International Scholars Journals

African Journal of Ecology and Ecosystems ISSN: 9428-167X Vol. 4 (1), pp. 234-241, January, 2017. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Species abundance, structure and seasonal variation of small mammals in the CCNP

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Accepted 28 November, 2016

In this study, we investigated species composition and abundance of small mammals (rodents and insectivores) in the recently established Chebera Churchura National Park, in Ethiopia between 2010 and 2011. Two study grids were established in seven selected habitats. In each grid, forty-nine Sherman live traps were used to capture the small mammals. A total of 704 individuals were captured in 5488 trap-nights. Among them, 682 (98.3%) were rodents and 12 (1.7%) were insectivores. These comprised 16 species of rodents and 2 species of insectivores. The captured species were: *Mastomys natalensis, Mastomys erythroleucus, Lemniscomys striatus, Arvicanthis nilotiucs, Arvicanthis dembeensis, Acomys cahirinus, Rattus rattus, Mus musculus, Stenocephalemys albipes, Gerbilliscus robusta, Lophuromys flavopunctatus, Pelomys harringtoni, Mus tentellus, Crocidura fumosa* and *Crocidura flavescens. Tachyoryctes splendens, Xerus rutilus* and *Hystrix cristata* were recorded as observed species. The abundance of species varied among habitats and between seasons. *M. natalensis* and *L. striatus* were the most abundant species, whereas *C. flavescens* was the least abundant. The age distribution and trap success of small mammals varied between seasons and among habitats. This study clearly shows that the park has a diverse fauna.

Key words: Abundance, Chebera Churchura, Ethiopia, small mammals.

INTRODUCTION

Small mammals comprise the highest proportion among the mammal species all over the world (Vaughan et al., 2000). A total of 5416 species of mammals are recorded globally, of which more than 2,277 species are rodents and insectivores (Wilson and Reeder, 2005). They account for about 42% of mammalian species (Wilson and Reeder, 2005). In Africa, small mammals are probably the most ubiquitous and numerous (Skinner and Chimimba, 2005). Over 1150 species of mammals are currently listed for Africa, but still more mammalian species, especially rodents, insectivores and bats, still await discovery (Kingdon, 1997). Many studies were carried out in the continent on small mammals (rodents and insectivores). These include, Skinner and Chimimba (2005) in Southern African Subregion, Avenant and Cavallini (2008) and Avenant (2011) in South Africa, Linzey and Kesner (1997) in Zimbabwe, Oguge (1995) in Kenya, and Leirs et al. (1994) in Tanzania. For instance, one study on the community structure of small mammals (Rodentia and Soricomorpha) from the Gulf of Guinea region of West Africa found 45 species of soricomorphs and 101 of rodents (Amori and Luiselli, 2011). However, ecological studies for small mammals in Africa focused mostly on the western region, with minimal attention on the eastern part of the continent (Habtamu and Bekele, 2008). Faunal exploration is an important component of the study in a given protected area. It helps in understanding the potential of the area in composition

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and diversity of animals as well as to carryout conservation action for the future. Information on the diversity of small mammals besides reinforcing scientific knowledge will boost the importance of the region to establish protected areas and refugia (Habtamu and Bekele, 2008). Moreover, small mammals are known to have ecological, economical, social and cultural values (Avenant, 2011). They play an important role in natural communities and provide the main supply of fresh food for many predators (Davies, 2002).

Ethiopia's past geological history, unique topography and great variation on climate is home for diverse biological resources (Yalden and Largen, 1992; Bekele, 1996b; Lavrenchenko et al., 1998; Takele et al., 2010). The country has 284 species of mammals of which 39.4% are small mammals (Lavrenchenko et al., 1997; Datiko et al., 2007; Habtamu and Bekele, 2008). The country possesses 84 rodent species of which 15 are endemic (Bekele, 1996a; Lavrenchenko et al., 1998), comprising 25% of the Ethiopian mammal fauna and about 50% of the total endemic species (Bekele, 1996b; Yalden et al., 1996; Datiko et al., 2007). Despite this diversity, only few studies on the taxonomy and population ecology of rodents have been conducted in Ethiopia (Bekele, 1996a).

A number of investigations was carried out to study several aspects of small mammals communities in some of the National Parks of the country including Alatish National Park (Habtamu and Bekele, 2008), Nechisar National Park (Datiko et al., 2007), Bale Mountains National Park (Yalden, 1988; Lavrenchenko et al., 1997) and Simen Mountains National Park (Yalden et al., 1996) and in central Ethiopia by Bekele and Leirs (1997). Many of the endemic mammals are associated with high altitude moorland and grassland habitats (Yalden and Largen, 1992; Bekele, 1996a), although the species diversity is less than many lowlands (Yalden and Largen, 1992). Few areas of the country are extensively surveyed for small mammals (Yalden and Largen, 1992; Bekele, 1996a, b), while composition, habitat use and population dynamics of the small mammal community are poorly known for many regions of Ethiopia. This fact is probably a result of inaccessibility, remoteness and inhospitable conditions of such areas (Bekele, 1996a, b; Habtamu and Bekele, 2008). The same is true for the small mammal of the Chebera-Churchura National Park (CCNP). The National Park is among the recently established ones in the country, and is located in the southwestern extensive lowland area of Ethiopia. This National Park is a key biological resource conservation area based on the diversity of large mammal fauna, birds and the unique ecosystem (Timer, 2005; Weldeyohanes, 2006). The park was established in 2005 (Timer, 2005). So far, no studies have been carried out on small mammal in the area. The current study aimed at investigating the species composition, abundance and seasonal variation of small mammals in the CCNP.

MATERIALS AND METHODS

Study area

CCNP is located along the southwestern part of Ethiopia. It is partly located within Dawro zone and in Konta special district, about 300 and 580 km southwest of Awassa and Addis Ababa, respectively. It covers an area of 1,250 km2 and lies between the coordinates 36°27'00''- 36°57'14''E longitude and 6°56'05''-7°08'02''N latitude (Timer, 2005). The Park is bordered by Konta special district to the north, Omo River to the south, Dawro zone to the east and southeast and Agare high mountains and Omo River to the west (Weldeyohanes, 2006). It lies at the centre of Omo-Gibe River Basin. There are four small crater lakes that are distributed in different parts of the Park area (Figure 1). The altitude of the area ranges from 550 to 1,700 m asl at the volcanic peaks of the western boundary (Timer, 2005; Weldeyohanes, 2006). It is characterized by few flat lands and highly undulating to rolling plains with incised river and perennial streams, valleys and gorges. The mean annual temperature of the area is 17°C. The monthly mean minimum temperature ranges between 10 and 11.4°C (June and August), and the maximum range of between 27 and 29°C (January and February) (Weldeyohanes, 2006). The rainfall distribution is unimodal, with one long rainy season between April and August. The average amount of annual rainfall in the area varies from 1,000 to 3,500 mm.

The natural vegetation of CCNP is highly diverse (Megaze, 2006; Weldeyohanes, 2006). For instance, the ground water forest type of vegetation is dominated by Podocarpus juniperus and broad-leaved tree species. The riverine forests is characterized by mixed vegetation dominated by plant species such as *Albizia grandibracteata, Aspilia mosambicensis, Arundo donax, Chionantus mildobradii, Ehretia cymosa* and Grewia ferrugunea. The grassland has scattered trees and covers the largest part of the Park. It is dominated by elephant grass (Pennisetum purpureum) and few scattered trees. Notable species in woodland are *Acacia brevispica, Combretum colinum, Combretum mole, Maytenus arbutifolia, Terminalia brownii* and *Vitex doniana* (Timer, 2005; Megaze, 2006). In the surroundings of CCNP, farmers commonly cultivate cereals, coffee and root crops for their food source. Land-use patterns include grazing, grass cutting, fire wood collection and timber for construction (Weldeyohanes, 2006). Wild honey harvesting and collection of spices and wild coffee are also carried in the Park (Timer, 2005).

Trapping

In a study of Capture-Mark-Recapture (CMR), non-volant small mammals were trapped using Sherman live traps (16 x 6.5 x 5.5 cm) during the dry and wet seasons between 2010 and 2011. Each grid was sampled once per a season from the same site. Before the start of current data collection, a preliminary survey was conducted on September 2010. This helped us to identify the boundaries of different habitat types and to decide the number of grids/sites. The vegetation of the study area is not markedly differentiated into habitat types. However, based on the classification of vegetation regions of Ethiopia (Yalden and Largen, 1992) and the habitat classification scheme of White and Edwards (2000), seven habitat types: ground water forest (GWF), riverine forest (RF), grassland (GL), wooded grassland (WGL), bushland (BL), lake shore (LS) and agricultural field (AF) were identified. Seven randomly selected sites were identified to represent each habitat type. At each habitat type, two permanent live trapping grids 4900 m2 were established. In each trapping site, a standard square (seven rows by seven columns) trapping grid was established during both seasons. A total of 49 Sherman live traps were set per grid at 10 m intervals between points. The traps were baited with peanut butter mixed

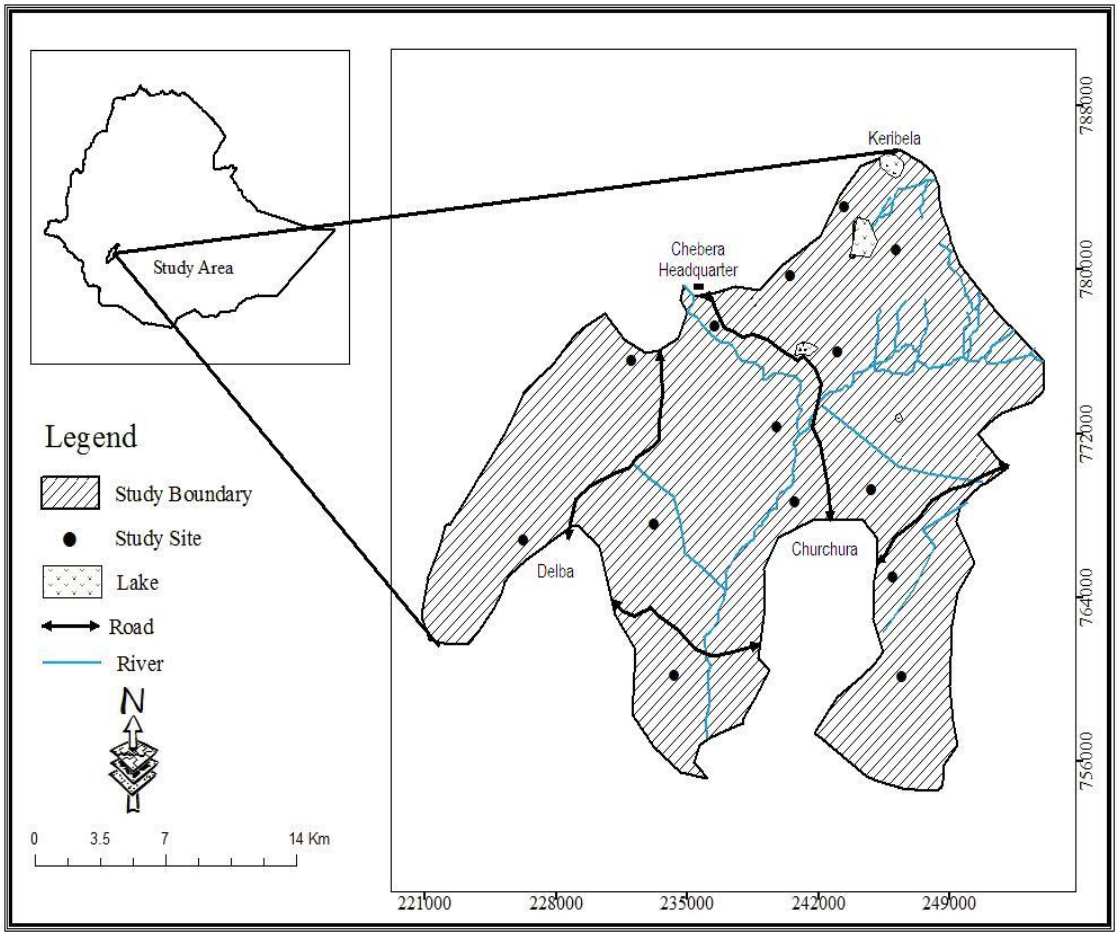

Figure 1. Location of the study sites/grids in Chebera-Churchura National Park, Ethiopia.

with crushed maize. To provide protection against the strong heat, traps were covered with hay and plant leaves during the dry season. The traps were checked twice a day (early morning between 07:00 and 09:00 h a.m., and late afternoon between 17:00 and 19:00 h p.m.) for three or five consecutive days depending on accessibility of the site. Each captured animal was identified, marked by toe clipping, and released at the site where it was trapped. In addition, body mass, sex and approximate age (juvenile, sub-adult and adult) was recorded. Reproductive condition (females: closed or perforated vagina; males: scrotal or abdominal testes) was also recorded (Bekele, 1996a). Age was determined by a compromise between body mass and reproductive condition (Bekele, 1996a, b; Habtamu and Bekele, 2008). Moreover, two or three representative individuals of each species were collected as voucher specimens from snap trapped animals. Thirty-six snap-traps were used along Sherman live-traps at the same time. The aim was to collect voucher specimen for identification. The traps were apart from the live trapping grids by about 200 m at each site to minimize the effect of home range. Skin and skull of the specimens were mounted and deposited in the Zoological Natural History Museum, Addis Ababa University. The specimens were compared and identified at species level by referring to additional reference materials deposited in the Museum. Data collected were analysed using SPSS version 16 computer software programme (SPSS Inc., Chicago, IL, USA) and descriptive statistics to compute the variation in relative abundance, total number of captures between seasons and habitats as well as between age groups.

RESULTS

A total of 18 (16 rodents and two insectivores) species of small mammals were recorded. Of these, 15 species of small mammals were captured during both dry and wet seasons of 5488 trap-nights and the remaining three species were recorded as observed species (Table 1). Out of the 704 small mammals trapped, 682 (98.3%) were rodents and 12 (1.7%) were insectivores. These small mammals were: *Mastomys natalensis, Lemniscomys striatus, Arvicanthis niloticus, Arvicanthis dembeensis, Mastomys erythroleucus, Acomys cahirinus, Rattus rattus, Mus musculus, Stenocephalemys albipes, Gerbilliscus robusta, Lophuromys flavopunctatus, Pelomys harringtoni, Mus tentellus, Crocidura fumosa, Crocidura flavescens, Tachyoryctes splendens, Xerus rutilus* and *Hystrix cristata.* Among these, *S. albipes* is a rodent endemic to Ethiopia (Bekele, 1996a, b). The total number of captures differed among species.

M. natalensis was the most abundant species constituting 29.0% of the total number of captures, followed by *L. striatus* (20.2%). *A. niloticus, A. dembeensis, M. erythroleucus* were recorded as 8.5, 6.7

Table 1. Species composition and relative abundance of live-trapped small mammals in the Chebera-Churchura National Park, Ethiopia (*= non-trapped/observed species).

Species	Total number of captures	Relative abundance (%)
Mastomys natalensis	204	29.0
Lemniscomys striatus	142	20.2
Arvicanthis niloticus	60	8.5
Arvicanthis dembeensis	52	7.4
Mastomys erythroleucus	44	6.2
Acomys cahirinus	40	5.7
Rattus rattus	37	5.3
Mus musculus	35	5.0
Stenocephalemys albipes	20	2.8
Gerbilliscus robusta	19	2.7
Lophuromys flavopunctatus	18	2.6
Pelomys harringtoni	13	1.8
Mus tentellus	8	1.1
Crocidura fumosa	8	1.1
Crocidura flavescens	4	0.6
*Tachyorctes splendens**	*	*
*Xerus rutilus**	*	*
*Hystrix cristata**	*	*
Total	704	100

Table 2. A abundance of trapped small mammal species in each habitat types (- shows absence of trapped individuals; GWF: ground water forest, RF: riverine forest, GL: grassland, WGL: wooded grassland, BL: bushland; LS: LS: lake shore, AF: agricultural field).

Species	Abundance of species in each habitat type						
	GWF	RF	GL	WGL	BL	LS	AF
M. natalensis	3.9	2.9	14.2	12.3	11.3	12.7	42.7
L. striatus	3.5	2.8	17.6	21.1	26.1	17.6	11.3
A. niloticus	-	-	18.3	21.7	16.6	6.7	36.7
A. dembeensis	-	-	7.7	11.5	15.4	5.8	59.6
M. erythroleucus	-	-	13.6	15.9	20.5	11.4	38.6
A. cahirinus	10.0	7.5	15.0	7.5	15.0	10.0	35.0
R. rattus	-	-	18.9	18.9	13.5	-	48.7
M. musculus	5.7	-	11.4	14.3	22.9	5.7	40.0
S. albipes	5.0	-	20.0	30.0	15.0	20.0	10.0
G. robusta	10.5	5.3	10.5	26.3	31.6	-	15.8
L. flavopunctatus	-	-	38.9	44.4	16.7	-	-
P. harringtoni	7.7	-	23.1	23.1	30.8	15.3	-
M. tentellus	-	-	25.0	25.0	37.5	-	12.5
C. fumosa	-	-	12.5	37.5	25.0	12.5	12.5
C. flavescens	-	-	25.0	50.0	-	25.0	-

and 6.2%, respectively. The other species were below 5% of the total number of captures (Table 1). The least abundant species were *M. tentellus, C. fumosa* and *C. flavescens*, with 1.1, 1.1 and 0.6%, respectively. Larger rodents such as porcupine (*H. cristata*), unstriped ground squirrel (*X. rutilus*) and the mole rat (*T. splendens*) were observed throughout the study area.

M. natalensis, L. striatus and *A. cahirinus* were recorded in all habitat types (Table 2), the highest abundance was 42.7% (agricultural field), 26.1% (bushland) and 35.0% (agricultural field) for *M. natalensis, L. striatus* and *A. cahirinus*, respectively. For these species, the lowest abundance was 3.1% *(M. natalensis)*, 2 .9% *(L. striatus)* and 7.5 *(A. cahirinus*) in

Table 3. Seasonal variation and sex distribution of small mammals trapped by live-trapping (-: absence).

Species	Seasons					
	2010 (Dry season)			2011 (Wet season)		
	Sex		Total number of captures	Sex		Total number of captures
	M	F		M	F	
M. natalensis	54	70	124	35	45	80
L. striatus	31	38	69	34	39	73
A. niloticus	20	23	43	8	9	17
A. dembeensis	17	15	32	10	10	20
M. erythroleucus	16	14	30	8	6	14
A. cahirinus	12	16	28	5	7	12
R. rattus	11	11	22	9	6	15
M. musculus	11	13	24	6	5	11
S. albipes	4	4	8	7	5	12
G. robusta	6	3	9	4	6	10
L. flavopunctatus	6	4	10	4	4	8
P. harringtoni	4	3	7	5	1	6
M. tentellus	-	-	-	3	5	8
C. fumosa	2	2	4	3	1	4
C. flavescens	3	1	4	-	-	-
Total	197	217	414	141	149	290

Table 4. Composition of different age groups of live-trapped small mammals.

Seasons	Age groups			Total catch	Relative abundance
Month/year	Adult	Sub-adult	Young (juveniles)		
Oct-Dec 2010 (Dry)	326	69	19	414	58.8%
Jun-Aug 2011 (Wet)	206	30	54	290	41.2%
Total	532	99	73	704	χ^2= 21.8, P < 0.05

riverine forest. *M. musculus* and *S. albipes* were captured in all habitats except the riverine forest, with variable abundance. *G. robusta* was not captured in agricultural field. The other species, *A. niloticus*, *A. dembeensis, M. erythroleucus, M. tentellus* and *C. fumosa* were captured in the same habitat types with variable abundance. Except for *M. tentellus* and *C. flavescens*, all species were captured both during wet and dry seasons (Table 3). The abundance of small mammals in the dry and wet seasons was 58.8 and 41.2%, respectively. The total number of captures was higher during the dry season than the wet season (58.8%; χ^2 = 21.8, df = 1, P < 0.05). *Crocidura flavescens* was only captured during the wet season and *M. tentellus* during the dry season. Out of the 704 captured individuals in all trapping occasions, females comprised 366 (52.0%) and males 338 individuals (48.0%; Table 3), which was statistically non-significant (χ^2=1.12, df = 1, P>0.05). However, as the number of individuals (abundance) increased the number of females also increased.

Adults comprised 532 (75.5%), sub-adults 99 (14.1%) and juveniles 73 individuals (10.4%; Table 4), each class statistically different from the others (χ^2 = 566.75, df = 2, P<0.05). During the wet season, juveniles comprised 54 (18.6%), sub-adults 30 (10.4%) and adults 206 (71.0%) individuals, whereas during the dry season, juveniles comprised 19 (4.6%), sub-adults 69 (16.7%) and adults 326 (78.7%) individuals. The variations in the number of sub-adults (χ^2 =15.36, df = 1, P < 0.05) and adults (χ^2 = 27.06, df = 1, P < 0.05) between seasons were significant. Out of the 73 juvenile rodents captured from different habitats during both seasons, 54 (74.0%) were captured during the wet and 19 (26.0%) during the dry season (χ^2 = 16.78, d.f. = 1, P <0.05).

Trap success did not differ among habitats (χ^2 = 3.72, df = 6, P>0.05; Table 5). The total number of captures did not vary between different habitats (χ^2 = 3.72, df = 6, P>0.05). However, the highest abundance was in agricultural field with 152 (21.6%) individuals and the lowest in riverine forest with 6 (0.9%) individuals during the dry and wet seasons, respectively. Maximum trap success from agricultural field (38.8%) and minimum from riverine forest (1.5%) were recorded during the dry and wet seasons, respectively. There were also variations in

Table 5. Trap success and relative abundance of small mammals in different habitats.

Habitat types	No. of grids	Month/year	Season	Total number of captures	Relative abundance	Trap night	Trap success
GWF	2	Oct-Dec/2010	Dry	14	2.0	392	3.6
	2	Jun-Aug/2011	Wet	9	1.3	392	2.3
RF	2	Oct-Dec/2010	Dry	8	1.1	392	2.0
	2	Jun-Aug/2011	Wet	6	0.9	392	1.5
GL	2	Oct-Dec/2010	Dry	64	9.1	392	16.3
	2	Jun-Aug/2011	Wet	48	6.8	392	12.2
WGL	2	Oct-Dec/2010	Dry	66	9.3	392	16.8
	2	Jun-Aug/2011	Wet	59	8.4	392	15.1
BL	2	Oct-Dec/2010	Dry	73	10.4	392	18.6
	2	Jun-Aug/2011	Wet	54	7.7	392	13.8
LS	2	Oct-Dec/2010	Dry	37	5.2	392	9.4
	2	Jun-Aug/2011	Wet	40	5.7	392	10.2
AF	2	Oct-Dec/2010	Dry	152	21.6	392	38.8
	2	Jun-Aug/2011	Wet	74	10.5	392	18.9

GWF: ground water forest, RF: riverine forest, GL: grassland, WGL: wooded grassland, BL: bushland; LS: lake shore, AF: agricultural field.

trap success among habitats and seasons ($\chi^2 = 96.8$, df = 13, $P<0.05$). The overall trap success of the study was 12.8%.

DISCUSSION

The present study revealed the presence of 18 species of small mammals in CCNP, indicating that the park is an ideal habitat for harboring small mammal species (rodents and insectivores). However, the study of Habtamu and Bekele (2008) revealed more species from Alatish National Park, northwestern Ethiopia. Also, great variations in the relative abundance of small mammals species were observed among habitats and between seasons. *M. natalensis* and *L. striatus* were the most abundant and widely distributed species in all habitat types, whereas *L. flavopunctatus* and *C. flavescens* were the least distributed and abundant species. Most small mammals are captured from grassland, wooded grassland and bushland, whereas ground water forest and riverine forest were very poor in species richness and abundance. Habtamu and Bekele (2008) and Marcello et al. (2008) also revealed similar findings. They noted the effect of vegetation cover and availability of resources on the abundance of animal species. This might be due to the homogeneous vegetation that is dominated by few species of tall trees in both forest types. In addition, the underground/open area under the forest habitat is open or less covered resulting in shortage of cover, food and diversity of microhabitats. Densely covered habitats with high diversity of plant species were preferred by most small mammal species in the study area. Similar results were found in Arbaminch forest (Datiko et al., 2007), and Alatish National Park (Habtamu and Bekele, 2008), both in Ethiopia.

Also, the total number of captures varied between seasons. Seasonality might cause the dynamic changes which occur in the habitats such as cover and food availability as noted by Oguge (1995) and Martin (1998). More individuals were captured from the agricultural field before harvest during the dry season. The trap success declined during the post-harvest period. The cropping system of the area possibly might have contributed to continuous supply and availability of alternative food and shelter for the species before harvest. Habitat complexity, food and cover availability are key factors influencing the overall distribution of rodents (Gebresilassie et al., 2004; Avenant and Cavallini, 2008). Moreover, lack of cover after harvest might have exposed the animals to predators which could force them to migrate to more suitable habitats (Hansson, 1999). Makundi et al. (2009) also noted that population size of small mammal species fluctuates greatly as a result of change in quality and quantity of resources in the environment. Studies also revealed that the availability (quality and quantity) of

resources also determine the movement pattern of small mammals (Kasso et al., 2010; Kilgore et al., 2010). The study of Gebresilassie et al. (2004) also revealed that farmlands provide essential resources better than grasslands before harvest.

During the present study, *M. tentellus* was not trapped during the dry season and *C. flavescens* during the wet season. This shows that extended study including both seasons will provide more information on the diversity and distribution of the species. The sex ratio of most species did not vary. However, the present study revealed that as the number of females increases in a population the abundance also increases. The study by Bekele (1996a), Datiko et al. (2007) and Habtamu and Bekele (2008) also found the same trend in central, south and northwestern part of the country, respectively. For some species, variation in age distribution was observed between seasons. Out of the total number of captured individuals, adults comprised the largest number of individuals (75.5%), followed by sub-adults (14.1%) and juveniles (10.4%). This might be related to the relative large home ranges for adults and sub-adults and small home ranges for young individuals of the same species (Shanker, 2001). In the present study, the number of pregnant females and juveniles was high during the wet season and low during the dry season, which was also observed in the study of Datiko et al. (2007). Even for the most abundant species (*M. natalensis* and *L. striatus*), pregnant and young individuals were rarely trapped during the dry season. This shows that breeding in most small mammal species was during the wet season. The wet season is full of more nutritious food which could promote breeding of animals (Jackson et al., 2004; Marcello et al., 2008). Our results are consistent with other studies that showed breeding patterns for many African rodents to be related to rainfall (Habtamu and Bekele, 2008; Takele et al., 2010; Girma et al., 2012).

Trap success differed between habitat types and seasons. In almost all habitat types, lower trap success was observed during the wet season and the abundance of most species increased during the dry season. The wet season was associated with reproduction for most rodent species (Bekele, 1996a; Marcello et al., 2008). The overall trap success varied among the seven habitats. The average total trap success was 12.8%. Similar studies in different parts of Ethiopia obtained higher trap successes: 19% for the high altitude locality of south Goba (Yalden et al., 1996), 18.7% for Harenna Forest (Yalden, 1988) and 17.6% for Arbaminch (Datiko et al., 2007). As compared to previous studies, a lower trap success was obtained in the present study. It might be related to habitat unsuitability and topographic variation of each of the area.

According to Avenant and Cavallini (2008) fire could be beneficial in that it allows new growth of more nutritious vegetation enabling quick recovery of the population of small mammals. However , in this study area the incidence of fire was very frequent which could have severe adverse effects on small mammal populations. In previous studies, fire was shown to lower the species diversity due to destruction of vast areas of their habitat and food resources, which could also lead to changes in the behavior (Haim and Izhaki, 1994; Clausnitzer, 2003). Similar effects might have contributed to the small mammal fauna of CCNP. Further studies focusing on individual species and their ecology are important. The CCNP ecosystem revealed that the inaccessible, remote areas of the country harbored unique and endemic species. Therefore, in order to have a comprehensive understanding of the area, assessing the ecology of each species within the geographic boundary of this newly established park should be a priority.

ACKNOWLEDGEMENTS

We thank Addis Ababa University for providing financial assistance. The help provided by all staff members of Chebera-Churchura National Park is greatly appreciated.

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