a significant contribution to explained variability as shown in the text (Tables 7.10-7.14).

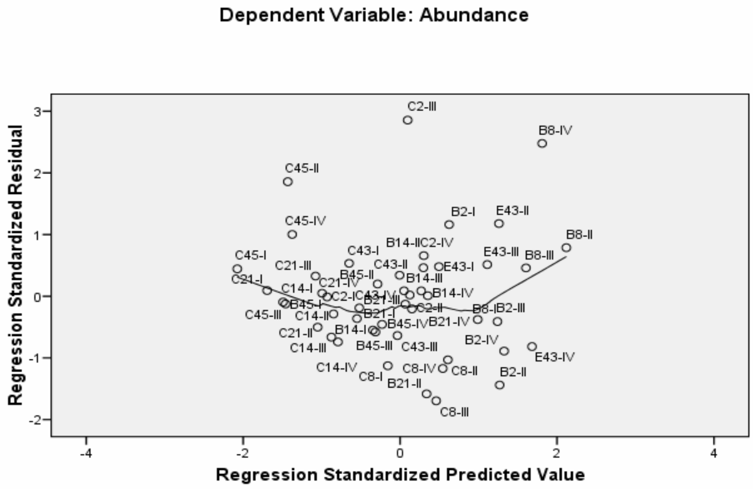
Abundance - Model I: Age-Int4Cat				95% Confidence Interval			
	R^2	*p*	Durbin-Watson	Lower bound	Upper bound	Tolerance	Power
	.485	.001	1.503				.95
HOLevel							
Age				-7.975	-.925	.832	
Int2Cat						.520	
SiteType				2.167	8.385	.925	
Seasonality							
S1						.604	
S2						.667	
S3						.630	
Abandonment				.755	9.762	.496	
TrapDeaths						.715	



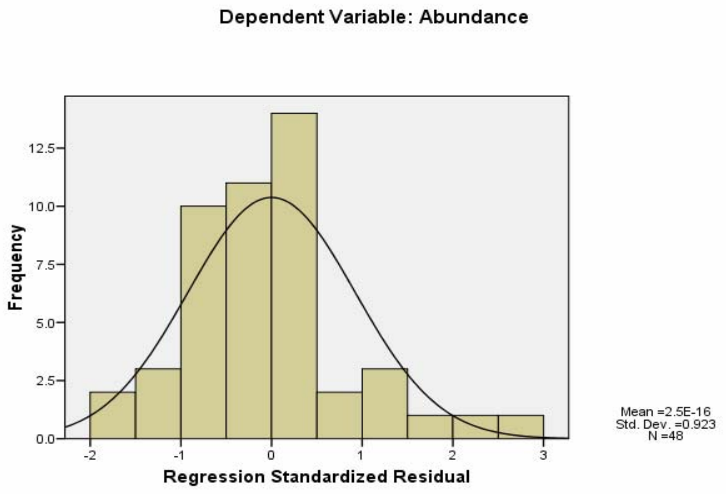


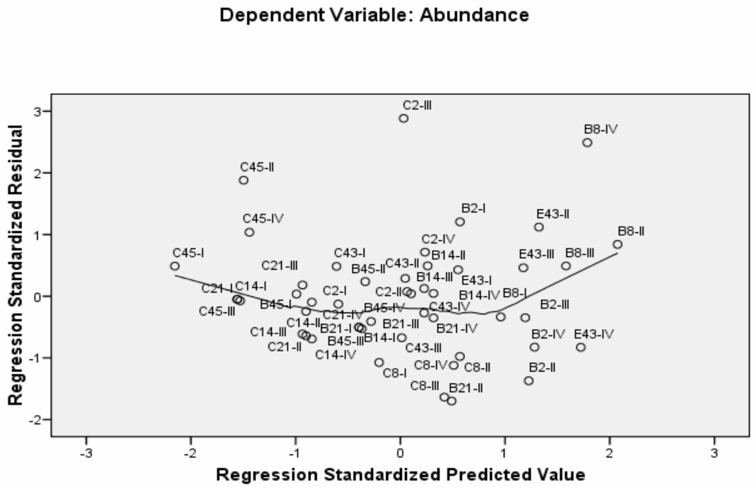
Abundance - Model I: AgeInt2Cat				95% Confidence Interval			
	R^2	*p*	Durbin-Watson	Lower bound	Upper bound	Tolerance	Power
	.501	.000	<u>1.540</u>				.99
HOLevel				-8.705	-1.876	.998	
SiteType				2.246	8.288	.925	
Seasonality							
S1						.604	
S2						.667	
S3						.630	
Abandonment				1.557	8.157	.872	
TrapDeaths						.718	



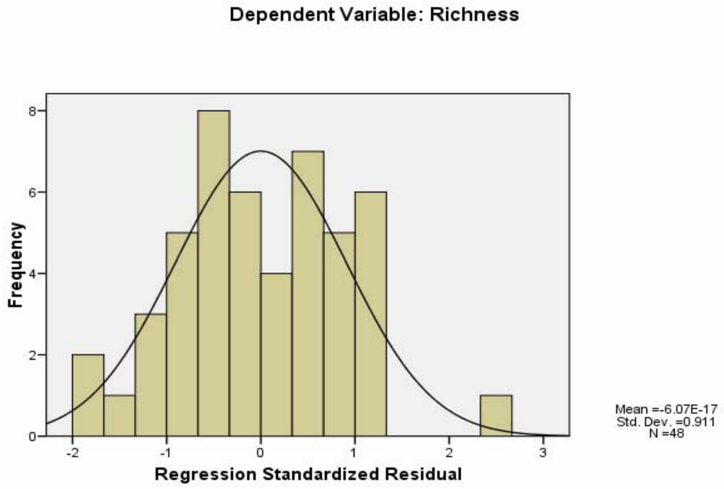


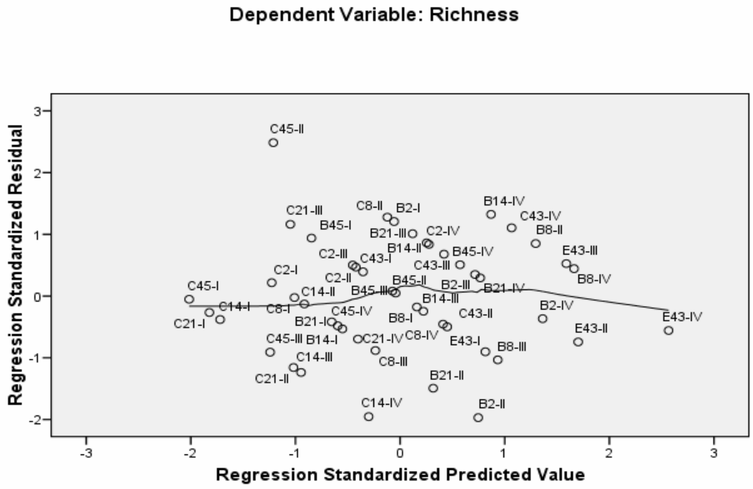
Abundabce - Model I: AgeInt4Cat	R^2	*p*	Durbin-Watson	95% Confidence Interval Lower bound	Upper bound	Tolerance	Power
	.489	.000	1.515				.99
HOLevel				-7.255	-1.352	.987	
SiteType				2.227	8.338	.925	
Seasonality							
S1						.604	
S2						.667	
S3						.630	
Abandonment				1.006	7.698	.868	
TrapDeaths						.717	



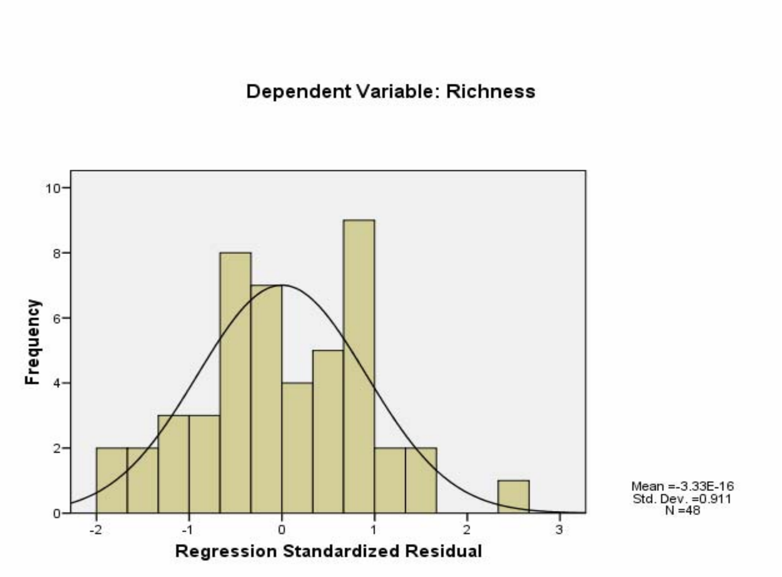


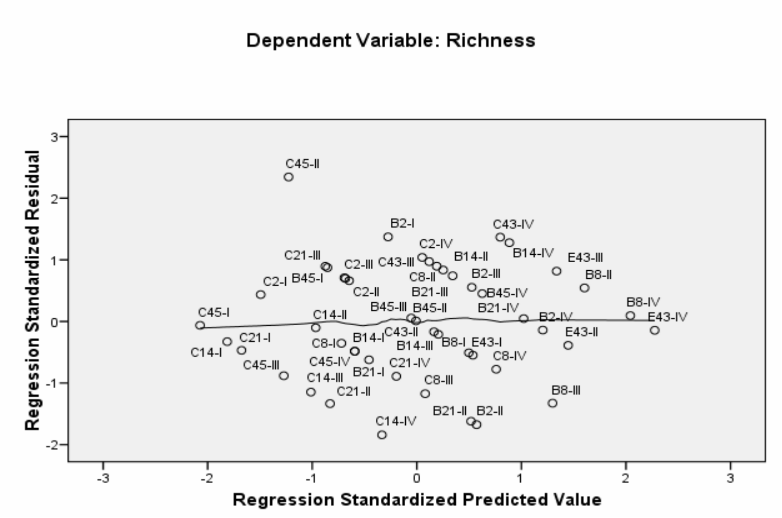
Richness - Model I: Age-Int2Cat	R^2	*p*	Durbin-Watson	95% Confidence Interval Lower bound	95% Confidence Interval Upper bound	Tolerance	Power
	.597	.000	2.378				.99
HOLevel							
Age						.767	
Int2Cat				-2.045	-.052	.473	
SiteType				.602	1.664	.925	
Seasonality							
S1				.021	1.539	.604	
S2				.028	1.472	.667	
S3				.633	2.120	.630	
Abandonment						.528	
TrapDeaths						.717	



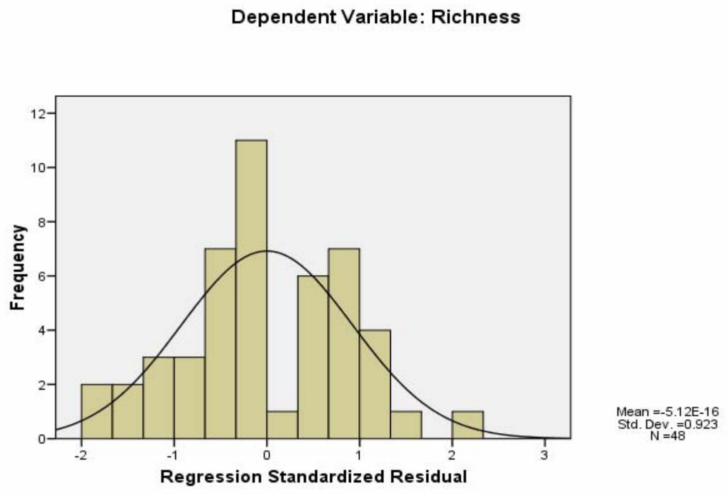


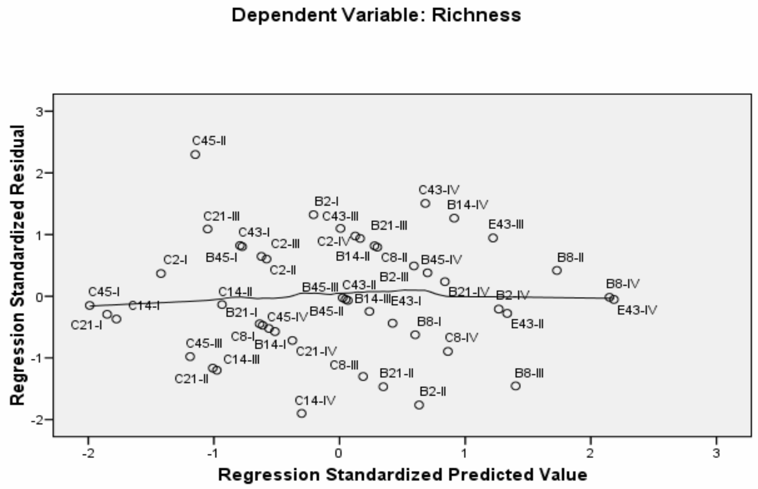
Richness - Model I: Age-Int4Cat	R^2	*p*	Durbin-Watson	95% Confidence Interval		Tolerance	Power
				Lower bound	Upper bound		
	.557	.000	<u>2.208</u>				.99
HOLevel							
Age						.832	
Int2Cat						.520	
SiteType				.585	1.698	.925	
Seasonality							
S1						.604	
S2						.667	
S3				.608	2.165	.630	
Abandonment				.019	1.631	.496	
TrapDeaths						.715	



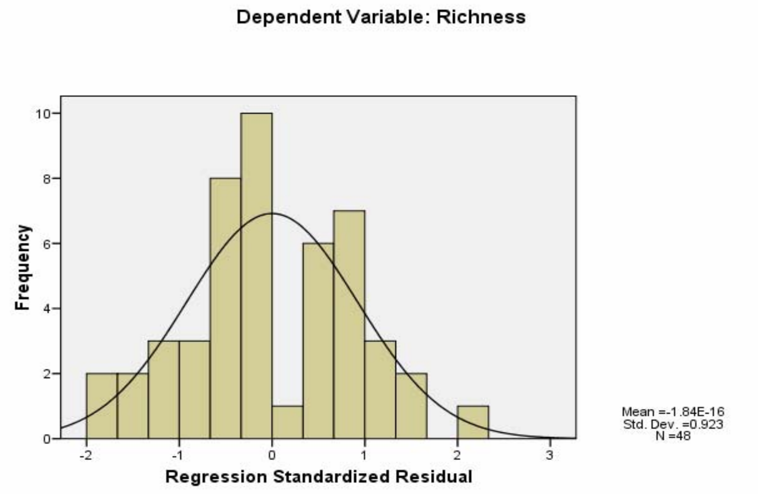


Richness - Model I: AgeInt2Cat				95% Confidence Interval			
	R^2	*p*	Durbin-Watson	Lower bound	Upper bound	Tolerance	Power
	.559	.000	2.216				.99
HOLevel						.998	
SiteType				.591	1.687	.925	
Seasonality							
S1				.005	1.572	.604	
S2				.004	1.496	.667	
S3				.616	2.150	.630	
Abandonment				.397	1.595	.872	
TrapDeaths						.718	

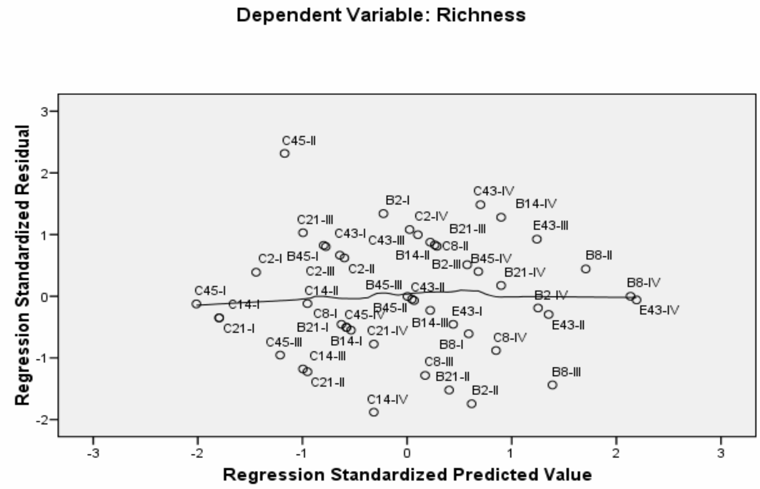




Richness - Model I: AgeInt4Cat				95% Confidence Interval			
	R^2	*p*	Durbin-Watson	Lower bound	Upper bound	Tolerance	Power
	.557	.000	<u>2.211</u>				.99
HOLevel						.987	
SiteType				.591	1.689	.925	
Seasonality							
S1				.006	1.575	.604	
S2				.003	1.497	.667	
S3				.616	2.153	.630	
Abandonment				.357	1.559	.868	
TrapDeaths						.717	

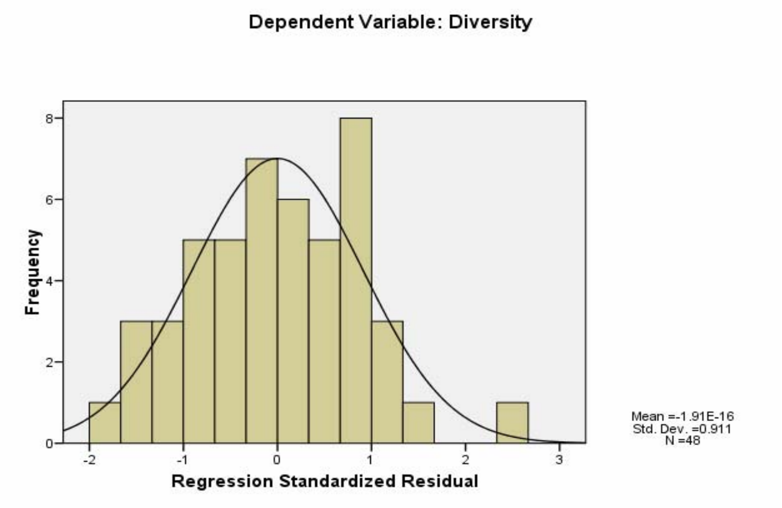


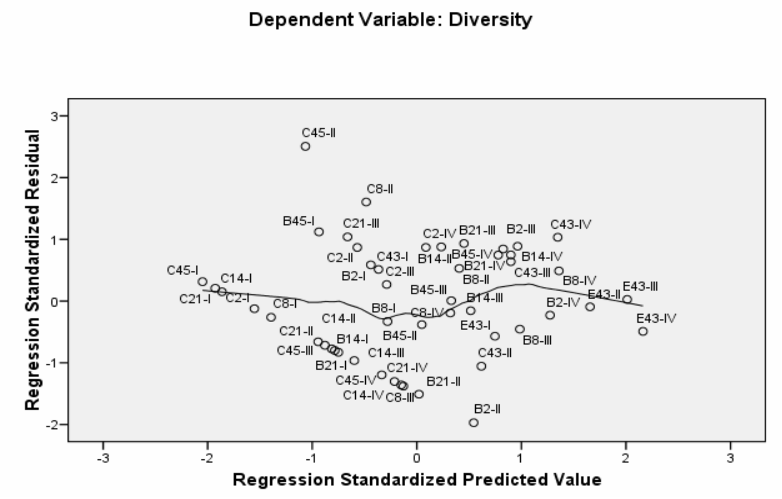
Dependent Variable: Richness



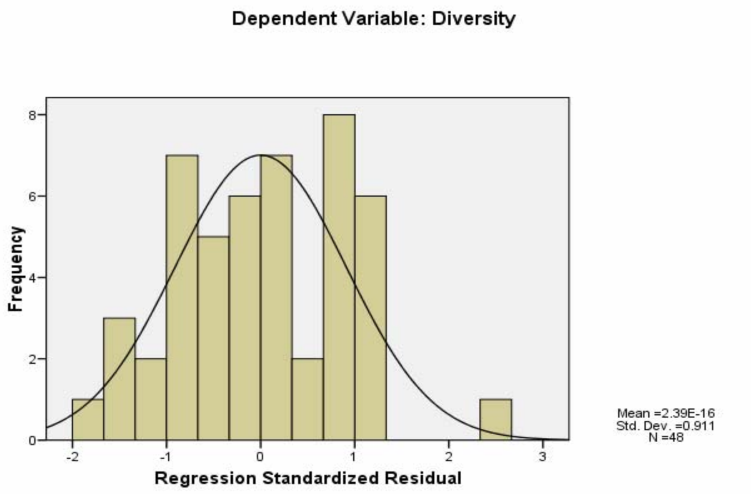
Dependent Variable: Richness

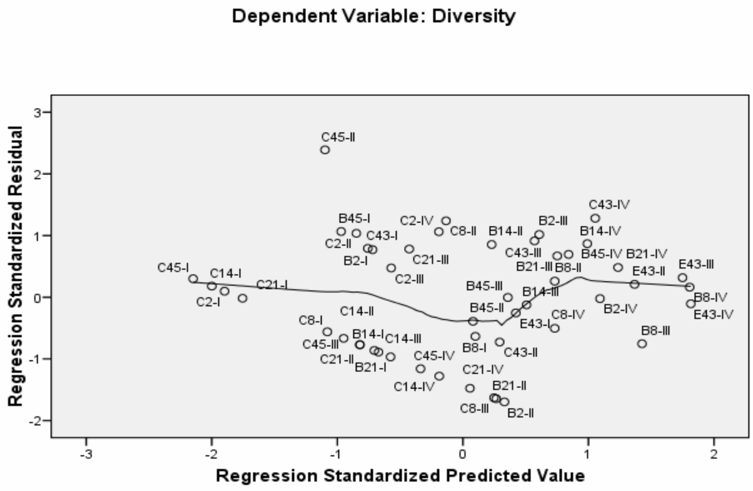
Diversity - Model I: Age-Int2Cat	R^2	*p*	Durbin-Watson[a]	95% Confidence Interval[b]		Tolerance	Power
				Lower bound	Upper bound		
	.483	.001	2.501				.95
HOLevel							
Age						.767	
Int2Cat				-.812	-.001	.473	
SiteType				.133	.565	.925	
Seasonality							
S1				.000	.617	.604	
S2				.103	.691	.667	
S3				.235	.840	.630	
Abandonment						.528	
TrapDeaths						.717	



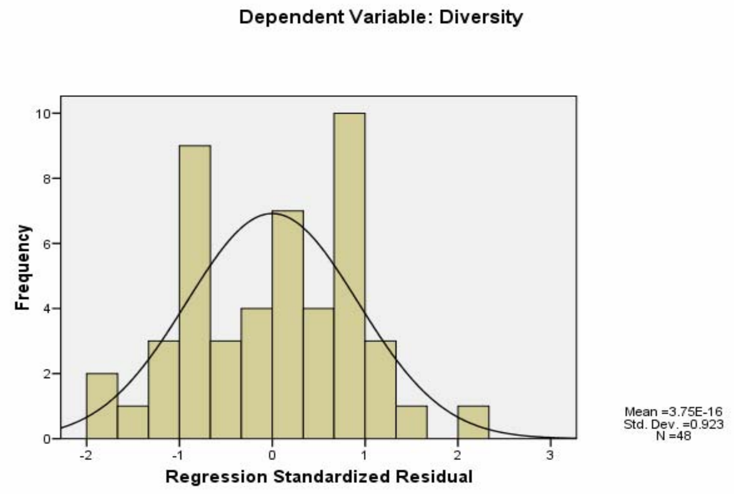


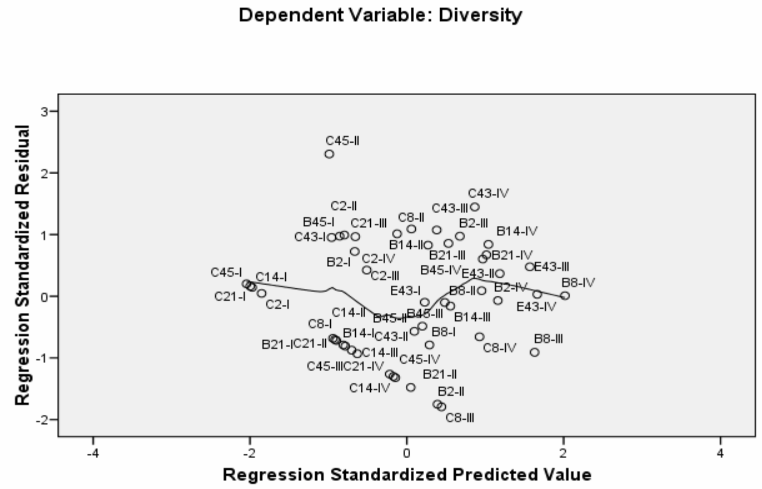
Diversity - Model I: Age-Int4Cat				95% Confidence Interval			
	R^2	p	Durbin-Watson	Lower bound	Upper bound	Tolerance	Power
	.439	.002	2.356				.95
HOLevel							
Age						.832	
Int2Cat						.520	
SiteType				.127	.578	.925	
Seasonality							
S1						.604	
S2				.090	.703	.667	
S3				.226	.856	.630	
Abandonment						.496	
TrapDeaths						.715	


Dependent Variable: Diversity

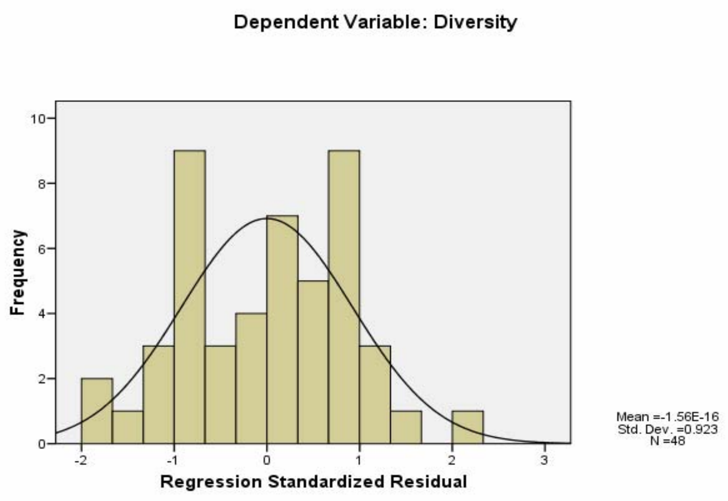

Dependent Variable: Diversity

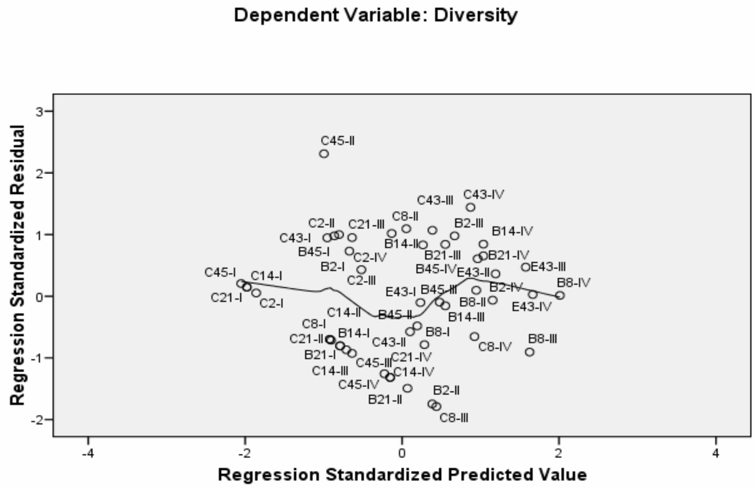
Diversity - Model I: AgeInt2Cat				95% Confidence Interval			
	R^2	*p*	Durbin-Watson	Lower bound	Upper bound	Tolerance	Power
	.431	.001	<u>2.325</u>				.95
HOLevel						.998	
SiteType				.128	.575	.925	
Seasonality							
S1						.604	
S2				.092	.701	.667	
S3				.227	.853	.630	
Abandonment				.063	.552	.872	
TrapDeaths						.718	



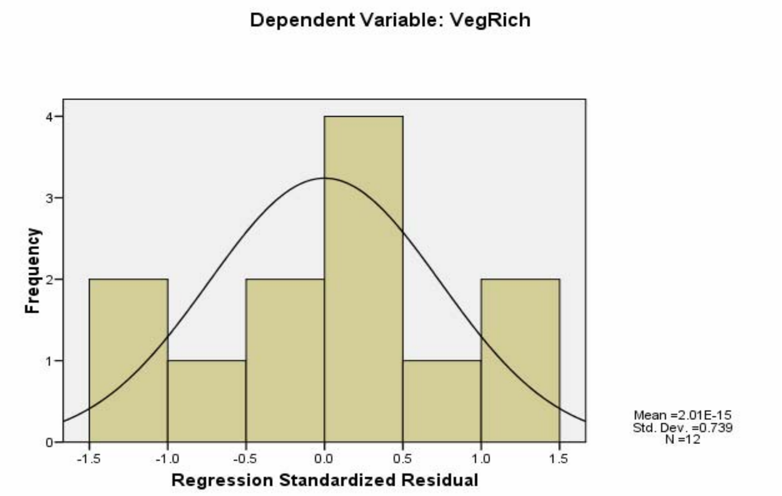


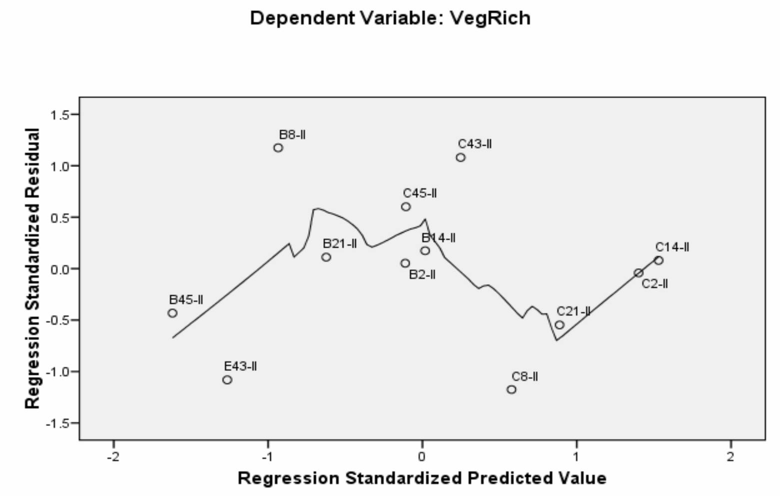
Diversity - Model I: AgeInt4Cat	R^2	*p*	Durbin-Watson	95% Confidence Interval Lower bound	95% Confidence Interval Upper bound	Tolerance	Power
	.430	.001	2.325				.95
HOLevel						.987	
SiteType				.128	.575	.925	
Seasonality							
S1						.604	
S2				.092	.701	.667	
S3				.227	.854	.630	
Abandonment				.058	.549	.868	
TrapDeaths						.717	



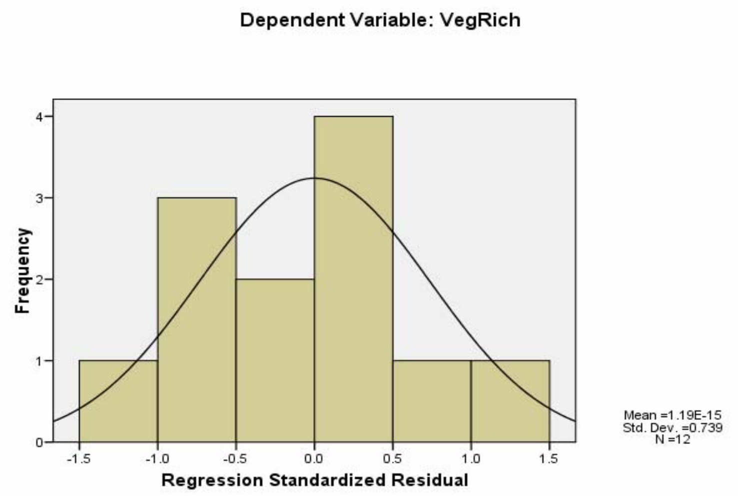


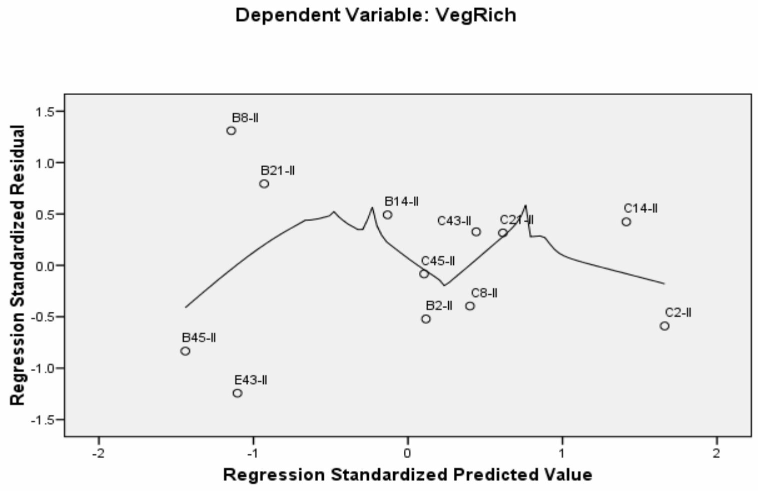
Richness - Model II: Age-Int2Cat				95% Confidence Interval			
	R^2	*p*	Durbin-Watson	Lower bound	Upper bound	Tolerance	Power
	.955	.001	1.732				.99
HOLevel							
Age						.620	
Int2Cat				.523	15.803	.193	
SiteType				-11.671	-6.662	1.000	
Abandonment						.440	
Households				-2.632	-.721	.396	



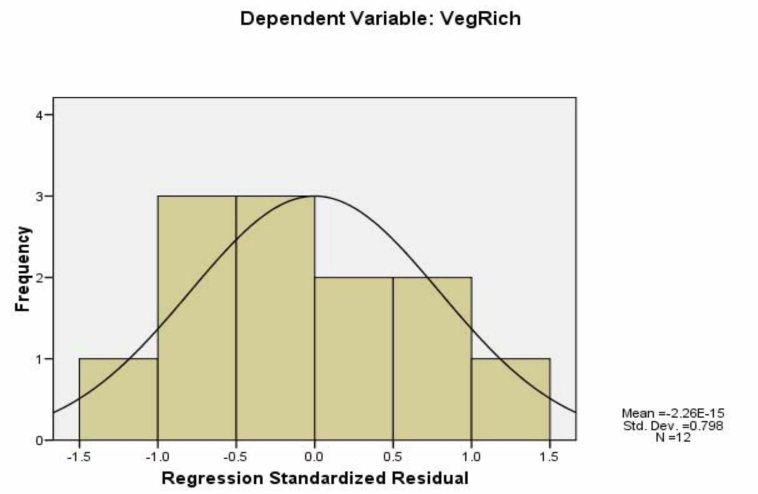


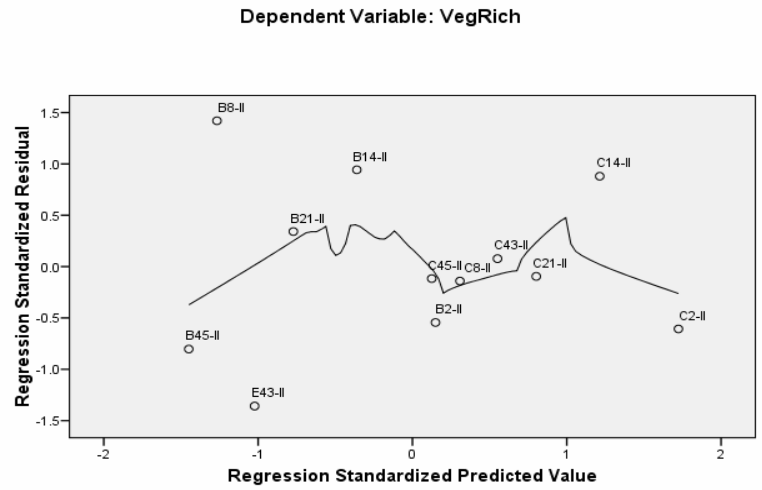
Richness - Model II: Age-Int4Cat	R^2	*p*	Durbin-Watson	95% Confidence Interval		Tolerance	Power
				Lower bound	Upper bound		
	.915	.004	1.564				.99
HOLevel							
Age				-10.525	-1.639	.697	
Int2Cat						.261	
SiteType				-12.616	-5.717	1.000	
Abandonment						.418	
Households				-2.381	-.003	.486	



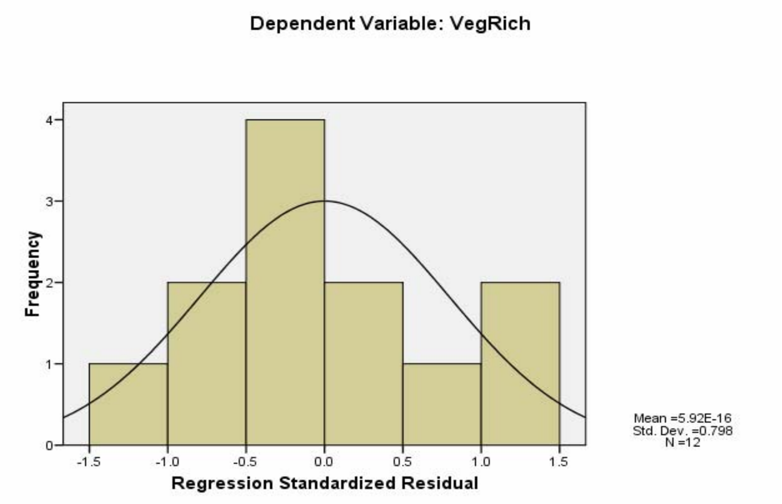


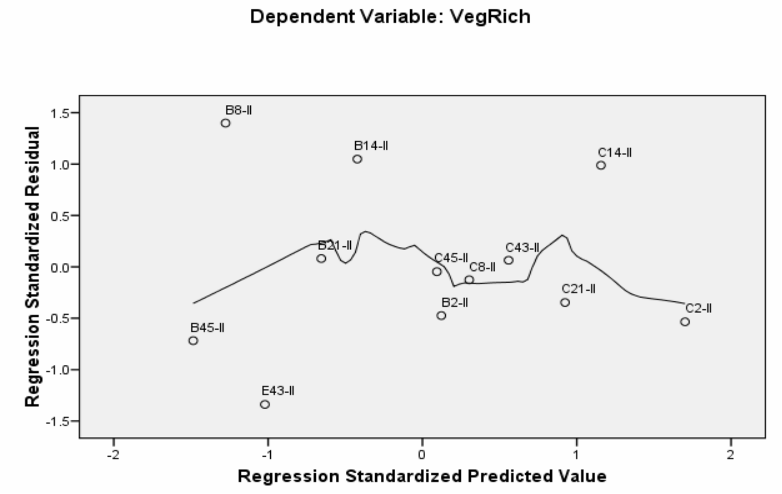
Richness - Model II: AgeInt2Cat	R^2	*p*	Durbin-Watson	95% Confidence Interval Lower bound	Upper bound	Tolerance	Power
	.939	.002	1.423				.99
HOLevel				-9.553	-.955	.991	
SiteType				-12.812	-5.522	1.000	
Abandonment						.970	
Households						.963	





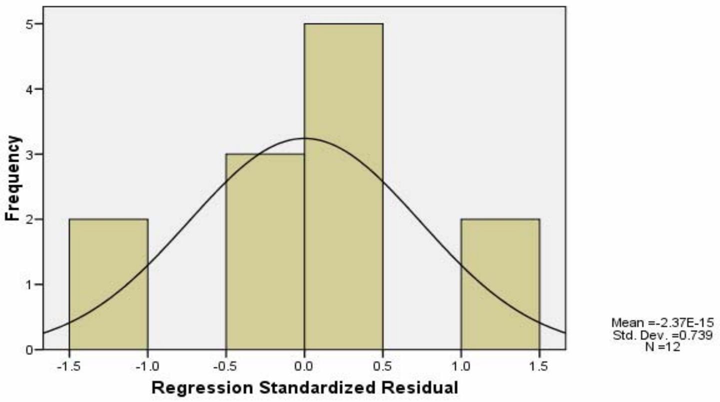
Richness - Model II: AgeInt4Cat				95% Confidence Interval			
	R^2	*p*	Durbin-Watson	Lower bound	Upper bound	Tolerance	Power
	.876	.003	1.482				.99
HOLevel				-8.210	-.644	.968	
SiteType				-12.897	-5.436	1.000	
Abandonment				-8.135	-.082	.966	
Households						.950	



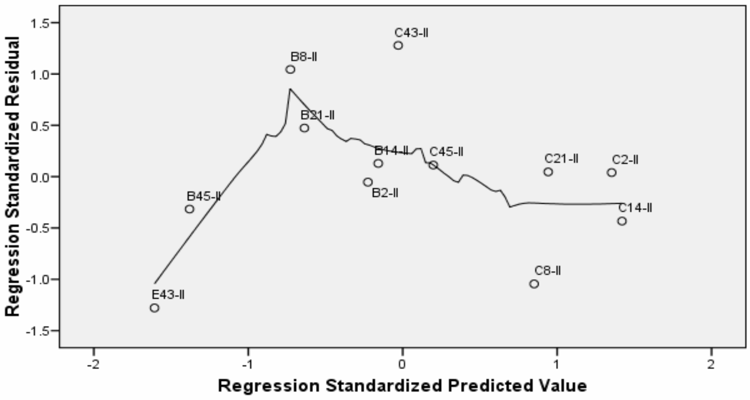


Diversity - Model II: Age-Int2Cat	R^2	*p*	Durbin-Watson	95% Confidence Interval		Tolerance	Power
				Lower bound	Upper bound		
	.906	.005	<u>1.824</u>				.99
HOLevel							
Age						.620	
Int2Cat						.193	
SiteType				-.930	-.408	1.000	
Abandonment						.440	
Households						.396	

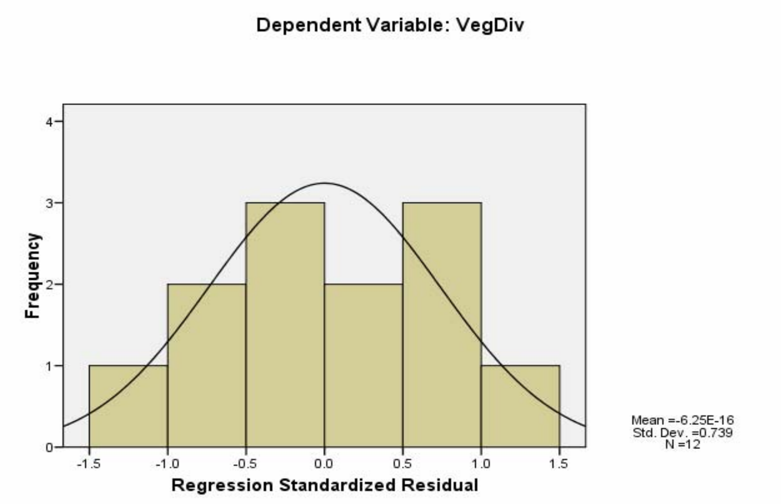
Dependent Variable: VegDiv

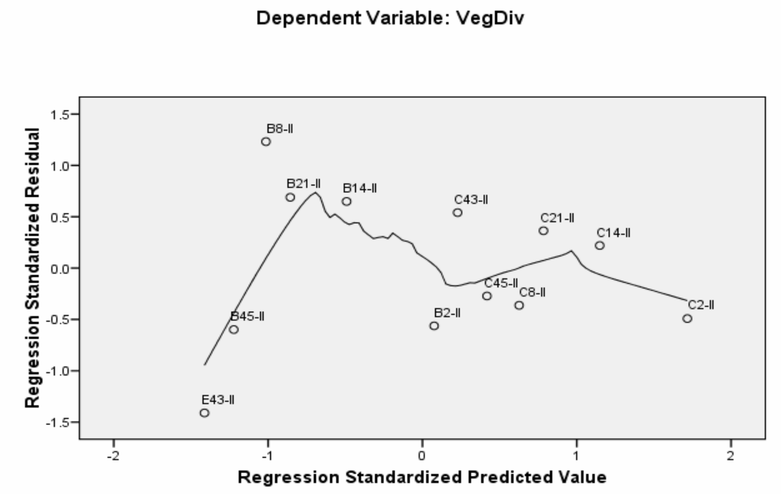


Dependent Variable: VegDiv

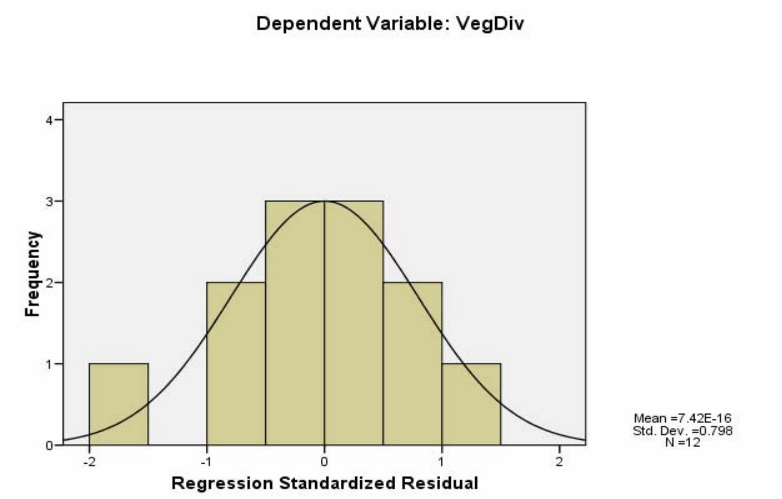


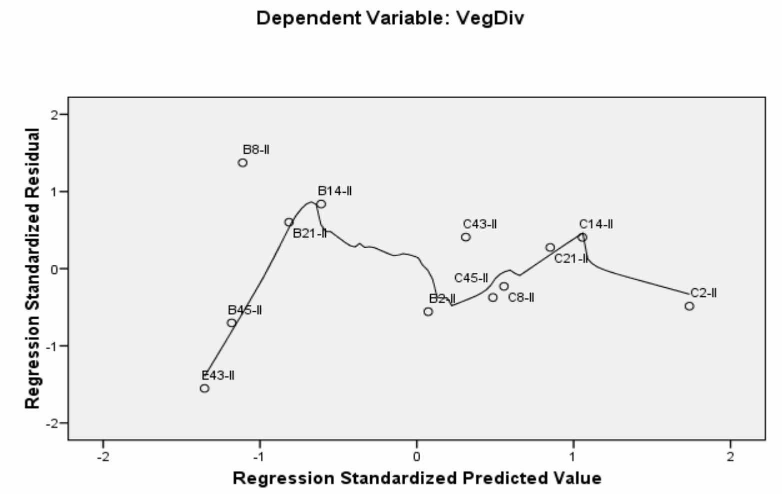
Diversity - Model II: Age-Int4Cat	R^2	*p*	Durbin-Watson	95% Confidence Interval		Tolerance	Power
				Lower bound	Upper bound		
	.839	.023	1.619				.99
HOLevel							
Age						.697	
Int2Cat						.261	
SiteType				-1.011	-.327	1.000	
Abandonment						.418	
Households						.486	



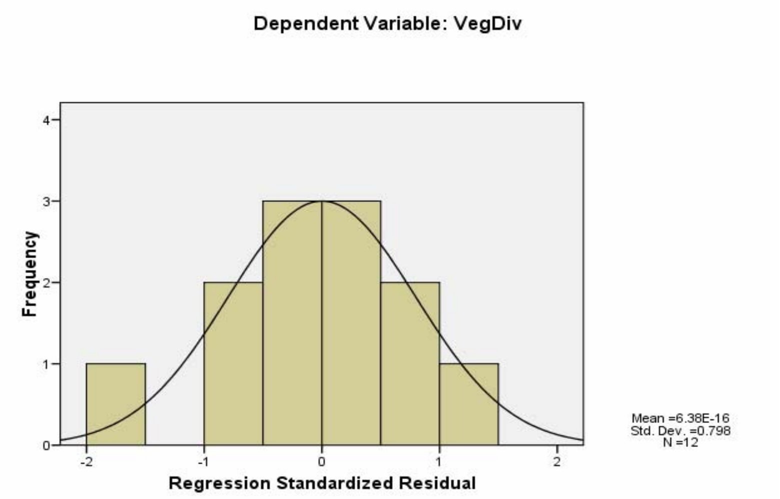


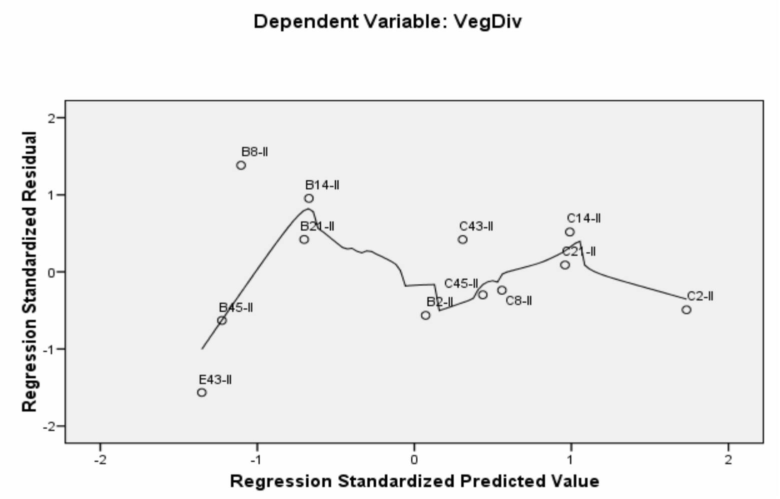
Diversity - Model II: AgeInt2Cat				95% Confidence Interval			
	R^2	*p*	Durbin-Watson	Lower bound	Upper bound	Tolerance	Power
	.814	.011	1.514				.99
HOLevel						.991	
SiteType				-.998	-.340	1.000	
Abandonment						.970	
Households						.963	





Richness - Model II: AgeInt4Cat	R^2	*p*	Durbin-Watson	95% Confidence Interval Lower bound	Upper bound	Tolerance	Power
	.818	.010	1.505				.99
HOLevel						.968	
SiteType				-.994	-.344	1.000	
Abandonment						.966	
Households						.950	





Appendix 6. Database of measurments of micromammalian fecal pellets collected from traps and from excavation of collapsed Maasai house (measurments in mm).

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumf-erence
sp-308	ind-381	aco	F	-	0.118	0.229	0.654	0.591
sp-309	ind-381	aco	F	-	0.065	0.222	0.371	0.766
sp-310	ind-381	aco	F	-	0.086	0.212	0.517	0.561
sp-311	ind-381	aco	F	-	0.077	0.214	0.457	0.683
sp-312	ind-381	aco	F	-	0.055	0.19	0.365	0.668
sp-313	ind-381	aco	F	-	0.088	0.219	0.508	0.647
sp-314	ind-381	aco	F	-	0.073	0.218	0.429	0.687
sp-315	ind-381	aco	F	-	0.109	0.23	0.601	0.577
sp-316	ind-381	aco	F	-	0.078	0.232	0.426	0.733
sp-317	ind-381	aco	F	-	0.105	0.218	0.611	0.59
sp-318	ind-381	aco	F	-	0.081	0.197	0.523	0.533
sp-319	ind-381	aco	F	-	0.063	0.206	0.388	0.734
sp-320	ind-381	aco	F	-	0.086	0.202	0.543	0.604
sp-321	ind-381	aco	F	-	0.086	0.245	0.445	0.742
sp-438	ind-349	aco	F	29	0.108	0.25	0.552	0.633
sp-439	ind-349	aco	F	29	0.152	0.274	0.705	0.599
sp-440	ind-349	aco	F	29	0.103	0.23	0.568	0.597
sp-441	ind-349	aco	F	29	0.062	0.195	0.402	0.641
sp-190	ind-367	aco	F	12.5	0.023	0.117	0.245	0.671
sp-191	ind-367	aco	F	12.5	0.03	0.133	0.289	0.662
sp-192	ind-367	aco	F	12.5	0.033	0.128	0.323	0.598
sp-193	ind-367	aco	F	12.5	0.025	0.123	0.261	0.632
sp-194	ind-367	aco	F	12.5	0.021	0.115	0.237	0.668
sp-195	ind-367	aco	F	12.5	0.046	0.17	0.344	0.65
sp-196	ind-367	aco	F	12.5	0.027	0.119	0.287	0.615
sp-197	ind-367	aco	F	12.5	0.031	0.133	0.296	0.607
sp-198	ind-367	aco	F	12.5	0.019	0.106	0.235	0.599
sp-199	ind-367	aco	F	12.5	0.042	0.152	0.352	0.645
sp-200	ind-367	aco	F	12.5	0.046	0.168	0.346	0.641
sp-201	ind-367	aco	F	12.5	0.026	0.121	0.277	0.66
sp-202	ind-367	aco	F	12.5	0.025	0.124	0.255	0.686
sp-203	ind-367	aco	F	12.5	0.027	0.137	0.254	0.704
sp-459	ind-389	aco	F	15	0.08	0.253	0.403	0.707
sp-460	ind-389	aco	F	15	0.078	0.23	0.43	0.756
sp-461	ind-389	aco	F	15	0.089	0.198	0.573	0.593
sp-462	ind-389	aco	F	15	0.053	0.168	0.399	0.646
sp-463	ind-389	aco	F	15	0.048	0.156	0.388	0.648
sp-464	ind-389	aco	F	15	0.043	0.158	0.342	0.632
sp-465	ind-389	aco	F	15	0.041	0.149	0.347	0.616
sp-466	ind-389	aco	F	15	0.045	0.151	0.375	0.613
sp-467	ind-389	aco	F	15	0.034	0.145	0.294	0.641
sp-468	ind-389	aco	F	15	0.028	0.124	0.292	0.632
sp-469	ind-389	aco	F	15	0.042	0.164	0.324	0.725
sp-470	ind-389	aco	F	15	0.03	0.133	0.287	0.641
sp-471	ind-389	aco	F	15	0.03	0.151	0.255	0.764
sp-472	ind-389	aco	F	15	0.07	0.18	0.494	0.579
sp-473	ind-389	aco	F	15	0.04	0.145	0.347	0.608

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumference
sp-244	ind-392	aco	F	29	0.096	0.247	0.496	0.724
sp-245	ind-392	aco	F	29	0.127	0.289	0.558	0.721
sp-246	ind-392	aco	F	29	0.101	0.252	0.509	0.711
sp-247	ind-392	aco	F	29	0.046	0.193	0.302	0.8
sp-248	ind-392	aco	F	29	0.06	0.209	0.367	0.732
sp-249	ind-392	aco	F	29	0.095	0.264	0.457	0.764
sp-250	ind-392	aco	F	29	0.073	0.225	0.416	0.738
sp-233	ind-393	aco	F	41	0.082	0.201	0.519	0.614
sp-234	ind-393	aco	F	41	0.051	0.17	0.384	0.66
sp-235	ind-393	aco	F	41	0.075	0.201	0.476	0.597
sp-236	ind-393	aco	F	41	0.102	0.2	0.652	0.507
sp-237	ind-393	aco	F	41	0.07	0.172	0.52	0.545
sp-238	ind-393	aco	F	41	0.087	0.211	0.526	0.602
sp-239	ind-393	aco	F	41	0.081	0.193	0.534	0.542
sp-240	ind-393	aco	F	41	0.063	0.209	0.384	0.702
sp-241	ind-393	aco	F	41	0.043	0.138	0.394	0.571
sp-242	ind-393	aco	F	41	0.065	0.18	0.461	0.607
sp-243	ind-393	aco	F	41	0.032	0.139	0.293	0.667
sp-269	ind-401	aco	F	41	0.084	0.241	0.445	0.702
sp-270	ind-401	aco	F	41	0.054	0.211	0.328	0.776
sp-271	ind-401	aco	F	41	0.081	0.237	0.438	0.739
sp-272	ind-401	aco	F	41	0.093	0.243	0.487	0.694
sp-273	ind-401	aco	F	41	0.133	0.303	0.557	0.677
sp-274	ind-401	aco	F	41	0.034	0.164	0.26	0.756
sp-275	ind-401	aco	F	41	0.139	0.247	0.719	0.52
sp-276	ind-401	aco	F	41	0.057	0.2	0.362	0.75
sp-277	ind-401	aco	F	41	0.13	0.283	0.587	0.7
sp-278	ind-401	aco	F	41	0.111	0.28	0.505	0.691
sp-173	ind-409	aco	F	28	0.15	0.273	0.697	0.577
sp-174	ind-409	aco	F	28	0.123	0.249	0.628	0.582
sp-175	ind-409	aco	F	28	0.121	0.264	0.584	0.669
sp-176	ind-409	aco	F	28	0.16	0.268	0.757	0.522
sp-177	ind-409	aco	F	28	0.095	0.254	0.476	0.745
sp-178	ind-409	aco	F	28	0.095	0.205	0.592	0.576
sp-179	ind-409	aco	F	28	0.114	0.226	0.643	0.604
sp-180	ind-409	aco	F	28	0.111	0.258	0.549	0.689
sp-262	ind-365	aco	M	6	0.021	0.11	0.245	0.655
sp-263	ind-365	aco	M	6	0.021	0.11	0.245	0.655
sp-264	ind-365	aco	M	6	0.013	0.081	0.205	0.627
sp-265	ind-365	aco	M	6	0.019	0.118	0.207	0.693
sp-266	ind-365	aco	M	6	0.018	0.104	0.221	0.648
sp-267	ind-365	aco	M	6	0.027	0.116	0.295	0.591
sp-268	ind-365	aco	M	6	0.027	0.105	0.325	0.532
sp-284	ind-366	aco	M	5	0.031	0.133	0.298	0.658
sp-285	ind-366	aco	M	5	0.029	0.136	0.276	0.7
sp-286	ind-366	aco	M	5	0.032	0.14	0.289	0.686
sp-287	ind-366	aco	M	5	0.035	0.144	0.307	0.669
sp-496	ind-388	aco	M	5	0.037	0.143	0.328	0.606
sp-497	ind-388	aco	M	5	0.033	0.141	0.298	0.659

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumf-erence
sp-498	ind-388	aco	M	5	0.034	0.145	0.3	0.699
sp-499	ind-388	aco	M	5	0.029	0.136	0.273	0.653
sp-500	ind-388	aco	M	5	0.034	0.14	0.311	0.654
sp-501	ind-388	aco	M	5	0.075	0.184	0.517	0.549
sp-502	ind-388	aco	M	5	0.048	0.133	0.458	0.485
sp-503	ind-388	aco	M	5	0.044	0.153	0.37	0.505
sp-504	ind-388	aco	M	5	0.02	0.108	0.235	0.676
sp-505	ind-388	aco	M	5	0.01	0.082	0.158	0.672
sp-506	ind-388	aco	M	5	0.011	0.085	0.16	0.747
sp-507	ind-388	aco	M	5	0.012	0.091	0.172	0.703
sp-508	ind-388	aco	M	5	0.013	0.081	0.205	0.634
sp-509	ind-388	aco	M	5	0.022	0.11	0.259	0.555
sp-510	ind-388	aco	M	5	0.019	0.115	0.214	0.677
sp-251	ind-390	aco	M	28	0.12	0.243	0.627	0.601
sp-252	ind-390	aco	M	28	0.083	0.185	0.575	0.526
sp-253	ind-390	aco	M	28	0.116	0.235	0.628	0.581
sp-254	ind-390	aco	M	28	0.082	0.188	0.555	0.527
sp-255	ind-390	aco	M	28	0.105	0.221	0.603	0.59
sp-256	ind-390	aco	M	28	0.094	0.242	0.496	0.687
sp-257	ind-390	aco	M	28	0.111	0.232	0.608	0.588
sp-258	ind-390	aco	M	28	0.104	0.224	0.59	0.554
sp-259	ind-390	aco	M	28	0.062	0.167	0.472	0.553
sp-260	ind-390	aco	M	28	0.095	0.211	0.572	0.594
sp-261	ind-390	aco	M	28	0.096	0.171	0.715	0.403
sp-68	ind-394	aco	M	27	0.118	0.282	0.533	0.72
sp-69	ind-394	aco	M	27	0.124	0.275	0.573	0.686
sp-70	ind-394	aco	M	27	0.105	0.246	0.542	0.681
sp-71	ind-394	aco	M	27	0.119	0.261	0.58	0.628
sp-72	ind-394	aco	M	27	0.136	0.269	0.646	0.674
sp-73	ind-394	aco	M	27	0.133	0.25	0.677	0.59
sp-74	ind-394	aco	M	27	0.125	0.261	0.611	0.647
sp-75	ind-394	aco	M	27	0.095	0.254	0.476	0.729
sp-76	ind-394	aco	M	27	0.127	0.271	0.599	0.667
sp-77	ind-394	aco	M	27	0.126	0.288	0.558	0.694
sp-116	ind-397	aco	M	35	0.135	0.224	0.765	0.515
sp-117	ind-397	aco	M	35	0.133	0.261	0.647	0.588
sp-118	ind-397	aco	M	35	0.15	0.263	0.725	0.581
sp-119	ind-397	aco	M	35	0.062	0.171	0.464	0.574
sp-65	ind-370	ele	F	60	0.202	0.393	0.653	0.722
sp-66	ind-370	ele	F	60	0.146	0.351	0.532	0.802
sp-67	ind-370	ele	F	60	0.18	0.374	0.613	0.776
sp-357	ind-372	ele	F	55	0.266	0.41	0.824	0.716
sp-358	ind-372	ele	F	55	0.415	0.475	1.113	0.655
sp-359	ind-372	ele	F	55	0.293	0.452	0.826	0.731
sp-360	ind-372	ele	F	55	0.383	0.428	1.139	0.626
sp-361	ind-372	ele	F	55	0.244	0.379	0.82	0.676
sp-362	ind-372	ele	F	55	0.335	0.438	0.973	0.702
sp-363	ind-372	ele	F	55	0.23	0.378	0.774	0.716
sp-364	ind-372	ele	F	55	0.202	0.382	0.673	0.768

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumf-erence
sp-365	ind-372	ele	F	55	0.211	0.385	0.698	0.753
sp-366	ind-372	ele	F	55	0.291	0.403	0.917	0.647
sp-367	ind-372	ele	F	55	0.195	0.364	0.68	0.729
sp-368	ind-372	ele	F	55	0.312	0.429	0.925	0.706
sp-369	ind-372	ele	F	55	0.263	0.411	0.816	0.699
sp-370	ind-372	ele	F	55	0.283	0.418	0.862	0.702
sp-371	ind-372	ele	F	55	0.205	0.381	0.687	0.728
sp-372	ind-372	ele	F	55	0.271	0.421	0.818	0.729
sp-279	ind-356	ele	M	30	0.235	0.341	0.88	0.58
sp-280	ind-356	ele	M	30	0.236	0.336	0.893	0.587
sp-281	ind-356	ele	M	30	0.146	0.29	0.641	0.665
sp-282	ind-356	ele	M	30	0.194	0.314	0.786	0.612
sp-283	ind-356	ele	M	30	0.181	0.337	0.684	0.661
sp-215	ind-368	ele	M	49	0.165	0.307	0.683	0.658
sp-216	ind-368	ele	M	49	0.155	0.304	0.65	0.667
sp-217	ind-368	ele	M	49	0.158	0.3	0.67	0.648
sp-218	ind-368	ele	M	49	0.167	0.297	0.716	0.627
sp-219	ind-368	ele	M	49	0.145	0.295	0.625	0.672
sp-220	ind-368	ele	M	49	0.198	0.351	0.717	0.67
sp-221	ind-368	ele	M	49	0.136	0.284	0.609	0.672
sp-222	ind-368	ele	M	49	0.251	0.373	0.858	0.649
sp-223	ind-368	ele	M	49	0.193	0.344	0.712	0.675
sp-224	ind-368	ele	M	49	0.144	0.289	0.636	0.65
sp-225	ind-368	ele	M	49	0.218	0.327	0.847	0.581
sp-226	ind-368	ele	M	49	0.174	0.324	0.683	0.668
sp-227	ind-368	ele	M	49	0.15	0.298	0.641	0.655
sp-228	ind-368	ele	M	49	0.164	0.308	0.679	0.634
sp-229	ind-368	ele	M	49	0.148	0.281	0.671	0.637
sp-230	ind-368	ele	M	49	0.137	0.299	0.582	0.702
sp-231	ind-368	ele	M	49	0.156	0.334	0.597	0.699
sp-232	ind-368	ele	M	49	0.098	0.243	0.512	0.661
sp-351	ind-374	ele	M	49	0.227	0.389	0.743	0.733
sp-352	ind-374	ele	M	49	0.25	0.397	0.802	0.716
sp-353	ind-374	ele	M	49	0.25	0.347	0.918	0.612
sp-354	ind-374	ele	M	49	0.176	0.344	0.651	0.661
sp-355	ind-374	ele	M	49	0.218	0.362	0.766	0.668
sp-356	ind-374	ele	M	49	0.295	0.443	0.847	0.733
sp-322	ind-350	ger	F	17	0.06	0.186	0.412	0.684
sp-323	ind-350	ger	F	17	0.075	0.199	0.478	0.649
sp-324	ind-350	ger	F	17	0.061	0.175	0.445	0.62
sp-325	ind-350	ger	F	17	0.063	0.188	0.425	0.687
sp-326	ind-350	ger	F	17	0.07	0.188	0.475	0.605
sp-327	ind-350	ger	F	17	0.062	0.184	0.431	0.638
sp-328	ind-350	ger	F	17	0.105	0.213	0.628	0.524
sp-329	ind-350	ger	F	17	0.054	0.204	0.338	0.759
sp-330	ind-350	ger	F	17	0.058	0.21	0.354	0.76
sp-331	ind-350	ger	F	17	0.063	0.206	0.39	0.725
sp-332	ind-350	ger	F	17	0.071	0.191	0.476	0.625
sp-333	ind-350	ger	F	17	0.071	0.2	0.455	0.66

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumf-erence
sp-334	ind-350	ger	F	17	0.066	0.194	0.434	0.606
sp-335	ind-350	ger	F	17	0.05	0.164	0.389	0.638
sp-336	ind-350	ger	F	17	0.052	0.197	0.337	0.77
sp-337	ind-350	ger	F	17	0.06	0.187	0.41	0.688
sp-338	ind-350	ger	F	17	0.06	0.219	0.347	0.778
sp-339	ind-350	ger	F	17	0.088	0.236	0.473	0.687
sp-340	ind-350	ger	F	17	0.067	0.192	0.445	0.648
sp-341	ind-350	ger	F	17	0.063	0.203	0.399	0.723
sp-342	ind-350	ger	F	17	0.056	0.209	0.339	0.797
sp-343	ind-350	ger	F	17	0.046	0.152	0.386	0.584
sp-344	ind-350	ger	F	17	0.065	0.187	0.44	0.629
sp-345	ind-350	ger	F	17	0.055	0.183	0.385	0.677
sp-346	ind-350	ger	F	17	0.059	0.179	0.422	0.641
sp-347	ind-350	ger	F	17	0.059	0.187	0.405	0.66
sp-348	ind-350	ger	F	17	0.076	0.221	0.436	0.665
sp-349	ind-350	ger	F	17	0.077	0.189	0.521	0.591
sp-350	ind-350	ger	F	17	0.057	0.171	0.428	0.591
sp-288	ind-378	ger	F	19	0.06	0.182	0.417	0.671
sp-289	ind-378	ger	F	19	0.067	0.2	0.425	0.644
sp-290	ind-378	ger	F	19	0.061	0.192	0.407	0.659
sp-291	ind-378	ger	F	19	0.081	0.235	0.436	0.742
sp-292	ind-378	ger	F	19	0.054	0.181	0.378	0.699
sp-293	ind-378	ger	F	19	0.059	0.187	0.401	0.641
sp-294	ind-378	ger	F	19	0.072	0.203	0.45	0.598
sp-295	ind-378	ger	F	19	0.061	0.172	0.45	0.576
sp-296	ind-378	ger	F	19	0.064	0.198	0.416	0.637
sp-297	ind-378	ger	F	19	0.039	0.173	0.288	0.697
sp-298	ind-378	ger	F	19	0.048	0.168	0.365	0.647
sp-299	ind-378	ger	F	19	0.047	0.172	0.349	0.647
sp-300	ind-378	ger	F	19	0.053	0.174	0.386	0.651
sp-301	ind-378	ger	F	19	0.054	0.186	0.371	0.717
sp-302	ind-378	ger	F	19	0.055	0.18	0.388	0.651
sp-303	ind-378	ger	F	19	0.05	0.18	0.351	0.705
sp-304	ind-378	ger	F	19	0.05	0.184	0.346	0.713
sp-305	ind-378	ger	F	19	0.067	0.203	0.418	0.656
sp-306	ind-378	ger	F	19	0.059	0.189	0.4	0.66
sp-307	ind-378	ger	F	19	0.077	0.226	0.435	0.684
sp-373	ind-386	ger	F	20	0.081	0.237	0.437	0.744
sp-374	ind-386	ger	F	20	0.074	0.225	0.42	0.74
sp-375	ind-386	ger	F	20	0.073	0.231	0.403	0.786
sp-376	ind-386	ger	F	20	0.099	0.26	0.484	0.651
sp-377	ind-386	ger	F	20	0.101	0.271	0.476	0.705
sp-378	ind-386	ger	F	20	0.088	0.233	0.483	0.693
sp-379	ind-386	ger	F	20	0.106	0.273	0.495	0.731
sp-380	ind-386	ger	F	20	0.082	0.229	0.455	0.722
sp-381	ind-386	ger	F	20	0.092	0.272	0.43	0.781
sp-382	ind-386	ger	F	20	0.099	0.248	0.51	0.7
sp-383	ind-386	ger	F	20	0.1	0.238	0.535	0.667
sp-384	ind-386	ger	F	20	0.099	0.238	0.53	0.669

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumf-erence
sp-385	ind-386	ger	F	20	0.131	0.263	0.634	0.648
sp-386	ind-386	ger	F	20	0.077	0.22	0.446	0.702
sp-387	ind-386	ger	F	20	0.072	0.237	0.386	0.759
sp-388	ind-386	ger	F	20	0.1	0.247	0.514	0.712
sp-389	ind-386	ger	F	20	0.083	0.245	0.434	0.744
sp-390	ind-386	ger	F	20	0.08	0.228	0.448	0.703
sp-391	ind-386	ger	F	20	0.127	0.288	0.564	0.724
sp-392	ind-386	ger	F	20	0.112	0.272	0.524	0.739
sp-393	ind-386	ger	F	20	0.071	0.227	0.399	0.747
sp-394	ind-386	ger	F	20	0.074	0.213	0.441	0.692
sp-395	ind-386	ger	F	20	0.11	0.252	0.555	0.691
sp-396	ind-386	ger	F	20	0.099	0.259	0.486	0.724
sp-397	ind-386	ger	F	20	0.087	0.256	0.431	0.755
sp-398	ind-386	ger	F	20	0.094	0.244	0.492	0.735
sp-442	ind-359	gra	F	27	0.086	0.202	0.546	0.598
sp-443	ind-359	gra	F	27	0.094	0.249	0.478	0.718
sp-444	ind-359	gra	F	27	0.117	0.232	0.641	0.591
sp-445	ind-359	gra	F	27	0.104	0.212	0.627	0.589
sp-446	ind-359	gra	F	27	0.09	0.207	0.555	0.589
sp-447	ind-359	gra	F	27	0.114	0.273	0.529	0.668
sp-448	ind-359	gra	F	27	0.057	0.2	0.365	0.67
sp-449	ind-359	gra	F	27	0.085	0.241	0.447	0.531
sp-450	ind-359	gra	F	27	0.082	0.205	0.507	0.625
sp-451	ind-359	gra	F	27	0.129	0.293	0.562	0.66
sp-452	ind-359	gra	F	27	0.178	0.301	0.751	0.594
sp-453	ind-359	gra	F	27	0.112	0.248	0.574	0.631
sp-454	ind-359	gra	F	27	0.134	0.279	0.61	0.663
sp-455	ind-359	gra	F	27	0.112	0.276	0.516	0.717
sp-456	ind-359	gra	F	27	0.061	0.183	0.425	0.599
sp-457	ind-359	gra	F	27	0.149	0.284	0.666	0.618
sp-458	ind-359	gra	F	27	0.102	0.21	0.619	0.537
sp-124	ind-380	gra	F	13	0.046	0.142	0.413	0.509
sp-125	ind-380	gra	F	13	0.062	0.164	0.485	0.476
sp-126	ind-380	gra	F	13	0.058	0.159	0.461	0.568
sp-127	ind-380	gra	F	13	0.047	0.151	0.395	0.618
sp-128	ind-380	gra	F	13	0.047	0.146	0.413	0.595
sp-129	ind-380	gra	F	13	0.048	0.124	0.497	0.444
sp-130	ind-380	gra	F	13	0.053	0.141	0.48	0.543
sp-131	ind-380	gra	F	13	0.064	0.17	0.482	0.407
sp-132	ind-380	gra	F	13	0.054	0.174	0.396	0.67
sp-133	ind-380	gra	F	13	0.05	0.127	0.497	0.492
sp-134	ind-380	gra	F	13	0.056	0.131	0.546	0.472
sp-135	ind-380	gra	F	13	0.033	0.128	0.326	0.602
sp-136	ind-380	gra	F	13	0.048	0.156	0.393	0.441
sp-137	ind-380	gra	F	13	0.05	0.13	0.49	0.445
sp-138	ind-380	gra	F	13	0.046	0.171	0.344	0.653
sp-139	ind-380	gra	F	13	0.038	0.154	0.318	0.66
sp-140	ind-380	gra	F	13	0.052	0.158	0.418	0.448
sp-92	ind-407	gra	F	39	0.098	0.236	0.528	0.652

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumf-erence
sp-93	ind-407	gra	F	39	0.138	0.318	0.551	0.733
sp-94	ind-407	gra	F	39	0.092	0.226	0.518	0.667
sp-95	ind-407	gra	F	39	0.113	0.243	0.591	0.65
sp-96	ind-407	gra	F	39	0.109	0.263	0.528	0.718
sp-97	ind-407	gra	F	39	0.107	0.207	0.66	0.523
sp-204	ind-406	lem	F	22	0.133	0.254	0.667	0.614
sp-205	ind-406	lem	F	22	0.11	0.231	0.607	0.586
sp-206	ind-406	lem	F	22	0.098	0.235	0.532	0.577
sp-207	ind-406	lem	F	22	0.111	0.225	0.63	0.597
sp-208	ind-406	lem	F	22	0.121	0.225	0.683	0.54
sp-209	ind-406	lem	F	22	0.096	0.216	0.566	0.594
sp-210	ind-406	lem	F	22	0.1	0.217	0.59	0.568
sp-211	ind-406	lem	F	22	0.102	0.234	0.555	0.655
sp-212	ind-406	lem	F	22	0.073	0.21	0.442	0.702
sp-213	ind-406	lem	F	22	0.1	0.226	0.56	0.667
sp-214	ind-406	lem	F	22	0.085	0.221	0.489	0.674
sp-530	ind-361	lem	M	32	0.105	0.231	0.578	0.594
sp-531	ind-361	lem	M	32	0.073	0.2	0.463	0.613
sp-532	ind-361	lem	M	32	0.067	0.205	0.416	0.687
sp-533	ind-361	lem	M	32	0.093	0.213	0.553	0.608
sp-534	ind-361	lem	M	32	0.083	0.211	0.503	0.655
sp-535	ind-361	lem	M	32	0.089	0.221	0.513	0.627
sp-536	ind-361	lem	M	32	0.084	0.188	0.571	0.556
sp-537	ind-361	lem	M	32	0.087	0.211	0.523	0.635
sp-538	ind-361	lem	M	32	0.089	0.188	0.605	0.496
sp-539	ind-361	lem	M	32	0.107	0.22	0.618	0.571
sp-540	ind-361	lem	M	32	0.055	0.191	0.37	0.655
sp-541	ind-361	lem	M	32	0.069	0.196	0.446	0.654
sp-542	ind-361	lem	M	32	0.078	0.214	0.465	0.633
sp-543	ind-361	lem	M	32	0.06	0.195	0.389	0.709
sp-544	ind-361	lem	M	32	0.104	0.224	0.592	0.589
sp-545	ind-361	lem	M	32	0.072	0.204	0.446	0.661
sp-546	ind-361	lem	M	32	0.11	0.225	0.622	0.566
sp-547	ind-361	lem	M	32	0.12	0.25	0.609	0.594
sp-548	ind-361	lem	M	32	0.106	0.22	0.611	0.559
sp-549	ind-361	lem	M	32	0.088	0.214	0.523	0.623
sp-550	ind-361	lem	M	32	0.069	0.191	0.456	0.651
sp-551	ind-361	lem	M	32	0.113	0.228	0.633	0.566
sp-552	ind-361	lem	M	32	0.116	0.229	0.642	0.538
sp-553	ind-361	lem	M	32	0.066	0.19	0.444	0.665
sp-554	ind-361	lem	M	32	0.09	0.22	0.524	0.636
sp-511	ind-379	lem	M	31	0.049	0.196	0.319	0.768
sp-512	ind-379	lem	M	31	0.07	0.223	0.402	0.61
sp-513	ind-379	lem	M	31	0.055	0.185	0.377	0.578
sp-514	ind-379	lem	M	31	0.056	0.203	0.353	0.688
sp-515	ind-379	lem	M	31	0.082	0.269	0.39	0.802
sp-516	ind-379	lem	M	31	0.088	0.236	0.476	0.732
sp-517	ind-379	lem	M	31	0.065	0.214	0.387	0.633
sp-518	ind-379	lem	M	31	0.061	0.221	0.35	0.763

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumf- erence
sp-519	ind-379	lem	M	31	0.061	0.192	0.404	0.612
sp-520	ind-379	lem	M	31	0.061	0.209	0.372	0.719
sp-521	ind-379	lem	M	31	0.046	0.168	0.346	0.659
sp-522	ind-379	lem	M	31	0.068	0.224	0.384	0.707
sp-523	ind-379	lem	M	31	0.086	0.264	0.412	0.79
sp-524	ind-379	lem	M	31	0.066	0.211	0.399	0.686
sp-525	ind-379	lem	M	31	0.075	0.206	0.463	0.682
sp-526	ind-379	lem	M	31	0.083	0.224	0.473	0.686
sp-527	ind-379	lem	M	31	0.093	0.254	0.468	0.761
sp-528	ind-379	lem	M	31	0.07	0.211	0.422	0.706
sp-529	ind-379	lem	M	31	0.067	0.211	0.403	0.709
sp-100	ind-357	mas	M	55	0.181	0.355	0.649	0.737
sp-101	ind-357	mas	M	55	0.148	0.316	0.597	0.742
sp-102	ind-357	mas	M	55	0.162	0.328	0.629	0.738
sp-103	ind-357	mas	M	55	0.168	0.321	0.667	0.678
sp-98	ind-357	mas	M	55	0.232	0.335	0.882	0.632
sp-99	ind-357	mas	M	55	0.204	0.304	0.853	0.601
sp-104	ind-357	mas	M	55	0.098	0.255	0.489	0.719
sp-105	ind-357	mas	M	55	0.088	0.232	0.481	0.65
sp-106	ind-357	mas	M	55	0.112	0.249	0.571	0.674
sp-107	ind-357	mas	M	55	0.109	0.277	0.502	0.707
sp-108	ind-357	mas	M	55	0.099	0.265	0.476	0.712
sp-109	ind-357	mas	M	55	0.069	0.208	0.42	0.686
sp-110	ind-357	mas	M	55	0.08	0.217	0.468	0.666
sp-111	ind-357	mas	M	55	0.072	0.229	0.4	0.698
sp-399	ind-382	mas	M	22	0.081	0.211	0.492	0.657
sp-400	ind-382	mas	M	22	0.055	0.191	0.366	0.745
sp-401	ind-382	mas	M	22	0.089	0.198	0.568	0.572
sp-402	ind-382	mas	M	22	0.102	0.221	0.589	0.601
sp-403	ind-382	mas	M	22	0.074	0.186	0.504	0.579
sp-404	ind-382	mas	M	22	0.094	0.239	0.5	0.711
sp-405	ind-382	mas	M	22	0.078	0.223	0.446	0.699
sp-406	ind-382	mas	M	22	0.054	0.169	0.403	0.602
sp-407	ind-382	mas	M	22	0.092	0.208	0.566	0.57
sp-408	ind-382	mas	M	22	0.063	0.18	0.448	0.609
sp-409	ind-382	mas	M	22	0.082	0.22	0.472	0.697
sp-410	ind-382	mas	M	22	0.048	0.155	0.394	0.615
sp-411	ind-382	mas	M	22	0.085	0.219	0.493	0.653
sp-412	ind-382	mas	M	22	0.065	0.198	0.42	0.67
sp-413	ind-382	mas	M	22	0.064	0.191	0.428	0.669
sp-414	ind-382	mas	M	22	0.075	0.221	0.433	0.732
sp-415	ind-382	mas	M	22	0.089	0.213	0.53	0.581
sp-416	ind-382	mas	M	22	0.058	0.202	0.369	0.729
sp-417	ind-382	mas	M	22	0.08	0.224	0.454	0.709
sp-418	ind-382	mas	M	22	0.101	0.197	0.653	0.537
sp-419	ind-382	mas	M	22	0.054	0.182	0.377	0.692
sp-420	ind-382	mas	M	22	0.09	0.204	0.56	0.581
sp-421	ind-382	mas	M	22	0.06	0.184	0.413	0.662
sp-474	ind-391	mas	M	39	0.128	0.281	0.579	0.673

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumf-erence
sp-475	ind-391	mas	M	39	0.113	0.299	0.483	0.792
sp-427	ind-402	mas	M	27	0.159	0.297	0.682	0.606
sp-428	ind-402	mas	M	27	0.15	0.3	0.637	0.639
sp-429	ind-402	mas	M	27	0.186	0.329	0.719	0.617
sp-430	ind-402	mas	M	27	0.201	0.328	0.779	0.6
sp-431	ind-402	mas	M	27	0.125	0.289	0.55	0.697
sp-432	ind-402	mas	M	27	0.086	0.264	0.413	0.741
sp-433	ind-402	mas	M	27	0.063	0.214	0.377	0.629
sp-434	ind-402	mas	M	27	0.136	0.305	0.567	0.704
sp-435	ind-402	mas	M	27	0.077	0.207	0.476	0.661
sp-436	ind-402	mas	M	27	0.119	0.293	0.518	0.7
sp-437	ind-402	mas	M	27	0.1	0.25	0.509	0.675
sp-422	ind-403	mas	M	22	0.137	0.321	0.542	0.774
sp-423	ind-403	mas	M	22	0.121	0.313	0.491	0.796
sp-424	ind-403	mas	M	22	0.141	0.309	0.58	0.745
sp-425	ind-403	mas	M	22	0.122	0.34	0.456	0.821
sp-426	ind-403	mas	M	22	0.171	0.343	0.633	0.736
sp-120	ind-408	mas	M	27	0.135	0.267	0.645	0.624
sp-121	ind-408	mas	M	27	0.138	0.272	0.643	0.666
sp-122	ind-408	mas	M	27	0.124	0.268	0.589	0.588
sp-123	ind-408	mas	M	27	0.111	0.265	0.533	0.688
sp-87	ind-400	tat	F	81	0.187	0.296	0.803	0.605
sp-88	ind-400	tat	F	81	0.178	0.27	0.839	0.559
sp-89	ind-400	tat	F	81	0.181	0.276	0.835	0.559
sp-90	ind-400	tat	F	81	0.153	0.255	0.765	0.582
sp-91	ind-400	tat	F	81	0.108	0.243	0.566	0.663
sp-181	ind-355	tat	M	85	0.13	0.247	0.671	0.577
sp-182	ind-355	tat	M	85	0.169	0.356	0.604	0.768
sp-183	ind-355	tat	M	85	0.179	0.327	0.697	0.697
sp-184	ind-355	tat	M	85	0.182	0.34	0.681	0.725
sp-185	ind-355	tat	M	85	0.145	0.306	0.602	0.727
sp-186	ind-355	tat	M	85	0.108	0.243	0.566	0.656
sp-187	ind-355	tat	M	85	0.127	0.322	0.504	0.789
sp-188	ind-355	tat	M	85	0.147	0.307	0.61	0.715
sp-189	ind-355	tat	M	85	0.116	0.292	0.508	0.778
sp-112	ind-375	tat	M	217	0.422	0.519	1.037	0.656
sp-113	ind-375	tat	M	217	0.322	0.474	0.866	0.681
sp-114	ind-375	tat	M	217	0.353	0.41	1.095	0.54
sp-115	ind-375	tat	M	217	0.307	0.431	0.906	0.657
sp-160	ind-376	tat	M	159	0.229	0.384	0.761	0.707
sp-161	ind-376	tat	M	159	0.294	0.422	0.888	0.665
sp-162	ind-376	tat	M	159	0.246	0.39	0.804	0.692
sp-163	ind-376	tat	M	159	0.206	0.369	0.709	0.66
sp-164	ind-376	tat	M	159	0.261	0.466	0.714	0.736
sp-165	ind-376	tat	M	159	0.151	0.274	0.703	0.586
sp-166	ind-376	tat	M	159	0.133	0.298	0.568	0.693
sp-167	ind-376	tat	M	159	0.252	0.432	0.744	0.737
sp-168	ind-376	tat	M	159	0.444	0.491	1.15	0.64
sp-169	ind-376	tat	M	159	0.216	0.361	0.761	0.634

Specimen No.	Individual No.	Taxon	Sex	Weight	Area	Minor	Major	Circumf-erence
sp-170	ind-376	tat	M	159	0.274	0.471	0.741	0.73
sp-171	ind-376	tat	M	159	0.191	0.342	0.711	0.658
sp-172	ind-376	tat	M	159	0.294	0.417	0.896	0.636
sp-555	House	-	-	-	0.125	0.288	0.552	0.742
sp-556	House	-	-	-	0.101	0.27	0.476	0.759
sp-557	House	-	-	-	0.1	0.283	0.448	0.801
sp-574	House	-	-	-	0.131	0.256	0.65	0.623
sp-575	House	-	-	-	0.123	0.281	0.558	0.694
sp-576	House	-	-	-	0.144	0.293	0.625	0.712
sp-577	House	-	-	-	0.097	0.25	0.491	0.729
sp-578	House	-	-	-	0.099	0.267	0.472	0.748
sp-579	House	-	-	-	0.225	0.353	0.81	0.646
sp-580	House	-	-	-	0.121	0.294	0.522	0.75
sp-581	House	-	-	-	0.146	0.293	0.635	0.646
sp-582	House	-	-	-	0.215	0.388	0.706	0.737
sp-583	House	-	-	-	0.19	0.403	0.6	0.832
sp-584	House	-	-	-	0.115	0.307	0.478	0.808
sp-585	House	-	-	-	0.067	0.203	0.418	0.647
sp-586	House	-	-	-	0.099	0.228	0.555	0.644
sp-558	House	-	-	-	0.103	0.26	0.504	0.717
sp-559	House	-	-	-	0.161	0.317	0.646	0.703
sp-560	House	-	-	-	0.148	0.337	0.557	0.783
sp-561	House	-	-	-	0.147	0.326	0.574	0.752
sp-562	House	-	-	-	0.051	0.198	0.324	0.795
sp-563	House	-	-	-	0.074	0.21	0.446	0.697
sp-564	House	-	-	-	0.162	0.35	0.589	0.685
sp-565	House	-	-	-	0.135	0.331	0.518	0.769
sp-566	House	-	-	-	0.256	0.38	0.857	0.642
sp-567	House	-	-	-	0.112	0.275	0.516	0.737
sp-568	House	-	-	-	0.126	0.27	0.596	0.683
sp-569	House	-	-	-	0.194	0.345	0.716	0.699
sp-570	House	-	-	-	0.184	0.347	0.673	0.716
sp-571	House	-	-	-	0.18	0.323	0.709	0.666
sp-572	House	-	-	-	0.191	0.347	0.703	0.704
sp-573	House	-	-	-	0.16	0.31	0.658	0.674

Appendix 7. Database of micromammalian molar specimens from prey assemblages of eagle owls and mongoose.

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG1	Mongoose	29	Acomys	LM1	Left	
MG1	Mongoose	30	Acomys	LM1	Left	
MG1	Mongoose	31	Acomys	LM1	Left	
MG1	Mongoose	51	Acomys	LM1	Left	50
MG1	Mongoose	28	Acomys	LM2	Left	
MG1	Mongoose	32	Acomys	LM2	Left	
MG1	Mongoose	33	Acomys	LM3	Right	
MG1	Mongoose	34	Acomys	LM3	Left	
MG1	Mongoose	27	Acomys	UM1	Right	
MG1	Mongoose	56	Acomys	UM1	Left	55
MG1	Mongoose	104	Acomys	UM1	Right	103
MG1	Mongoose	108	Acomys	UM1	Left	107
MG1	Mongoose	110	Acomys	UM1	Right	109
MG1	Mongoose	105	Acomys	UM2	Right	103
MG1	Mongoose	111	Acomys	UM2	Right	109
MG1	Mongoose	106	Acomys	UM3	Right	103
MG1	Mongoose	120	Crocidura	LM1	Left	119
MG1	Mongoose	127	Crocidura	LM1	Left	126
MG1	Mongoose	134	Crocidura	LM1	Left	133
MG1	Mongoose	138	Crocidura	LM1	Left	137
MG1	Mongoose	144	Crocidura	LM1	Left	143
MG1	Mongoose	150	Crocidura	LM1	Left	149
MG1	Mongoose	157	Crocidura	LM1	Right	156
MG1	Mongoose	163	Crocidura	LM1	Right	162
MG1	Mongoose	121	Crocidura	LM2	Left	119
MG1	Mongoose	128	Crocidura	LM2	Left	126
MG1	Mongoose	135	Crocidura	LM2	Left	133
MG1	Mongoose	139	Crocidura	LM2	Left	137
MG1	Mongoose	145	Crocidura	LM2	Left	143
MG1	Mongoose	151	Crocidura	LM2	Left	149
MG1	Mongoose	158	Crocidura	LM2	Right	156
MG1	Mongoose	164	Crocidura	LM2	Right	162
MG1	Mongoose	122	Crocidura	LM3	Left	119
MG1	Mongoose	129	Crocidura	LM3	Left	126
MG1	Mongoose	136	Crocidura	LM3	Left	133
MG1	Mongoose	140	Crocidura	LM3	Left	137
MG1	Mongoose	146	Crocidura	LM3	Left	143
MG1	Mongoose	152	Crocidura	LM3	Left	149
MG1	Mongoose	159	Crocidura	LM3	Right	156
MG1	Mongoose	165	Crocidura	LM3	Right	162
MG1	Mongoose	167	Crocidura	UM1	Left	166
MG1	Mongoose	171	Crocidura	UM1	Left	170
MG1	Mongoose	174	Crocidura	UM1	Right	173
MG1	Mongoose	181	Crocidura	UM1	Left	180
MG1	Mongoose	189	Crocidura	UM1	Left	188
MG1	Mongoose	192	Crocidura	UM1	Right	191
MG1	Mongoose	199	Crocidura	UM1	Right	198

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG1	Mongoose	205	Crocidura	UM1	Right	204
MG1	Mongoose	175	Crocidura	UM2	Right	173
MG1	Mongoose	182	Crocidura	UM2	Left	180
MG1	Mongoose	193	Crocidura	UM2	Right	191
MG1	Mongoose	194	Crocidura	UM2	Right	191
MG1	Mongoose	200	Crocidura	UM2	Right	198
MG1	Mongoose	206	Crocidura	UM2	Right	204
MG1	Mongoose	183	Crocidura	UM3	Left	180
MG1	Mongoose	113	Mus	UM2	Left	112
MG1	Mongoose	5	Tatera	LM1	Left	
MG1	Mongoose	6	Tatera	LM1	Left	
MG1	Mongoose	7	Tatera	LM1	Left	
MG1	Mongoose	8	Tatera	LM1	Left	
MG1	Mongoose	36	Tatera	LM1	Right	35
MG1	Mongoose	13	Tatera	LM2	Left	
MG1	Mongoose	14	Tatera	LM2	Right	
MG1	Mongoose	15	Tatera	LM2	Right	
MG1	Mongoose	37	Tatera	LM2	Right	35
MG1	Mongoose	39	Tatera	LM2	Left	38
MG1	Mongoose	19	Tatera	LM3	Left	
MG1	Mongoose	118	Tatera	LM3	Right	117
MG1	Mongoose	1	Tatera	UM1	Left	
MG1	Mongoose	2	Tatera	UM1	Right	
MG1	Mongoose	3	Tatera	UM1	Right	
MG1	Mongoose	4	Tatera	UM1	Left	
MG1	Mongoose	58	Tatera	UM1	Right	57
MG1	Mongoose	62	Tatera	UM1	Left	61
MG1	Mongoose	16	Tatera	UM2	Left	
MG1	Mongoose	17	Tatera	UM2	Left	
MG1	Mongoose	18	Tatera	UM2	Right	
MG1	Mongoose	60	Tatera	UM2	Left	59
MG1	Mongoose	63	Tatera	UM2	Left	61
MG1	Mongoose	25	Tatera	UM3	Left	
MG1	Mongoose	26	Tatera	UM3	Right	
MG1	Mongoose	54	Taterillus	Indet.		
MG1	Mongoose	9	Taterillus	LM1	Left	
MG1	Mongoose	11	Taterillus	LM1	Right	
MG1	Mongoose	41	Taterillus	LM1	Left	40
MG1	Mongoose	44	Taterillus	LM1	Left	43
MG1	Mongoose	46	Taterillus	LM1	Right	45
MG1	Mongoose	49	Taterillus	LM1	Right	48
MG1	Mongoose	53	Taterillus	LM1	Right	52
MG1	Mongoose	20	Taterillus	LM2	Left	
MG1	Mongoose	21	Taterillus	LM2	Left	
MG1	Mongoose	22	Taterillus	LM2	Right	
MG1	Mongoose	23	Taterillus	LM2	Right	
MG1	Mongoose	24	Taterillus	LM2	Right	
MG1	Mongoose	42	Taterillus	LM2	Left	40
MG1	Mongoose	47	Taterillus	LM2	Right	45

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG1	Mongoose	10	Taterillus	UM1	Right	
MG1	Mongoose	12	Taterillus	UM1	Right	
MG1	Mongoose	65	Taterillus	UM1	Right	64
MG1	Mongoose	67	Taterillus	UM1	Right	66
MG1	Mongoose	69	Taterillus	UM1	Right	68
MG1	Mongoose	72	Taterillus	UM1	Left	71
MG1	Mongoose	75	Taterillus	UM1	Left	74
MG1	Mongoose	77	Taterillus	UM1	Left	76
MG1	Mongoose	81	Taterillus	UM1	Right	80
MG1	Mongoose	84	Taterillus	UM1	Left	83
MG1	Mongoose	86	Taterillus	UM1	Right	85
MG1	Mongoose	88	Taterillus	UM1	Right	87
MG1	Mongoose	91	Taterillus	UM1	Right	90
MG1	Mongoose	94	Taterillus	UM1	Left	93
MG1	Mongoose	97	Taterillus	UM1	Left	96
MG1	Mongoose	100	Taterillus	UM1	Left	99
MG1	Mongoose	102	Taterillus	UM1	Left	101
MG1	Mongoose	115	Taterillus	UM1	Left	114
MG1	Mongoose	70	Taterillus	UM2	Right	68
MG1	Mongoose	73	Taterillus	UM2	Left	71
MG1	Mongoose	78	Taterillus	UM2	Left	76
MG1	Mongoose	82	Taterillus	UM2	Right	80
MG1	Mongoose	89	Taterillus	UM2	Right	87
MG1	Mongoose	92	Taterillus	UM2	Right	90
MG1	Mongoose	95	Taterillus	UM2	Left	93
MG1	Mongoose	98	Taterillus	UM2	Left	96
MG1	Mongoose	116	Taterillus	UM2	Left	114
MG1	Mongoose	79	Taterillus	UM3	Left	76
MG3	Mongoose	8	Acomys	LM1	Left	
MG3	Mongoose	123	Acomys	UM1	Left	122
MG3	Mongoose	124	Acomys	UM2	Left	122
MG3	Mongoose	125	Acomys	UM3	Left	122
MG3	Mongoose	149	Crocidura	LM1	Left	148
MG3	Mongoose	155	Crocidura	LM1	Right	154
MG3	Mongoose	162	Crocidura	LM1	Left	161
MG3	Mongoose	169	Crocidura	LM1	Right	168
MG3	Mongoose	176	Crocidura	LM1	Left	175
MG3	Mongoose	182	Crocidura	LM1	Right	181
MG3	Mongoose	150	Crocidura	LM2	Left	148
MG3	Mongoose	156	Crocidura	LM2	Right	154
MG3	Mongoose	163	Crocidura	LM2	Left	161
MG3	Mongoose	170	Crocidura	LM2	Right	168
MG3	Mongoose	177	Crocidura	LM2	Left	175
MG3	Mongoose	183	Crocidura	LM2	Right	181
MG3	Mongoose	157	Crocidura	LM3	Right	154
MG3	Mongoose	164	Crocidura	LM3	Left	161
MG3	Mongoose	171	Crocidura	LM3	Right	168
MG3	Mongoose	178	Crocidura	LM3	Left	175
MG3	Mongoose	184	Crocidura	LM3	Right	181

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG3	Mongoose	186	Crocidura	UM1	Right	185
MG3	Mongoose	195	Crocidura	UM1	Left	194
MG3	Mongoose	203	Crocidura	UM1	Left	202
MG3	Mongoose	212	Crocidura	UM1	Right	211
MG3	Mongoose	187	Crocidura	UM2	Right	185
MG3	Mongoose	196	Crocidura	UM2	Left	194
MG3	Mongoose	204	Crocidura	UM2	Left	202
MG3	Mongoose	213	Crocidura	UM2	Right	211
MG3	Mongoose	188	Crocidura	UM3	Right	185
MG3	Mongoose	197	Crocidura	UM3	Left	194
MG3	Mongoose	205	Crocidura	UM3	Left	202
MG3	Mongoose	46	Dendromus	LM1	Left	45
MG3	Mongoose	84	Dendromus	LM1	Right	83
MG3	Mongoose	47	Dendromus	LM2	Left	45
MG3	Mongoose	85	Dendromus	LM2	Right	83
MG3	Mongoose	9	Gerbillus	LM1	Left	
MG3	Mongoose	10	Gerbillus	LM1	Right	
MG3	Mongoose	11	Gerbillus	LM1	Left	
MG3	Mongoose	39	Gerbillus	LM1	Left	38
MG3	Mongoose	41	Gerbillus	LM1	Right	40
MG3	Mongoose	49	Gerbillus	LM1	Right	48
MG3	Mongoose	54	Gerbillus	LM1	Right	53
MG3	Mongoose	57	Gerbillus	LM1	Right	56
MG3	Mongoose	61	Gerbillus	LM1	Right	60
MG3	Mongoose	65	Gerbillus	LM1	Left	64
MG3	Mongoose	68	Gerbillus	LM1	Left	67
MG3	Mongoose	72	Gerbillus	LM1	Right	71
MG3	Mongoose	77	Gerbillus	LM1	Right	76
MG3	Mongoose	81	Gerbillus	LM1	Right	80
MG3	Mongoose	88	Gerbillus	LM1	Right	87
MG3	Mongoose	93	Gerbillus	LM1	Right	92
MG3	Mongoose	18	Gerbillus	LM2	Right	
MG3	Mongoose	19	Gerbillus	LM2	Left	
MG3	Mongoose	20	Gerbillus	LM2	Left	
MG3	Mongoose	21	Gerbillus	LM2	Left	
MG3	Mongoose	43	Gerbillus	LM2	Left	42
MG3	Mongoose	50	Gerbillus	LM2	Right	48
MG3	Mongoose	58	Gerbillus	LM2	Right	56
MG3	Mongoose	62	Gerbillus	LM2	Right	60
MG3	Mongoose	69	Gerbillus	LM2	Left	67
MG3	Mongoose	73	Gerbillus	LM2	Right	71
MG3	Mongoose	78	Gerbillus	LM2	Right	76
MG3	Mongoose	82	Gerbillus	LM2	Right	80
MG3	Mongoose	89	Gerbillus	LM2	Right	87
MG3	Mongoose	94	Gerbillus	LM2	Right	92
MG3	Mongoose	24	Gerbillus	LM3	Left	
MG3	Mongoose	25	Gerbillus	LM3	Left	
MG3	Mongoose	26	Gerbillus	LM3	Right	
MG3	Mongoose	44	Gerbillus	LM3	Left	42

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG3	Mongoose	51	Gerbillus	LM3	Right	48
MG3	Mongoose	59	Gerbillus	LM3	Right	56
MG3	Mongoose	74	Gerbillus	LM3	Right	71
MG3	Mongoose	90	Gerbillus	LM3	Right	87
MG3	Mongoose	95	Gerbillus	LM3	Right	92
MG3	Mongoose	3	Gerbillus	UM1	Left	
MG3	Mongoose	4	Gerbillus	UM1	Right	
MG3	Mongoose	6	Gerbillus	UM1	Right	
MG3	Mongoose	127	Gerbillus	UM1	Right	126
MG3	Mongoose	129	Gerbillus	UM1	Right	128
MG3	Mongoose	133	Gerbillus	UM1	Right	132
MG3	Mongoose	140	Gerbillus	UM1	Left	139
MG3	Mongoose	143	Gerbillus	UM1	Left	124
MG3	Mongoose	14	Gerbillus	UM2	Left	
MG3	Mongoose	15	Gerbillus	UM2	Right	
MG3	Mongoose	16	Gerbillus	UM2	Right	
MG3	Mongoose	23	Gerbillus	UM2	Left	
MG3	Mongoose	134	Gerbillus	UM2	Right	132
MG3	Mongoose	141	Gerbillus	UM2	Left	139
MG3	Mongoose	147	Gerbillus	UM2	Right	146
MG3	Mongoose	117	Gerbillus	UM3	Right	
MG3	Mongoose	135	Gerbillus	UM3	Right	132
MG3	Mongoose	98	Grammomys	LM1	Left	97
MG3	Mongoose	102	Grammomys	LM1	Right	101
MG3	Mongoose	13	Grammomys	LM2	Left	
MG3	Mongoose	99	Grammomys	LM2	Left	97
MG3	Mongoose	103	Grammomys	LM2	Right	101
MG3	Mongoose	22	Grammomys	LM3	Left	
MG3	Mongoose	100	Grammomys	LM3	Left	97
MG3	Mongoose	104	Grammomys	LM3	Right	101
MG3	Mongoose	5	Grammomys	UM1	Right	
MG3	Mongoose	27	Indet.			
MG3	Mongoose	12	Mus	LM1	Left	
MG3	Mongoose	107	Mus	LM1	Left	106
MG3	Mongoose	109	Mus	LM1	Left	108
MG3	Mongoose	113	Mus	LM1	Right	112
MG3	Mongoose	116	Mus	LM1	Left	115
MG3	Mongoose	110	Mus	LM2	Left	108
MG3	Mongoose	111	Mus	LM3	Left	108
MG3	Mongoose	7	Mus	UM1	Left	
MG3	Mongoose	137	Mus	UM1	Right	136
MG3	Mongoose	138	Mus	UM2	Right	136
MG3	Mongoose	145	Mus	UM2	Left	144
MG3	Mongoose	29	Taterillus	LM1	Right	28
MG3	Mongoose	31	Taterillus	LM1	Left	30
MG3	Mongoose	36	Taterillus	LM1	Left	35
MG3	Mongoose	17	Taterillus	LM2	Right	
MG3	Mongoose	32	Taterillus	LM2	Left	30
MG3	Mongoose	37	Taterillus	LM2	Left	35

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG3	Mongoose	33	Taterillus	LM3	Left	30
MG3	Mongoose	1	Taterillus	UM1	Left	
MG3	Mongoose	2	Taterillus	UM1	Right	
MG3	Mongoose	119	Taterillus	UM1	Left	118
MG3	Mongoose	120	Taterillus	UM2	Left	118
MG3	Mongoose	131	Taterillus	UM2	Right	130
MG3	Mongoose	121	Taterillus	UM3	Left	118
MG4	Mongoose	44	Acomys	LM1	Left	
MG4	Mongoose	50	Acomys	LM1	Left	
MG4	Mongoose	91	Acomys	LM1	Right	90
MG4	Mongoose	100	Acomys	LM1	Right	99
MG4	Mongoose	113	Acomys	LM1	Right	112
MG4	Mongoose	92	Acomys	LM2	Right	90
MG4	Mongoose	101	Acomys	LM2	Right	99
MG4	Mongoose	114	Acomys	LM2	Right	112
MG4	Mongoose	93	Acomys	LM3	Right	90
MG4	Mongoose	144	Acomys	LM3	Right	143
MG4	Mongoose	27	Acomys	UM1	Right	
MG4	Mongoose	40	Acomys	UM1	Left	
MG4	Mongoose	49	Acomys	UM1	Right	
MG4	Mongoose	274	Acomys	UM1	Left	273
MG4	Mongoose	308	Acomys	UM1	Left	307
MG4	Mongoose	317	Crocidura	LM1	Right	316
MG4	Mongoose	324	Crocidura	LM1	Right	323
MG4	Mongoose	325	Crocidura	LM1	Right	323
MG4	Mongoose	318	Crocidura	LM2	Right	316
MG4	Mongoose	330	Crocidura	UM1	Right	329
MG4	Mongoose	332	Crocidura	UM1	Left	
MG4	Mongoose	331	Crocidura	UM2	Right	329
MG4	Mongoose	334	Elephantulus	LM1	Right	
MG4	Mongoose	337	Elephantulus	LM1	Left	336
MG4	Mongoose	338	Elephantulus	LM2	Left	336
MG4	Mongoose	339	Elephantulus	LM3	Left	336
MG4	Mongoose	333	Elephantulus	LP4	Right	
MG4	Mongoose	335	Elephantulus	UM1	Left	
MG4	Mongoose	341	Elephantulus	UM1	Right	340
MG4	Mongoose	342	Elephantulus	UM2	Right	340
MG4	Mongoose	343	Elephantulus	UM3	Right	340
MG4	Mongoose	24	Gerbillus	LM1	Left	
MG4	Mongoose	25	Gerbillus	LM1	Left	
MG4	Mongoose	26	Gerbillus	LM1	Right	
MG4	Mongoose	28	Gerbillus	LM1	Right	
MG4	Mongoose	29	Gerbillus	LM1	Left	
MG4	Mongoose	30	Gerbillus	LM1	Right	
MG4	Mongoose	31	Gerbillus	LM1	Right	
MG4	Mongoose	32	Gerbillus	LM1	Right	
MG4	Mongoose	37	Gerbillus	LM1	Left	
MG4	Mongoose	38	Gerbillus	LM1	Left	
MG4	Mongoose	39	Gerbillus	LM1	Left	

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG4	Mongoose	41	Gerbillus	LM1	Left	
MG4	Mongoose	42	Gerbillus	LM1	Right	
MG4	Mongoose	45	Gerbillus	LM1	Right	
MG4	Mongoose	47	Gerbillus	LM1	Right	
MG4	Mongoose	48	Gerbillus	LM1	Right	
MG4	Mongoose	52	Gerbillus	LM1	Left	51
MG4	Mongoose	57	Gerbillus	LM1	Right	56
MG4	Mongoose	62	Gerbillus	LM1	Right	61
MG4	Mongoose	67	Gerbillus	LM1	Right	66
MG4	Mongoose	72	Gerbillus	LM1	Left	71
MG4	Mongoose	84	Gerbillus	LM1	Left	83
MG4	Mongoose	95	Gerbillus	LM1	Right	94
MG4	Mongoose	104	Gerbillus	LM1	Left	103
MG4	Mongoose	111	Gerbillus	LM1	Right	110
MG4	Mongoose	118	Gerbillus	LM1	Left	117
MG4	Mongoose	126	Gerbillus	LM1	Left	125
MG4	Mongoose	133	Gerbillus	LM1	Left	132
MG4	Mongoose	139	Gerbillus	LM1	Right	138
MG4	Mongoose	141	Gerbillus	LM1	Right	140
MG4	Mongoose	154	Gerbillus	LM1	Right	153
MG4	Mongoose	165	Gerbillus	LM1	Right	164
MG4	Mongoose	169	Gerbillus	LM1	Left	168
MG4	Mongoose	172	Gerbillus	LM1	Left	171
MG4	Mongoose	174	Gerbillus	LM1	Right	173
MG4	Mongoose	186	Gerbillus	LM1	Right	185
MG4	Mongoose	214	Gerbillus	LM1	Right	213
MG4	Mongoose	287	Gerbillus	LM1	Left	286
MG4	Mongoose	294	Gerbillus	LM1	Left	293
MG4	Mongoose	53	Gerbillus	LM2	Left	51
MG4	Mongoose	58	Gerbillus	LM2	Right	56
MG4	Mongoose	63	Gerbillus	LM2	Right	61
MG4	Mongoose	68	Gerbillus	LM2	Right	66
MG4	Mongoose	73	Gerbillus	LM2	Left	71
MG4	Mongoose	85	Gerbillus	LM2	Left	83
MG4	Mongoose	96	Gerbillus	LM2	Right	94
MG4	Mongoose	105	Gerbillus	LM2	Left	103
MG4	Mongoose	119	Gerbillus	LM2	Left	117
MG4	Mongoose	134	Gerbillus	LM2	Left	132
MG4	Mongoose	136	Gerbillus	LM2	Left	135
MG4	Mongoose	156	Gerbillus	LM2	Right	155
MG4	Mongoose	163	Gerbillus	LM2	Right	162
MG4	Mongoose	166	Gerbillus	LM2	Right	164
MG4	Mongoose	188	Gerbillus	LM2	Right	187
MG4	Mongoose	208	Gerbillus	LM2	Left	
MG4	Mongoose	209	Gerbillus	LM2	Left	
MG4	Mongoose	210	Gerbillus	LM2	Right	
MG4	Mongoose	211	Gerbillus	LM2	Right	
MG4	Mongoose	212	Gerbillus	LM2	Right	
MG4	Mongoose	215	Gerbillus	LM2	Right	213

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG4	Mongoose	288	Gerbillus	LM2	Left	286
MG4	Mongoose	292	Gerbillus	LM2	Left	
MG4	Mongoose	54	Gerbillus	LM3	Left	51
MG4	Mongoose	59	Gerbillus	LM3	Right	56
MG4	Mongoose	64	Gerbillus	LM3	Right	61
MG4	Mongoose	69	Gerbillus	LM3	Right	66
MG4	Mongoose	120	Gerbillus	LM3	Left	117
MG4	Mongoose	157	Gerbillus	LM3	Right	155
MG4	Mongoose	289	Gerbillus	LM3	Left	286
MG4	Mongoose	1	Gerbillus	UM1	Left	
MG4	Mongoose	2	Gerbillus	UM1	Right	
MG4	Mongoose	6	Gerbillus	UM1	Left	
MG4	Mongoose	7	Gerbillus	UM1	Right	
MG4	Mongoose	8	Gerbillus	UM1	Right	
MG4	Mongoose	9	Gerbillus	UM1	Right	
MG4	Mongoose	10	Gerbillus	UM1	Left	
MG4	Mongoose	11	Gerbillus	UM1	Left	
MG4	Mongoose	12	Gerbillus	UM1	Right	
MG4	Mongoose	13	Gerbillus	UM1	Left	
MG4	Mongoose	14	Gerbillus	UM1	Left	
MG4	Mongoose	33	Gerbillus	UM1	Left	
MG4	Mongoose	34	Gerbillus	UM1	Right	
MG4	Mongoose	35	Gerbillus	UM1	Left	
MG4	Mongoose	36	Gerbillus	UM1	Left	
MG4	Mongoose	43	Gerbillus	UM1	Right	
MG4	Mongoose	46	Gerbillus	UM1	Left	
MG4	Mongoose	217	Gerbillus	UM1	Right	216
MG4	Mongoose	223	Gerbillus	UM1	Left	222
MG4	Mongoose	226	Gerbillus	UM1	Left	225
MG4	Mongoose	229	Gerbillus	UM1	Right	228
MG4	Mongoose	233	Gerbillus	UM1	Right	232
MG4	Mongoose	237	Gerbillus	UM1	Right	236
MG4	Mongoose	244	Gerbillus	UM1	Right	243
MG4	Mongoose	248	Gerbillus	UM1	Left	247
MG4	Mongoose	254	Gerbillus	UM1	Left	253
MG4	Mongoose	257	Gerbillus	UM1	Left	256
MG4	Mongoose	259	Gerbillus	UM1	Right	258
MG4	Mongoose	262	Gerbillus	UM1	Left	261
MG4	Mongoose	264	Gerbillus	UM1	Left	263
MG4	Mongoose	269	Gerbillus	UM1	Right	268
MG4	Mongoose	302	Gerbillus	UM1	Left	301
MG4	Mongoose	304	Gerbillus	UM1	Left	303
MG4	Mongoose	204	Gerbillus	UM2	Left	
MG4	Mongoose	205	Gerbillus	UM2	Right	
MG4	Mongoose	206	Gerbillus	UM2	Right	
MG4	Mongoose	207	Gerbillus	UM2	Right	
MG4	Mongoose	224	Gerbillus	UM2	Left	222
MG4	Mongoose	227	Gerbillus	UM2	Left	225
MG4	Mongoose	230	Gerbillus	UM2	Right	228

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG4	Mongoose	234	Gerbillus	UM2	Right	232
MG4	Mongoose	238	Gerbillus	UM2	Right	236
MG4	Mongoose	246	Gerbillus	UM2	Left	245
MG4	Mongoose	249	Gerbillus	UM2	Left	247
MG4	Mongoose	255	Gerbillus	UM2	Left	253
MG4	Mongoose	260	Gerbillus	UM2	Right	258
MG4	Mongoose	265	Gerbillus	UM2	Left	263
MG4	Mongoose	267	Gerbillus	UM2	Right	266
MG4	Mongoose	270	Gerbillus	UM2	Right	268
MG4	Mongoose	272	Gerbillus	UM2	Right	271
MG4	Mongoose	305	Gerbillus	UM2	Left	303
MG4	Mongoose	310	Gerbillus	UM2	Left	309
MG4	Mongoose	231	Gerbillus	UM3	Right	228
MG4	Mongoose	235	Gerbillus	UM3	Right	232
MG4	Mongoose	239	Gerbillus	UM3	Right	236
MG4	Mongoose	250	Gerbillus	UM3	Left	247
MG4	Mongoose	306	Gerbillus	UM3	Left	303
MG4	Mongoose	241	Grammomys	UM1	Right	240
MG4	Mongoose	242	Grammomys	UM2	Right	240
MG4	Mongoose	276	Grammomys	UM2	Left	275
MG4	Mongoose	277	Grammomys	UM3	Left	275
MG4	Mongoose	107	Mus	LM1	Right	106
MG4	Mongoose	123	Mus	LM1	Right	122
MG4	Mongoose	129	Mus	LM1	Left	128
MG4	Mongoose	146	Mus	LM1	Right	145
MG4	Mongoose	150	Mus	LM1	Left	149
MG4	Mongoose	159	Mus	LM1	Left	158
MG4	Mongoose	176	Mus	LM1	Left	175
MG4	Mongoose	181	Mus	LM1	Left	180
MG4	Mongoose	190	Mus	LM1	Left	189
MG4	Mongoose	280	Mus	LM1	Right	279
MG4	Mongoose	284	Mus	LM1	Right	283
MG4	Mongoose	296	Mus	LM1	Left	295
MG4	Mongoose	108	Mus	LM2	Right	106
MG4	Mongoose	124	Mus	LM2	Right	122
MG4	Mongoose	130	Mus	LM2	Left	128
MG4	Mongoose	147	Mus	LM2	Right	145
MG4	Mongoose	151	Mus	LM2	Left	149
MG4	Mongoose	160	Mus	LM2	Left	158
MG4	Mongoose	177	Mus	LM2	Left	175
MG4	Mongoose	182	Mus	LM2	Left	180
MG4	Mongoose	281	Mus	LM2	Right	279
MG4	Mongoose	285	Mus	LM2	Right	283
MG4	Mongoose	297	Mus	LM2	Left	295
MG4	Mongoose	148	Mus	LM3	Right	145
MG4	Mongoose	161	Mus	LM3	Left	158
MG4	Mongoose	178	Mus	LM3	Left	175
MG4	Mongoose	183	Mus	LM3	Left	180
MG4	Mongoose	282	Mus	LM3	Right	279

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG4	Mongoose	15	Mus	UM1	Left	
MG4	Mongoose	312	Mus	UM1	Right	311
MG4	Mongoose	203	Mus	UM2	Right	
MG4	Mongoose	278	Mus	UM2	Right	
MG4	Mongoose	313	Mus	UM2	Right	311
MG4	Mongoose	16	Taterillus	LM1	Right	
MG4	Mongoose	17	Taterillus	LM1	Right	
MG4	Mongoose	18	Taterillus	LM1	Left	
MG4	Mongoose	19	Taterillus	LM1	Left	
MG4	Mongoose	20	Taterillus	LM1	Left	
MG4	Mongoose	21	Taterillus	LM1	Right	
MG4	Mongoose	22	Taterillus	LM1	Left	
MG4	Mongoose	23	Taterillus	LM1	Right	
MG4	Mongoose	76	Taterillus	LM1	Right	75
MG4	Mongoose	81	Taterillus	LM1	Left	80
MG4	Mongoose	88	Taterillus	LM1	Right	87
MG4	Mongoose	116	Taterillus	LM1	Right	115
MG4	Mongoose	291	Taterillus	LM1	Right	290
MG4	Mongoose	299	Taterillus	LM1	Right	298
MG4	Mongoose	77	Taterillus	LM2	Right	75
MG4	Mongoose	82	Taterillus	LM2	Left	80
MG4	Mongoose	89	Taterillus	LM2	Right	87
MG4	Mongoose	98	Taterillus	LM2	Left	97
MG4	Mongoose	193	Taterillus	LM2	Right	
MG4	Mongoose	194	Taterillus	LM2	Right	
MG4	Mongoose	195	Taterillus	LM2	Right	
MG4	Mongoose	196	Taterillus	LM2	Right	
MG4	Mongoose	197	Taterillus	LM2	Left	
MG4	Mongoose	198	Taterillus	LM2	Left	
MG4	Mongoose	199	Taterillus	LM2	Left	
MG4	Mongoose	200	Taterillus	LM2	Left	
MG4	Mongoose	201	Taterillus	LM2	Left	
MG4	Mongoose	202	Taterillus	LM2	Left	
MG4	Mongoose	300	Taterillus	LM2	Right	298
MG4	Mongoose	78	Taterillus	LM3	Right	75
MG4	Mongoose	3	Taterillus	UM1	Left	
MG4	Mongoose	4	Taterillus	UM1	Right	
MG4	Mongoose	5	Taterillus	UM1	Right	
MG4	Mongoose	219	Taterillus	UM1	Right	218
MG4	Mongoose	221	Taterillus	UM1	Right	220
MG4	Mongoose	252	Taterillus	UM1	Left	251
MG4	Mongoose	315	Taterillus	UM1	Right	314
MG4	Mongoose	191	Taterillus	UM2	Right	
MG4	Mongoose	192	Taterillus	UM2	Right	
MG5	Mongoose	96	Acomys	LM1	Right	
MG5	Mongoose	97	Acomys	LM1	Right	
MG5	Mongoose	98	Acomys	LM1	Left	
MG5	Mongoose	99	Acomys	LM1	Left	
MG5	Mongoose	100	Acomys	LM1	Left	

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG5	Mongoose	101	Acomys	LM1	Left	
MG5	Mongoose	321	Acomys	LM1	Right	320
MG5	Mongoose	358	Acomys	LM1	Left	357
MG5	Mongoose	375	Acomys	LM1	Right	374
MG5	Mongoose	378	Acomys	LM1	Left	377
MG5	Mongoose	420	Acomys	LM1	Right	419
MG5	Mongoose	137	Acomys	LM2	Left	
MG5	Mongoose	138	Acomys	LM2	Left	
MG5	Mongoose	139	Acomys	LM2	Left	
MG5	Mongoose	140	Acomys	LM2	Left	
MG5	Mongoose	141	Acomys	LM2	Right	
MG5	Mongoose	322	Acomys	LM2	Right	320
MG5	Mongoose	345	Acomys	LM2	Right	344
MG5	Mongoose	379	Acomys	LM2	Left	377
MG5	Mongoose	421	Acomys	LM2	Right	419
MG5	Mongoose	135	Acomys	LM3	Left	
MG5	Mongoose	136	Acomys	LM3	Right	
MG5	Mongoose	323	Acomys	LM3	Right	320
MG5	Mongoose	108	Acomys	UM1	Right	
MG5	Mongoose	112	Acomys	UM1	Right	
MG5	Mongoose	113	Acomys	UM1	Right	
MG5	Mongoose	191	Acomys	UM1	Right	190
MG5	Mongoose	214	Acomys	UM1	Left	213
MG5	Mongoose	224	Acomys	UM1	Right	223
MG5	Mongoose	239	Acomys	UM1	Left	238
MG5	Mongoose	251	Acomys	UM1	Left	250
MG5	Mongoose	130	Acomys	UM2	Right	
MG5	Mongoose	131	Acomys	UM2	Right	
MG5	Mongoose	215	Acomys	UM2	Left	213
MG5	Mongoose	225	Acomys	UM2	Right	223
MG5	Mongoose	252	Acomys	UM2	Left	250
MG5	Mongoose	192	Acomys	UM3	Right	190
MG5	Mongoose	226	Acomys	UM3	Right	223
MG5	Mongoose	478	Crocidura	LM1	Right	477
MG5	Mongoose	485	Crocidura	LM1	Right	484
MG5	Mongoose	490	Crocidura	LM1	Left	489
MG5	Mongoose	496	Crocidura	LM1	Left	495
MG5	Mongoose	503	Crocidura	LM1	Right	502
MG5	Mongoose	508	Crocidura	LM1	Left	507
MG5	Mongoose	511	Crocidura	LM1	Left	510
MG5	Mongoose	479	Crocidura	LM2	Right	477
MG5	Mongoose	486	Crocidura	LM2	Right	484
MG5	Mongoose	491	Crocidura	LM2	Left	489
MG5	Mongoose	497	Crocidura	LM2	Left	495
MG5	Mongoose	512	Crocidura	LM2	Left	510
MG5	Mongoose	480	Crocidura	LM3	Right	477
MG5	Mongoose	487	Crocidura	LM3	Right	484
MG5	Mongoose	492	Crocidura	LM3	Left	489
MG5	Mongoose	498	Crocidura	LM3	Left	495

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG5	Mongoose	515	Crocidura	UM1	Left	514
MG5	Mongoose	526	Crocidura	UM1	Right	525
MG5	Mongoose	534	Crocidura	UM1	Right	533
MG5	Mongoose	516	Crocidura	UM2	Left	514
MG5	Mongoose	527	Crocidura	UM2	Right	525
MG5	Mongoose	535	Crocidura	UM2	Right	533
MG5	Mongoose	85	Gerbillus	LM1	Right	
MG5	Mongoose	86	Gerbillus	LM1	Left	
MG5	Mongoose	87	Gerbillus	LM1	Right	
MG5	Mongoose	88	Gerbillus	LM1	Left	
MG5	Mongoose	89	Gerbillus	LM1	Right	
MG5	Mongoose	90	Gerbillus	LM1	Right	
MG5	Mongoose	91	Gerbillus	LM1	Left	
MG5	Mongoose	92	Gerbillus	LM1	Right	
MG5	Mongoose	93	Gerbillus	LM1	Left	
MG5	Mongoose	94	Gerbillus	LM1	Right	
MG5	Mongoose	95	Gerbillus	LM1	Left	
MG5	Mongoose	299	Gerbillus	LM1	Left	298
MG5	Mongoose	301	Gerbillus	LM1	Right	300
MG5	Mongoose	340	Gerbillus	LM1	Left	339
MG5	Mongoose	343	Gerbillus	LM1	Left	342
MG5	Mongoose	349	Gerbillus	LM1	Right	348
MG5	Mongoose	353	Gerbillus	LM1	Left	352
MG5	Mongoose	356	Gerbillus	LM1	Left	355
MG5	Mongoose	360	Gerbillus	LM1	Left	359
MG5	Mongoose	362	Gerbillus	LM1	Right	361
MG5	Mongoose	367	Gerbillus	LM1	Right	366
MG5	Mongoose	371	Gerbillus	LM1	Right	370
MG5	Mongoose	382	Gerbillus	LM1	Right	381
MG5	Mongoose	385	Gerbillus	LM1	Right	384
MG5	Mongoose	387	Gerbillus	LM1	Right	386
MG5	Mongoose	390	Gerbillus	LM1	Right	389
MG5	Mongoose	397	Gerbillus	LM1	Left	396
MG5	Mongoose	401	Gerbillus	LM1	Left	400
MG5	Mongoose	405	Gerbillus	LM1	Left	404
MG5	Mongoose	410	Gerbillus	LM1	Right	409
MG5	Mongoose	412	Gerbillus	LM1	Left	411
MG5	Mongoose	415	Gerbillus	LM1	Left	414
MG5	Mongoose	424	Gerbillus	LM1	Left	423
MG5	Mongoose	437	Gerbillus	LM1	Left	436
MG5	Mongoose	441	Gerbillus	LM1	Right	440
MG5	Mongoose	142	Gerbillus	LM2	Left	
MG5	Mongoose	143	Gerbillus	LM2	Left	
MG5	Mongoose	144	Gerbillus	LM2	Left	
MG5	Mongoose	145	Gerbillus	LM2	Left	
MG5	Mongoose	146	Gerbillus	LM2	Right	
MG5	Mongoose	147	Gerbillus	LM2	Right	
MG5	Mongoose	148	Gerbillus	LM2	Right	
MG5	Mongoose	303	Gerbillus	LM2	Right	302

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG5	Mongoose	350	Gerbillus	LM2	Right	348
MG5	Mongoose	354	Gerbillus	LM2	Left	352
MG5	Mongoose	363	Gerbillus	LM2	Right	361
MG5	Mongoose	365	Gerbillus	LM2	Left	364
MG5	Mongoose	368	Gerbillus	LM2	Right	366
MG5	Mongoose	372	Gerbillus	LM2	Right	370
MG5	Mongoose	391	Gerbillus	LM2	Right	389
MG5	Mongoose	398	Gerbillus	LM2	Left	396
MG5	Mongoose	402	Gerbillus	LM2	Left	400
MG5	Mongoose	406	Gerbillus	LM2	Left	404
MG5	Mongoose	416	Gerbillus	LM2	Left	414
MG5	Mongoose	425	Gerbillus	LM2	Left	423
MG5	Mongoose	438	Gerbillus	LM2	Left	436
MG5	Mongoose	156	Gerbillus	LM3	Left	
MG5	Mongoose	351	Gerbillus	LM3	Right	348
MG5	Mongoose	407	Gerbillus	LM3	Left	404
MG5	Mongoose	417	Gerbillus	LM3	Left	414
MG5	Mongoose	426	Gerbillus	LM3	Left	423
MG5	Mongoose	439	Gerbillus	LM3	Left	436
MG5	Mongoose	102	Gerbillus	UM1	Right	
MG5	Mongoose	103	Gerbillus	UM1	Left	
MG5	Mongoose	104	Gerbillus	UM1	Left	
MG5	Mongoose	105	Gerbillus	UM1	Right	
MG5	Mongoose	106	Gerbillus	UM1	Left	
MG5	Mongoose	107	Gerbillus	UM1	Right	
MG5	Mongoose	109	Gerbillus	UM1	Left	
MG5	Mongoose	110	Gerbillus	UM1	Right	
MG5	Mongoose	111	Gerbillus	UM1	Left	
MG5	Mongoose	114	Gerbillus	UM1	Left	
MG5	Mongoose	115	Gerbillus	UM1	Right	
MG5	Mongoose	116	Gerbillus	UM1	Left	
MG5	Mongoose	117	Gerbillus	UM1	Left	
MG5	Mongoose	118	Gerbillus	UM1	Right	
MG5	Mongoose	119	Gerbillus	UM1	Left	
MG5	Mongoose	120	Gerbillus	UM1	Left	
MG5	Mongoose	158	Gerbillus	UM1	Right	157
MG5	Mongoose	177	Gerbillus	UM1	Left	176
MG5	Mongoose	181	Gerbillus	UM1	Right	180
MG5	Mongoose	184	Gerbillus	UM1	Left	183
MG5	Mongoose	188	Gerbillus	UM1	Left	187
MG5	Mongoose	197	Gerbillus	UM1	Left	196
MG5	Mongoose	241	Gerbillus	UM1	Left	240
MG5	Mongoose	244	Gerbillus	UM1	Left	243
MG5	Mongoose	248	Gerbillus	UM1	Right	247
MG5	Mongoose	254	Gerbillus	UM1	Left	253
MG5	Mongoose	256	Gerbillus	UM1	Left	255
MG5	Mongoose	259	Gerbillus	UM1	Left	258
MG5	Mongoose	262	Gerbillus	UM1	Left	261
MG5	Mongoose	265	Gerbillus	UM1	Right	264

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG5	Mongoose	272	Gerbillus	UM1	Left	271
MG5	Mongoose	121	Gerbillus	UM2	Right	
MG5	Mongoose	122	Gerbillus	UM2	Right	
MG5	Mongoose	123	Gerbillus	UM2	Right	
MG5	Mongoose	124	Gerbillus	UM2	Right	
MG5	Mongoose	125	Gerbillus	UM2	Right	
MG5	Mongoose	126	Gerbillus	UM2	Right	
MG5	Mongoose	127	Gerbillus	UM2	Right	
MG5	Mongoose	128	Gerbillus	UM2	Left	
MG5	Mongoose	129	Gerbillus	UM2	Left	
MG5	Mongoose	134	Gerbillus	UM2	Right	
MG5	Mongoose	159	Gerbillus	UM2	Right	157
MG5	Mongoose	175	Gerbillus	UM2	Right	
MG5	Mongoose	178	Gerbillus	UM2	Left	176
MG5	Mongoose	182	Gerbillus	UM2	Right	180
MG5	Mongoose	186	Gerbillus	UM2	Right	185
MG5	Mongoose	189	Gerbillus	UM2	Left	187
MG5	Mongoose	242	Gerbillus	UM2	Left	240
MG5	Mongoose	245	Gerbillus	UM2	Left	243
MG5	Mongoose	249	Gerbillus	UM2	Right	247
MG5	Mongoose	257	Gerbillus	UM2	Left	255
MG5	Mongoose	260	Gerbillus	UM2	Left	258
MG5	Mongoose	263	Gerbillus	UM2	Left	261
MG5	Mongoose	266	Gerbillus	UM2	Right	264
MG5	Mongoose	273	Gerbillus	UM2	Left	271
MG5	Mongoose	149	Gerbillus	UM3	Left	
MG5	Mongoose	179	Gerbillus	UM3	Left	176
MG5	Mongoose	246	Gerbillus	UM3	Left	243
MG5	Mongoose	429	Grammomys	LM1	Right	428
MG5	Mongoose	433	Grammomys	LM1	Left	432
MG5	Mongoose	430	Grammomys	LM2	Right	428
MG5	Mongoose	434	Grammomys	LM2	Left	432
MG5	Mongoose	431	Grammomys	LM3	Right	428
MG5	Mongoose	435	Grammomys	LM3	Left	432
MG5	Mongoose	199	Grammomys	UM1	Right	198
MG5	Mongoose	200	Grammomys	UM2	Right	198
MG5	Mongoose	201	Grammomys	UM3	Right	198
MG5	Mongoose	81	Indet.			
MG5	Mongoose	152	Indet.			
MG5	Mongoose	133	Mus	LM1	Right	
MG5	Mongoose	443	Mus	LM1	Left	442
MG5	Mongoose	447	Mus	LM1	Right	446
MG5	Mongoose	450	Mus	LM1	Right	449
MG5	Mongoose	455	Mus	LM1	Left	454
MG5	Mongoose	457	Mus	LM1	Left	456
MG5	Mongoose	461	Mus	LM1	Right	460
MG5	Mongoose	464	Mus	LM1	Left	463
MG5	Mongoose	467	Mus	LM1	Left	466
MG5	Mongoose	132	Mus	LM2	Right	

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG5	Mongoose	444	Mus	LM2	Left	442
MG5	Mongoose	451	Mus	LM2	Right	449
MG5	Mongoose	458	Mus	LM2	Left	456
MG5	Mongoose	462	Mus	LM2	Right	460
MG5	Mongoose	465	Mus	LM2	Left	463
MG5	Mongoose	468	Mus	LM2	Left	466
MG5	Mongoose	452	Mus	LM3	Right	449
MG5	Mongoose	469	Mus	LM3	Left	466
MG5	Mongoose	268	Mus	UM1	Left	267
MG5	Mongoose	275	Mus	UM1	Left	274
MG5	Mongoose	278	Mus	UM1	Right	277
MG5	Mongoose	269	Mus	UM2	Left	267
MG5	Mongoose	276	Mus	UM2	Left	274
MG5	Mongoose	279	Mus	UM2	Right	277
MG5	Mongoose	270	Mus	UM3	Left	267
MG5	Mongoose	1	Tatera	LM1	Right	
MG5	Mongoose	2	Tatera	LM1	Left	
MG5	Mongoose	6	Tatera	LM1	Right	
MG5	Mongoose	7	Tatera	LM1	Left	
MG5	Mongoose	9	Tatera	LM1	Right	
MG5	Mongoose	11	Tatera	LM1	Right	
MG5	Mongoose	12	Tatera	LM1	Right	
MG5	Mongoose	14	Tatera	LM1	Left	
MG5	Mongoose	15	Tatera	LM1	Right	
MG5	Mongoose	16	Tatera	LM1	Left	
MG5	Mongoose	17	Tatera	LM1	Right	
MG5	Mongoose	472	Tatera	LM1	Right	471
MG5	Mongoose	476	Tatera	LM1	Left	475
MG5	Mongoose	25	Tatera	LM2	Right	
MG5	Mongoose	26	Tatera	LM2	Right	
MG5	Mongoose	27	Tatera	LM2	Right	
MG5	Mongoose	28	Tatera	LM2	Right	
MG5	Mongoose	29	Tatera	LM2	Right	
MG5	Mongoose	30	Tatera	LM2	Right	
MG5	Mongoose	31	Tatera	LM2	Right	
MG5	Mongoose	32	Tatera	LM2	Left	
MG5	Mongoose	33	Tatera	LM2	Left	
MG5	Mongoose	34	Tatera	LM2	Left	
MG5	Mongoose	35	Tatera	LM2	Left	
MG5	Mongoose	36	Tatera	LM2	Left	
MG5	Mongoose	473	Tatera	LM2	Right	471
MG5	Mongoose	474	Tatera	LM3	Right	471
MG5	Mongoose	3	Tatera	UM1	Right	
MG5	Mongoose	4	Tatera	UM1	Right	
MG5	Mongoose	5	Tatera	UM1	Left	
MG5	Mongoose	8	Tatera	UM1	Left	
MG5	Mongoose	10	Tatera	UM1	Right	
MG5	Mongoose	13	Tatera	UM1	Left	
MG5	Mongoose	18	Tatera	UM1	Left	

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG5	Mongoose	19	Tatera	UM1	Right	
MG5	Mongoose	281	Tatera	UM1	Left	280
MG5	Mongoose	284	Tatera	UM1	Right	283
MG5	Mongoose	288	Tatera	UM1	Right	287
MG5	Mongoose	20	Tatera	UM2	Right	
MG5	Mongoose	21	Tatera	UM2	Right	
MG5	Mongoose	22	Tatera	UM2	Right	
MG5	Mongoose	23	Tatera	UM2	Left	
MG5	Mongoose	24	Tatera	UM2	Left	
MG5	Mongoose	282	Tatera	UM2	Left	280
MG5	Mongoose	286	Tatera	UM2	Left	285
MG5	Mongoose	290	Tatera	UM2	Right	289
MG5	Mongoose	80	Tatera	UM3	Right	
MG5	Mongoose	291	Tatera	UM3	Right	289
MG5	Mongoose	37	Taterillus	LM1	Left	
MG5	Mongoose	38	Taterillus	LM1	Right	
MG5	Mongoose	40	Taterillus	LM1	Right	
MG5	Mongoose	44	Taterillus	LM1	Right	
MG5	Mongoose	45	Taterillus	LM1	Left	
MG5	Mongoose	46	Taterillus	LM1	Right	
MG5	Mongoose	47	Taterillus	LM1	Right	
MG5	Mongoose	48	Taterillus	LM1	Right	
MG5	Mongoose	49	Taterillus	LM1	Left	
MG5	Mongoose	50	Taterillus	LM1	Left	
MG5	Mongoose	293	Taterillus	LM1	Right	292
MG5	Mongoose	297	Taterillus	LM1	Right	296
MG5	Mongoose	308	Taterillus	LM1	Right	307
MG5	Mongoose	310	Taterillus	LM1	Right	309
MG5	Mongoose	313	Taterillus	LM1	Right	312
MG5	Mongoose	318	Taterillus	LM1	Left	317
MG5	Mongoose	326	Taterillus	LM1	Left	325
MG5	Mongoose	328	Taterillus	LM1	Right	327
MG5	Mongoose	331	Taterillus	LM1	Right	330
MG5	Mongoose	334	Taterillus	LM1	Right	333
MG5	Mongoose	336	Taterillus	LM1	Left	335
MG5	Mongoose	338	Taterillus	LM1	Right	337
MG5	Mongoose	347	Taterillus	LM1	Right	346
MG5	Mongoose	394	Taterillus	LM1	Left	393
MG5	Mongoose	70	Taterillus	LM2	Right	
MG5	Mongoose	71	Taterillus	LM2	Right	
MG5	Mongoose	72	Taterillus	LM2	Right	
MG5	Mongoose	73	Taterillus	LM2	Right	
MG5	Mongoose	74	Taterillus	LM2	Right	
MG5	Mongoose	75	Taterillus	LM2	Left	
MG5	Mongoose	76	Taterillus	LM2	Left	
MG5	Mongoose	77	Taterillus	LM2	Left	
MG5	Mongoose	78	Taterillus	LM2	Left	
MG5	Mongoose	79	Taterillus	LM2	Left	
MG5	Mongoose	83	Taterillus	LM2		

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG5	Mongoose	294	Taterillus	LM2	Right	292
MG5	Mongoose	305	Taterillus	LM2	Left	304
MG5	Mongoose	311	Taterillus	LM2	Right	309
MG5	Mongoose	314	Taterillus	LM2	Right	312
MG5	Mongoose	316	Taterillus	LM2	Right	315
MG5	Mongoose	153	Taterillus	LM3	Left	
MG5	Mongoose	154	Taterillus	LM3	Left	
MG5	Mongoose	155	Taterillus	LM3	Right	
MG5	Mongoose	295	Taterillus	LM3	Right	292
MG5	Mongoose	306	Taterillus	LM3	Left	304
MG5	Mongoose	39	Taterillus	UM1	Right	
MG5	Mongoose	41	Taterillus	UM1	Right	
MG5	Mongoose	42	Taterillus	UM1	Left	
MG5	Mongoose	43	Taterillus	UM1	Right	
MG5	Mongoose	51	Taterillus	UM1	Left	
MG5	Mongoose	52	Taterillus	UM1	Right	
MG5	Mongoose	53	Taterillus	UM1	Left	
MG5	Mongoose	54	Taterillus	UM1	Left	
MG5	Mongoose	55	Taterillus	UM1	Right	
MG5	Mongoose	56	Taterillus	UM1	Left	
MG5	Mongoose	57	Taterillus	UM1	Left	
MG5	Mongoose	58	Taterillus	UM1	Right	
MG5	Mongoose	59	Taterillus	UM1	Right	
MG5	Mongoose	82	Taterillus	UM1	Left	
MG5	Mongoose	162	Taterillus	UM1	Right	160
MG5	Mongoose	166	Taterillus	UM1	Left	165
MG5	Mongoose	168	Taterillus	UM1	Right	167
MG5	Mongoose	170	Taterillus	UM1	Right	169
MG5	Mongoose	172	Taterillus	UM1	Right	171
MG5	Mongoose	203	Taterillus	UM1	Left	202
MG5	Mongoose	206	Taterillus	UM1	Right	205
MG5	Mongoose	209	Taterillus	UM1	Right	208
MG5	Mongoose	211	Taterillus	UM1	Left	210
MG5	Mongoose	217	Taterillus	UM1	Right	216
MG5	Mongoose	220	Taterillus	UM1	Left	219
MG5	Mongoose	222	Taterillus	UM1	Left	221
MG5	Mongoose	228	Taterillus	UM1	Right	227
MG5	Mongoose	231	Taterillus	UM1	Right	230
MG5	Mongoose	234	Taterillus	UM1	Left	233
MG5	Mongoose	236	Taterillus	UM1	Left	235
MG5	Mongoose	60	Taterillus	UM2	Left	
MG5	Mongoose	61	Taterillus	UM2	Left	
MG5	Mongoose	62	Taterillus	UM2	Left	
MG5	Mongoose	63	Taterillus	UM2	Left	
MG5	Mongoose	64	Taterillus	UM2	Left	
MG5	Mongoose	65	Taterillus	UM2	Left	
MG5	Mongoose	66	Taterillus	UM2	Right	
MG5	Mongoose	67	Taterillus	UM2	Right	
MG5	Mongoose	68	Taterillus	UM2	Right	

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
MG5	Mongoose	69	Taterillus	UM2	Right	
MG5	Mongoose	161	Taterillus	UM2	Right	160
MG5	Mongoose	164	Taterillus	UM2	Left	163
MG5	Mongoose	173	Taterillus	UM2	Right	171
MG5	Mongoose	194	Taterillus	UM2	Right	193
MG5	Mongoose	204	Taterillus	UM2	Left	202
MG5	Mongoose	207	Taterillus	UM2	Right	205
MG5	Mongoose	212	Taterillus	UM2	Left	210
MG5	Mongoose	218	Taterillus	UM2	Right	216
MG5	Mongoose	229	Taterillus	UM2	Right	227
MG5	Mongoose	232	Taterillus	UM2	Right	230
MG5	Mongoose	237	Taterillus	UM2	Left	235
MG5	Mongoose	150	Taterillus	UM3	Left	
MG5	Mongoose	151	Taterillus	UM3	Right	
MG5	Mongoose	174	Taterillus	UM3	Right	171
MG5	Mongoose	195	Taterillus	UM3	Right	193
EO4	Eagle owl	24	Dendromus	LM1	Right	23
EO4	Eagle owl	29	Dendromus	LM1	Left	28
EO4	Eagle owl	25	Dendromus	LM2	Right	23
EO4	Eagle owl	30	Dendromus	LM2	Left	28
EO4	Eagle owl	26	Dendromus	LM3	Right	23
EO4	Eagle owl	255	Dendromus	UM1	Left	254
EO4	Eagle owl	259	Dendromus	UM1	Right	258
EO4	Eagle owl	256	Dendromus	UM2	Left	254
EO4	Eagle owl	260	Dendromus	UM2	Right	258
EO4	Eagle owl	10	Gerbillus	LM1	Right	
EO4	Eagle owl	11	Gerbillus	LM1	Right	
EO4	Eagle owl	16	Gerbillus	LM1	Right	15
EO4	Eagle owl	21	Gerbillus	LM1	Right	20
EO4	Eagle owl	32	Gerbillus	LM1	Right	31
EO4	Eagle owl	36	Gerbillus	LM1	Right	35
EO4	Eagle owl	41	Gerbillus	LM1	Right	40
EO4	Eagle owl	45	Gerbillus	LM1	Left	44
EO4	Eagle owl	50	Gerbillus	LM1	Left	49
EO4	Eagle owl	53	Gerbillus	LM1	Right	52
EO4	Eagle owl	57	Gerbillus	LM1	Left	56
EO4	Eagle owl	61	Gerbillus	LM1	Left	60
EO4	Eagle owl	65	Gerbillus	LM1	Right	64
EO4	Eagle owl	68	Gerbillus	LM1	Left	67
EO4	Eagle owl	73	Gerbillus	LM1	Left	72
EO4	Eagle owl	78	Gerbillus	LM1	Left	77
EO4	Eagle owl	83	Gerbillus	LM1	Left	82
EO4	Eagle owl	92	Gerbillus	LM1	Right	91
EO4	Eagle owl	96	Gerbillus	LM1	Right	95
EO4	Eagle owl	100	Gerbillus	LM1	Left	99
EO4	Eagle owl	104	Gerbillus	LM1	Right	103
EO4	Eagle owl	108	Gerbillus	LM1	Left	107
EO4	Eagle owl	113	Gerbillus	LM1	Right	112
EO4	Eagle owl	117	Gerbillus	LM1	Right	116

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
EO4	Eagle owl	121	Gerbillus	LM1	Left	120
EO4	Eagle owl	124	Gerbillus	LM1	Right	123
EO4	Eagle owl	128	Gerbillus	LM1	Right	127
EO4	Eagle owl	132	Gerbillus	LM1	Left	131
EO4	Eagle owl	137	Gerbillus	LM1	Left	136
EO4	Eagle owl	141	Gerbillus	LM1	Right	140
EO4	Eagle owl	145	Gerbillus	LM1	Left	144
EO4	Eagle owl	149	Gerbillus	LM1	Right	148
EO4	Eagle owl	153	Gerbillus	LM1	Left	152
EO4	Eagle owl	156	Gerbillus	LM1	Right	155
EO4	Eagle owl	161	Gerbillus	LM1	Right	160
EO4	Eagle owl	164	Gerbillus	LM1	Left	163
EO4	Eagle owl	179	Gerbillus	LM1	Left	178
EO4	Eagle owl	184	Gerbillus	LM1	Left	183
EO4	Eagle owl	188	Gerbillus	LM1	Left	187
EO4	Eagle owl	192	Gerbillus	LM1	Right	191
EO4	Eagle owl	197	Gerbillus	LM1	Right	196
EO4	Eagle owl	201	Gerbillus	LM1	Right	200
EO4	Eagle owl	205	Gerbillus	LM1	Right	204
EO4	Eagle owl	209	Gerbillus	LM1	Left	208
EO4	Eagle owl	213	Gerbillus	LM1	Left	212
EO4	Eagle owl	234	Gerbillus	LM1	Right	233
EO4	Eagle owl	14	Gerbillus	LM2	Left	
EO4	Eagle owl	17	Gerbillus	LM2	Right	15
EO4	Eagle owl	33	Gerbillus	LM2	Right	31
EO4	Eagle owl	37	Gerbillus	LM2	Right	35
EO4	Eagle owl	42	Gerbillus	LM2	Right	40
EO4	Eagle owl	46	Gerbillus	LM2	Left	44
EO4	Eagle owl	54	Gerbillus	LM2	Right	52
EO4	Eagle owl	58	Gerbillus	LM2	Left	56
EO4	Eagle owl	62	Gerbillus	LM2	Left	60
EO4	Eagle owl	66	Gerbillus	LM2	Right	64
EO4	Eagle owl	69	Gerbillus	LM2	Left	67
EO4	Eagle owl	74	Gerbillus	LM2	Left	72
EO4	Eagle owl	79	Gerbillus	LM2	Left	77
EO4	Eagle owl	84	Gerbillus	LM2	Left	82
EO4	Eagle owl	90	Gerbillus	LM2	Right	89
EO4	Eagle owl	93	Gerbillus	LM2	Right	91
EO4	Eagle owl	97	Gerbillus	LM2	Right	95
EO4	Eagle owl	101	Gerbillus	LM2	Left	99
EO4	Eagle owl	105	Gerbillus	LM2	Right	103
EO4	Eagle owl	109	Gerbillus	LM2	Left	107
EO4	Eagle owl	114	Gerbillus	LM2	Right	112
EO4	Eagle owl	118	Gerbillus	LM2	Right	116
EO4	Eagle owl	125	Gerbillus	LM2	Right	123
EO4	Eagle owl	129	Gerbillus	LM2	Right	127
EO4	Eagle owl	133	Gerbillus	LM2	Left	131
EO4	Eagle owl	138	Gerbillus	LM2	Left	136
EO4	Eagle owl	142	Gerbillus	LM2	Right	140

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
EO4	Eagle owl	146	Gerbillus	LM2	Left	144
EO4	Eagle owl	150	Gerbillus	LM2	Right	148
EO4	Eagle owl	157	Gerbillus	LM2	Right	155
EO4	Eagle owl	165	Gerbillus	LM2	Left	163
EO4	Eagle owl	169	Gerbillus	LM2	Right	168
EO4	Eagle owl	173	Gerbillus	LM2	Right	172
EO4	Eagle owl	176	Gerbillus	LM2	Left	175
EO4	Eagle owl	180	Gerbillus	LM2	Left	178
EO4	Eagle owl	185	Gerbillus	LM2	Left	183
EO4	Eagle owl	189	Gerbillus	LM2	Left	187
EO4	Eagle owl	193	Gerbillus	LM2	Right	191
EO4	Eagle owl	198	Gerbillus	LM2	Right	196
EO4	Eagle owl	202	Gerbillus	LM2	Right	200
EO4	Eagle owl	210	Gerbillus	LM2	Left	208
EO4	Eagle owl	214	Gerbillus	LM2	Left	212
EO4	Eagle owl	223	Gerbillus	LM2	Left	222
EO4	Eagle owl	235	Gerbillus	LM2	Right	233
EO4	Eagle owl	18	Gerbillus	LM3	Right	15
EO4	Eagle owl	34	Gerbillus	LM3	Right	31
EO4	Eagle owl	38	Gerbillus	LM3	Right	35
EO4	Eagle owl	47	Gerbillus	LM3	Left	44
EO4	Eagle owl	63	Gerbillus	LM3	Left	60
EO4	Eagle owl	70	Gerbillus	LM3	Left	67
EO4	Eagle owl	75	Gerbillus	LM3	Left	72
EO4	Eagle owl	80	Gerbillus	LM3	Left	77
EO4	Eagle owl	87	Gerbillus	LM3	Left	86
EO4	Eagle owl	110	Gerbillus	LM3	Left	107
EO4	Eagle owl	134	Gerbillus	LM3	Left	131
EO4	Eagle owl	139	Gerbillus	LM3	Left	136
EO4	Eagle owl	158	Gerbillus	LM3	Right	155
EO4	Eagle owl	166	Gerbillus	LM3	Left	163
EO4	Eagle owl	170	Gerbillus	LM3	Right	168
EO4	Eagle owl	181	Gerbillus	LM3	Left	178
EO4	Eagle owl	194	Gerbillus	LM3	Right	191
EO4	Eagle owl	203	Gerbillus	LM3	Right	200
EO4	Eagle owl	206	Gerbillus	LM3	Right	204
EO4	Eagle owl	215	Gerbillus	LM3	Left	212
EO4	Eagle owl	243	Gerbillus	LM3	Left	
EO4	Eagle owl	4	Gerbillus	UM1	Left	
EO4	Eagle owl	5	Gerbillus	UM1	Right	
EO4	Eagle owl	6	Gerbillus	UM1	Left	
EO4	Eagle owl	7	Gerbillus	UM1	Left	
EO4	Eagle owl	8	Gerbillus	UM1	Left	
EO4	Eagle owl	9	Gerbillus	UM1	Right	
EO4	Eagle owl	245	Gerbillus	UM1	Left	244
EO4	Eagle owl	250	Gerbillus	UM1	Right	249
EO4	Eagle owl	263	Gerbillus	UM1	Left	262
EO4	Eagle owl	268	Gerbillus	UM1	Left	267
EO4	Eagle owl	272	Gerbillus	UM1	Left	271

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
EO4	Eagle owl	277	Gerbillus	UM1	Left	276
EO4	Eagle owl	280	Gerbillus	UM1	Right	279
EO4	Eagle owl	287	Gerbillus	UM1	Right	286
EO4	Eagle owl	291	Gerbillus	UM1	Left	290
EO4	Eagle owl	295	Gerbillus	UM1	Left	294
EO4	Eagle owl	299	Gerbillus	UM1	Right	298
EO4	Eagle owl	303	Gerbillus	UM1	Left	302
EO4	Eagle owl	306	Gerbillus	UM1	Right	305
EO4	Eagle owl	310	Gerbillus	UM1	Right	309
EO4	Eagle owl	314	Gerbillus	UM1	Right	313
EO4	Eagle owl	320	Gerbillus	UM1	Right	319
EO4	Eagle owl	324	Gerbillus	UM1	Left	323
EO4	Eagle owl	327	Gerbillus	UM1	Left	326
EO4	Eagle owl	331	Gerbillus	UM1	Right	330
EO4	Eagle owl	334	Gerbillus	UM1	Right	333
EO4	Eagle owl	338	Gerbillus	UM1	Right	337
EO4	Eagle owl	342	Gerbillus	UM1	Right	341
EO4	Eagle owl	344	Gerbillus	UM1	Right	343
EO4	Eagle owl	347	Gerbillus	UM1	Right	346
EO4	Eagle owl	350	Gerbillus	UM1	Right	349
EO4	Eagle owl	353	Gerbillus	UM1	Left	352
EO4	Eagle owl	357	Gerbillus	UM1	Left	356
EO4	Eagle owl	359	Gerbillus	UM1	Left	358
EO4	Eagle owl	362	Gerbillus	UM1	Right	361
EO4	Eagle owl	365	Gerbillus	UM1	Right	364
EO4	Eagle owl	369	Gerbillus	UM1	Right	368
EO4	Eagle owl	372	Gerbillus	UM1	Left	371
EO4	Eagle owl	376	Gerbillus	UM1	Left	375
EO4	Eagle owl	380	Gerbillus	UM1	Right	379
EO4	Eagle owl	382	Gerbillus	UM1	Right	381
EO4	Eagle owl	385	Gerbillus	UM1	Right	384
EO4	Eagle owl	388	Gerbillus	UM1	Left	387
EO4	Eagle owl	392	Gerbillus	UM1	Left	391
EO4	Eagle owl	416	Gerbillus	UM1	Right	415
EO4	Eagle owl	12	Gerbillus	UM2	Right	
EO4	Eagle owl	13	Gerbillus	UM2	Left	
EO4	Eagle owl	246	Gerbillus	UM2	Left	244
EO4	Eagle owl	251	Gerbillus	UM2	Right	249
EO4	Eagle owl	264	Gerbillus	UM2	Left	262
EO4	Eagle owl	269	Gerbillus	UM2	Left	267
EO4	Eagle owl	273	Gerbillus	UM2	Left	271
EO4	Eagle owl	281	Gerbillus	UM2	Right	279
EO4	Eagle owl	284	Gerbillus	UM2	Left	283
EO4	Eagle owl	288	Gerbillus	UM2	Right	286
EO4	Eagle owl	292	Gerbillus	UM2	Left	290
EO4	Eagle owl	296	Gerbillus	UM2	Left	294
EO4	Eagle owl	300	Gerbillus	UM2	Right	298
EO4	Eagle owl	304	Gerbillus	UM2	Left	302
EO4	Eagle owl	307	Gerbillus	UM2	Right	305

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
EO4	Eagle owl	311	Gerbillus	UM2	Right	309
EO4	Eagle owl	315	Gerbillus	UM2	Right	313
EO4	Eagle owl	317	Gerbillus	UM2	Right	316
EO4	Eagle owl	321	Gerbillus	UM2	Right	319
EO4	Eagle owl	325	Gerbillus	UM2	Left	323
EO4	Eagle owl	328	Gerbillus	UM2	Left	326
EO4	Eagle owl	332	Gerbillus	UM2	Right	330
EO4	Eagle owl	335	Gerbillus	UM2	Right	333
EO4	Eagle owl	339	Gerbillus	UM2	Right	337
EO4	Eagle owl	345	Gerbillus	UM2	Right	343
EO4	Eagle owl	348	Gerbillus	UM2	Right	346
EO4	Eagle owl	351	Gerbillus	UM2	Right	349
EO4	Eagle owl	354	Gerbillus	UM2	Left	352
EO4	Eagle owl	360	Gerbillus	UM2	Left	358
EO4	Eagle owl	363	Gerbillus	UM2	Right	361
EO4	Eagle owl	366	Gerbillus	UM2	Right	364
EO4	Eagle owl	370	Gerbillus	UM2	Right	368
EO4	Eagle owl	373	Gerbillus	UM2	Left	371
EO4	Eagle owl	377	Gerbillus	UM2	Left	375
EO4	Eagle owl	383	Gerbillus	UM2	Right	381
EO4	Eagle owl	386	Gerbillus	UM2	Right	384
EO4	Eagle owl	389	Gerbillus	UM2	Left	387
EO4	Eagle owl	393	Gerbillus	UM2	Left	391
EO4	Eagle owl	417	Gerbillus	UM2	Right	415
EO4	Eagle owl	247	Gerbillus	UM3	Left	244
EO4	Eagle owl	252	Gerbillus	UM3	Right	249
EO4	Eagle owl	265	Gerbillus	UM3	Left	262
EO4	Eagle owl	274	Gerbillus	UM3	Left	271
EO4	Eagle owl	282	Gerbillus	UM3	Right	279
EO4	Eagle owl	285	Gerbillus	UM3	Left	283
EO4	Eagle owl	289	Gerbillus	UM3	Right	286
EO4	Eagle owl	293	Gerbillus	UM3	Left	290
EO4	Eagle owl	297	Gerbillus	UM3	Left	294
EO4	Eagle owl	301	Gerbillus	UM3	Right	298
EO4	Eagle owl	308	Gerbillus	UM3	Right	305
EO4	Eagle owl	312	Gerbillus	UM3	Right	309
EO4	Eagle owl	318	Gerbillus	UM3	Right	316
EO4	Eagle owl	322	Gerbillus	UM3	Right	319
EO4	Eagle owl	329	Gerbillus	UM3	Left	326
EO4	Eagle owl	336	Gerbillus	UM3	Right	333
EO4	Eagle owl	340	Gerbillus	UM3	Right	337
EO4	Eagle owl	355	Gerbillus	UM3	Left	352
EO4	Eagle owl	367	Gerbillus	UM3	Right	364
EO4	Eagle owl	374	Gerbillus	UM3	Left	371
EO4	Eagle owl	378	Gerbillus	UM3	Left	375
EO4	Eagle owl	390	Gerbillus	UM3	Left	387
EO4	Eagle owl	394	Gerbillus	UM3	Left	391
EO4	Eagle owl	218	Mus	LM1	Right	217
EO4	Eagle owl	225	Mus	LM1	Left	224

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
EO4	Eagle owl	227	Mus	LM1	Left	226
EO4	Eagle owl	231	Mus	LM1	Left	230
EO4	Eagle owl	237	Mus	LM1	Right	236
EO4	Eagle owl	241	Mus	LM1	Left	240
EO4	Eagle owl	219	Mus	LM2	Right	217
EO4	Eagle owl	228	Mus	LM2	Left	226
EO4	Eagle owl	232	Mus	LM2	Left	230
EO4	Eagle owl	238	Mus	LM2	Right	236
EO4	Eagle owl	220	Mus	LM3	Right	217
EO4	Eagle owl	396	Mus	UM1	Left	395
EO4	Eagle owl	400	Mus	UM1	Left	399
EO4	Eagle owl	404	Mus	UM1	Right	403
EO4	Eagle owl	397	Mus	UM2	Left	395
EO4	Eagle owl	401	Mus	UM2	Left	399
EO4	Eagle owl	405	Mus	UM2	Right	403
EO4	Eagle owl	398	Mus	UM3	Left	395
EO4	Eagle owl	402	Mus	UM3	Left	399
EO4	Eagle owl	1	Tatera	LM1	Right	
EO4	Eagle owl	3	Tatera	LM2	Left	
EO4	Eagle owl	2	Tatera	UM1	Left	
EO4	Eagle owl	407	Taterillus	UM1	Left	406
EO4	Eagle owl	410	Taterillus	UM1	Left	409
EO4	Eagle owl	413	Taterillus	UM1	Left	412
EO4	Eagle owl	408	Taterillus	UM2	Left	406
EO4	Eagle owl	411	Taterillus	UM2	Left	409
EO4	Eagle owl	414	Taterillus	UM2	Left	412
EO2	Eagle owl	154	Acomys	UM1	Left	153
EO2	Eagle owl	155	Acomys	UM2	Left	513
EO2	Eagle owl	200	Crocidura	LM1	Left	199
EO2	Eagle owl	207	Crocidura	LM1	Right	206
EO2	Eagle owl	201	Crocidura	LM2	Left	199
EO2	Eagle owl	208	Crocidura	LM2	Right	206
EO2	Eagle owl	202	Crocidura	LM3	Left	199
EO2	Eagle owl	209	Crocidura	LM3	Right	206
EO2	Eagle owl	214	Crocidura	UM1	Left	213
EO2	Eagle owl	219	Crocidura	UM1	Right	218
EO2	Eagle owl	215	Crocidura	UM2	Left	213
EO2	Eagle owl	220	Crocidura	UM2	Right	218
EO2	Eagle owl	216	Crocidura	UM3	Left	213
EO2	Eagle owl	221	Crocidura	UM3	Right	218
EO2	Eagle owl	6	Gerbillus	LM1	Right	
EO2	Eagle owl	7	Gerbillus	LM1	Left	
EO2	Eagle owl	17	Gerbillus	LM1	Right	
EO2	Eagle owl	23	Gerbillus	LM1	Left	22
EO2	Eagle owl	27	Gerbillus	LM1	Right	26
EO2	Eagle owl	37	Gerbillus	LM1	Left	36
EO2	Eagle owl	40	Gerbillus	LM1	Left	39
EO2	Eagle owl	44	Gerbillus	LM1	Left	43
EO2	Eagle owl	49	Gerbillus	LM1	Left	48

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
EO2	Eagle owl	53	Gerbillus	LM1	Left	52
EO2	Eagle owl	56	Gerbillus	LM1	Right	55
EO2	Eagle owl	60	Gerbillus	LM1	Right	59
EO2	Eagle owl	68	Gerbillus	LM1	Right	67
EO2	Eagle owl	77	Gerbillus	LM1	Left	76
EO2	Eagle owl	81	Gerbillus	LM1	Left	80
EO2	Eagle owl	84	Gerbillus	LM1	Right	83
EO2	Eagle owl	88	Gerbillus	LM1	Right	87
EO2	Eagle owl	91	Gerbillus	LM1	Left	90
EO2	Eagle owl	95	Gerbillus	LM1	Left	94
EO2	Eagle owl	99	Gerbillus	LM1	Right	98
EO2	Eagle owl	103	Gerbillus	LM1	Left	102
EO2	Eagle owl	106	Gerbillus	LM1	Right	105
EO2	Eagle owl	109	Gerbillus	LM1	Left	108
EO2	Eagle owl	119	Gerbillus	LM1	Right	118
EO2	Eagle owl	9	Gerbillus	LM2	Right	
EO2	Eagle owl	10	Gerbillus	LM2	Left	
EO2	Eagle owl	11	Gerbillus	LM2	Left	
EO2	Eagle owl	12	Gerbillus	LM2	Left	
EO2	Eagle owl	15	Gerbillus	LM2	Left	
EO2	Eagle owl	16	Gerbillus	LM2	Left	
EO2	Eagle owl	20	Gerbillus	LM2	Right	19
EO2	Eagle owl	24	Gerbillus	LM2	Left	22
EO2	Eagle owl	30	Gerbillus	LM2	Left	29
EO2	Eagle owl	41	Gerbillus	LM2	Left	39
EO2	Eagle owl	45	Gerbillus	LM2	Left	43
EO2	Eagle owl	50	Gerbillus	LM2	Left	48
EO2	Eagle owl	57	Gerbillus	LM2	Right	55
EO2	Eagle owl	61	Gerbillus	LM2	Right	59
EO2	Eagle owl	64	Gerbillus	LM2	Right	63
EO2	Eagle owl	69	Gerbillus	LM2	Right	67
EO2	Eagle owl	73	Gerbillus	LM2	Right	72
EO2	Eagle owl	78	Gerbillus	LM2	Left	76
EO2	Eagle owl	85	Gerbillus	LM2	Right	83
EO2	Eagle owl	92	Gerbillus	LM2	Left	90
EO2	Eagle owl	96	Gerbillus	LM2	Left	94
EO2	Eagle owl	100	Gerbillus	LM2	Right	98
EO2	Eagle owl	104	Gerbillus	LM2	Left	102
EO2	Eagle owl	120	Gerbillus	LM2	Right	118
EO2	Eagle owl	21	Gerbillus	LM3	Right	19
EO2	Eagle owl	46	Gerbillus	LM3	Left	43
EO2	Eagle owl	65	Gerbillus	LM3	Right	63
EO2	Eagle owl	70	Gerbillus	LM3	Right	67
EO2	Eagle owl	74	Gerbillus	LM3	Right	72
EO2	Eagle owl	2	Gerbillus	UM1	Right	
EO2	Eagle owl	3	Gerbillus	UM1	Left	
EO2	Eagle owl	4	Gerbillus	UM1	Left	
EO2	Eagle owl	5	Gerbillus	UM1	Right	
EO2	Eagle owl	18	Gerbillus	UM1	Left	

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
EO2	Eagle owl	122	Gerbillus	UM1	Left	121
EO2	Eagle owl	130	Gerbillus	UM1	Left	129
EO2	Eagle owl	137	Gerbillus	UM1	Left	136
EO2	Eagle owl	140	Gerbillus	UM1	Right	139
EO2	Eagle owl	144	Gerbillus	UM1	Right	143
EO2	Eagle owl	147	Gerbillus	UM1	Left	146
EO2	Eagle owl	151	Gerbillus	UM1	Left	150
EO2	Eagle owl	157	Gerbillus	UM1	Left	156
EO2	Eagle owl	161	Gerbillus	UM1	Right	160
EO2	Eagle owl	165	Gerbillus	UM1	Left	164
EO2	Eagle owl	168	Gerbillus	UM1	Left	167
EO2	Eagle owl	171	Gerbillus	UM1	Right	170
EO2	Eagle owl	175	Gerbillus	UM1	Left	174
EO2	Eagle owl	178	Gerbillus	UM1	Right	177
EO2	Eagle owl	181	Gerbillus	UM1	Left	180
EO2	Eagle owl	185	Gerbillus	UM1	Left	184
EO2	Eagle owl	187	Gerbillus	UM1	Right	186
EO2	Eagle owl	190	Gerbillus	UM1	Right	189
EO2	Eagle owl	193	Gerbillus	UM1	Right	192
EO2	Eagle owl	13	Gerbillus	UM2	Right	
EO2	Eagle owl	14	Gerbillus	UM2	Right	
EO2	Eagle owl	123	Gerbillus	UM2	Left	121
EO2	Eagle owl	131	Gerbillus	UM2	Left	129
EO2	Eagle owl	134	Gerbillus	UM2	Right	133
EO2	Eagle owl	138	Gerbillus	UM2	Left	136
EO2	Eagle owl	141	Gerbillus	UM2	Right	139
EO2	Eagle owl	145	Gerbillus	UM2	Right	143
EO2	Eagle owl	148	Gerbillus	UM2	Left	146
EO2	Eagle owl	152	Gerbillus	UM2	Left	150
EO2	Eagle owl	158	Gerbillus	UM2	Left	156
EO2	Eagle owl	162	Gerbillus	UM2	Right	160
EO2	Eagle owl	166	Gerbillus	UM2	Left	164
EO2	Eagle owl	169	Gerbillus	UM2	Left	167
EO2	Eagle owl	172	Gerbillus	UM2	Right	170
EO2	Eagle owl	176	Gerbillus	UM2	Left	174
EO2	Eagle owl	179	Gerbillus	UM2	Right	177
EO2	Eagle owl	182	Gerbillus	UM2	Left	180
EO2	Eagle owl	188	Gerbillus	UM2	Right	186
EO2	Eagle owl	191	Gerbillus	UM2	Right	189
EO2	Eagle owl	194	Gerbillus	UM2	Right	192
EO2	Eagle owl	132	Gerbillus	UM3	Left	129
EO2	Eagle owl	135	Gerbillus	UM3	Right	133
EO2	Eagle owl	142	Gerbillus	UM3	Right	139
EO2	Eagle owl	149	Gerbillus	UM3	Left	146
EO2	Eagle owl	159	Gerbillus	UM3	Left	156
EO2	Eagle owl	163	Gerbillus	UM3	Right	160
EO2	Eagle owl	173	Gerbillus	UM3	Right	170
EO2	Eagle owl	183	Gerbillus	UM3	Left	180
EO2	Eagle owl	112	Mus	LM1	Right	111

Assemblage	Accumulator	No.	Genus	Part	Side	Ariculated with no.
EO2	Eagle owl	116	Mus	LM1	Left	115
EO2	Eagle owl	113	Mus	LM2	Right	111
EO2	Eagle owl	126	Mus	UM1	Right	125
EO2	Eagle owl	196	Mus	UM1	Left	195
EO2	Eagle owl	127	Mus	UM2	Right	125
EO2	Eagle owl	197	Mus	UM2	Left	195
EO2	Eagle owl	128	Mus	UM3	Right	125
EO2	Eagle owl	198	Mus	UM3	Left	195
EO2	Eagle owl	33	Taterillus	LM1	Right	32
EO2	Eagle owl	34	Taterillus	LM2	Right	32
EO2	Eagle owl	1	Taterillus	UM1	Left	
EO2	Eagle owl	8	Taterillus	UM2	Left	