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Research article

Composition and seasonality of rodent diet in Chimit Kola, Blue Nile Gorge, Ethiopia

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ABSTRACT

A study on the composition and seasonality of rodent diet was carried out during 2020–2022 years in Chimit Kola to determine the type, relative proportion and seasonality of food items consumed. A total of 166 stomach contents that belong to six rodent species (*Mastomys awashensis*, *Acomys louisae*, *Arvicanthis raffertyi*, *Lophuromys simensis*, *Gerbilliscus* sp. and *Lemniscomys macculus*) were investigated. Parametric and non-parametric analyses of variance were used to test the difference. Leaves and stems, seeds, invertebrates, fruits and unidentified food matters were the food items identified in the stomach contents of rodents. There was a significant variation in food items consumed among rodent species. *Arvicanthis raffertyi* and *L. macculus* consumed more leaves and stems whereas *L. simensis, A. louisae* and *Gerbilliscus* sp. mostly fed on invertebrates. *Mastomys awashensis* consumed relatively more seeds (30%) than any other rodent species (ranging from 14 to 28%). *Acomys louisae*, *L. simensis* and *Gerbilliscus* sp. consumed more leaves and stems during the dry season and invertebrates during the wet season. Similarly, *A. raffertyi* consumed more leaves and stems during the wet season and seeds during the dry season. However, the diet of *M. awashensis* and *L. macculus* and some food items (fruits and unidentified food matters) of most rodent species were similar between seasons. *Mastomys awashensis* significantly consumed a higher proportion of seeds in the fallowland (44%) than in other habitats (ranging from 19 to 31%). Similarly, *A. louisae* and *L. macculus* consumed a significantly higher proportion of invertebrates in bushland (53%) and riverine forests (48%) than in other habitats (ranging from 16 to 47%), respectively. The present finding concluded that these rodent species are diet generalists, feeding on a variety of available resources depending on seasons and habitats. The study documents the diet composition of these rodent species for the first time. Thus, the management and conservation of these rodents should be in consideration of their feeding habits and factors that influence their diets.

1. Introduction

Food is an essential resource required for the survival of species. It plays a great role in determining the life-history strategies, evolution and ecological role of animals [1,2]. Rodents show a wide range of diet preferences that range from diet generalists to specialists [2]. For a long time, rodents have been grouped into three (omnivore, carnivore and herbivore) trophic categories. Recently, these grouping was updated into eight diet categories based on their feeding preference which included granivore, frugivore, specialist

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herbivore, folivore, omnivore, carnivore, vermivore and unknown matter [2]. This classification is based on food items most often consumed by rodent species or when more than 50% of the rodent diet accounts for a particular food type [3]. However, this grouping does not mean individual species are obligate feeders concerning any particular diet rather they are a simplification of the complexity of diets as most species consume foods opportunistically [4].

Communities that have similar resource requirements such as food often display intra-and interspecific competitions [5]. As a result, the winner of the competition utilizes the resources and survives in those resource-limited environments. However, some species coexist despite their ecological requirements which can be explained by the concept of resource partitioning [5,6].

Many rodent species display a shift in feeding behavior depending on the availability of food sources [7]. For instance, most Muridae species feed on primary plants but they opportunistically incorporate some amounts of arthropod foods when their first food choice is scarce [4,8]. Some studies have shown that the diet of *Arvicanthis, Lophuromy* and *Acomys* primarily consists of plants during the dry season but their diet predominates insects when the abundance of invertebrates increases during the wet season [6,8–10]. Similarly, some rodent species such as *Gerbilliscus* and *Mastomys* feed on primarily seeds and insects but they switch their diet to a relatively less nutritious diet such as leaves and stems when their primary foods are limited [9,11]. A shift in the feeding preference of animal species is one means of survival when they face food scarcity [7]. Diet composition and feeding behavior can influence community structure, species diversity and relative abundance of rodent species [6]. Information on the diets of animals is a pre-requisite for most ecological studies and conservation planning [6,8]. However, diet composition and feeding preference data of most rodent species are disparate both in level detail and coverage [2] which is also the case in Ethiopia. Thus, the study aimed to investigate the dietary composition and effects of season and habitat types on the feeding behavior of rodent species in Chimit Kola, Blue Nile Gorge, Ethiopia.

2. Materials and methods

2.1. Description of the study area

The study was carried out in Chimit Kola, Gozamin district, Ethiopia. It is located in the Blue Nile Gorge, between coordinates of 10.020951°–10.183523°83 N and 37.485688°–37.575281° E. with an altitudinal range of 920–2080 m a.s.l. (Fig. 1). Wooded grassland, forests and bushland are among the habitats found in the Chimit Kola. The part of the wooded grassland, forest and bushland are fragmented by small-scale farming. The total area of Chimit Kola including fragmented farmland and investment areas is about 15, 625 ha.

The climate of the study area is characterized mainly by two seasons which are locally known as Kiremt and Bega [12]. The rainfall distribution is an unimodal type and occurs in Kiremt (wet season), covering the period from June to September. In some cases, a few intermittent showers of rain occur from March to May. Bega season (from October to February) is usually characterized by hot and dry during the day and cool during the night times. The mean maximum and mean minimum temperatures of the area were 35 °C and 9.8 °C, respectively. The mean annual temperature and total annual precipitations are 21.9 °C and 1222 mm, respectively [13].

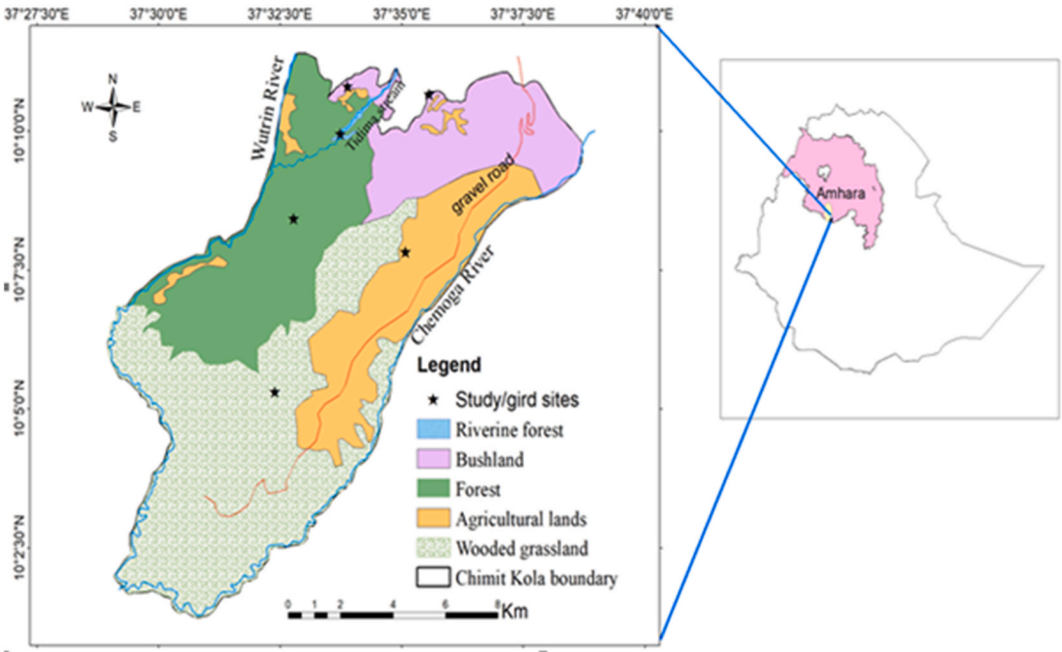

Fig. 1. Map of Chimit Kola.

According to Friis et al. [14], the ecosystem of the Chimit Kola area is classified under the *Combretum-Terminalia* woodland ecosystem. The vegetation structure includes wooded grassland (grassland), forest, bushland, mixed shrub and riverine vegetation. The grassland habitat covers most of the lowland parts and the vegetation community of grassland is characterized by different species of grasses, scattered trees, shrubs and herbs. The most common plant species that occur in the study area include different species of thatch grass (*Hyparrhenia* sp.), *Gastridium* sp., patches of a few elephant grass species (*Pennisetum* sp.) and others. Some of the dominant tree species growing in grassland areas are *Acacia* sp., *Balanite* sp., *Anogeissus* sp., *Pterocarpus* sp. *Combretum* and *Terminalia* sp.

The forest vegetation covers the hilly escarpments and along the base of Jiblat and Mutera Mountains. The most common plant community found in the forest includes different species of plants that belong to the genus *Piliostigmata*, *Acacia*, *Combretum*, *Terminalia*, *Sterculia* and others. Shrub plants such as *Rosa* sp., *Carissa* sp., *Vernonia* sp. and *Entada abyssinica* are the dominant species.

The riverine forest is located along the Chemoga River and Tidima stream. The vegetation is composed of different species of trees, grasses, herbs and woody shrub plants. The most common plant species include different tree species of *Acacia* sp., *Ficus* sp., *Pilostigmata* sp., *Dombia* sp. and other woody shrubs. Among grasses, *Cynodon* sp. and *Pennisetum* sp., are the most common. Bushland is located along the steep slope of the rocky escarpments. The vegetation of bushland is composed of different species of shrubs, few trees, grasses and herbs. The mixed shrub is located relatively close to human settlements. It is characterized by some patchy vegetation which is a mixture of natural and plantation vegetation. There are also a few patches of land left alone without cropping (fallowland) for different reasons within the agricultural investment area. These fallowland are covered by short grass, herbs and scattered shrubs.

2.2. Methods

2.2.1. Study design and data collection

The study was conducted from December 2020 to December 2022. A total of six habitats were selected purposively to account for habitat variabilities. A permanent line trapping design was established in each habitat to capture rodents for stomach content analyses [15]. A total of 20 snap traps were placed along two line transects at 10 m intervals in each habitat for three consecutive nights [15,16]. Trapping was carried out four times: two during the wet (in August 2021 and 2022) and two during the dry seasons (in December 2020 and 2021) in each habitat. Traps were checked twice daily, early morning (6:00–7:00 h) and late afternoon (17:00–18:00 h). Each trap station was marked with a plastic sheet for easy tracking during trap checking. Each trap was baited with peanut butter mixed with barley flour to attract rodents. The stomach of the rodent was carefully removed using a surgical knife and preserved in 70% alcohol for microscopic examination [17].

2.2.2. Species identification and stomach content analyses

Rodents were identified at the species level using molecular analyses. DNA barcoding was carried out by extracting the cytochrome *b* (Cytb) gene, a suitable marker for the identification of rodent species, from liver tissue following the Jena Bioscience Protocol (Jena Bioscience GmbH, Germany). The entire Cytb gene sequence (1140 bp) was amplified using a set of primers L14723 and H15915 as described in Lecompte et al. [18].

The stomach was pealed using a surgical knife and its content was poured onto a beaker and mixed thoroughly. Mixing of stomach contents ensures a uniform distribution of food items that might have occurred in layers in the stomach. The mixed stomach contents were swirled with small amounts of detergents and washed with distilled water to dissolve fatty substances that hinder the identification of food fragments [19]. The content was then filtered with 0.4 mm mesh to avoid the fine particles which are difficult to identify and obscure the identification process [17,19]. The filtered stomach content was spread uniformly on a Petri dish, laying over a 2×2 mm transparent gird and ten field locations were investigated under a stereomicroscope (echo LAB, SM 230H) with 7–45× magnification [17,20].

The food items observed from stomach content were grouped into six categories: leaves and stems, seeds, invertebrates (mostly insects), fruits (flesh fruits), hairs (rodent hairs) and unidentified food matter [19]. The recognition of epidermal tissue under the microscope is considered a positive indication of the presence of plant food fragments [10,21]. Seeds were identified by the presence of a seed coat or intact seed. The presence of insect food fragments was confirmed by the observation of legs, exoskeleton, sclerites, antennae fragments and the color of chitin [10].

2.2.3. Data analyses

The percentage occurrence of each food item was calculated by dividing the number of stomachs in which a particular food type was recorded by the total number of stomachs examined multiplied by 100 [19,22]. The relative percentage abundance of each food type was determined by scoring the number of gird boxes containing a given food type and dividing by the total number of gird boxes containing any food type [6,19,22]. When more than one food item is observed in a single gird box, the item close to the centre of the gird is recorded.

To test whether the relative abundance of food type changes between seasons, study habitats and between rodents, both parametric and non-parametric analyses of variance were used. *Lophuromys simensis* was excluded from the analysis of diet habitat comparison as it was restricted to a single habitat. Analysis of variance (ANOVA) was used to test food items such as leaves and stems, seeds and insects as they met parametric assumption while the remaining food items: fruits, hairs and unidentified food items used the Kruskal-Wallis test. Tukey's post hoc and Dunn's multiple comparison tests were used following a significant difference in ANOVA and Kruskal-Wallis test, respectively [17,19]. All statistical analyses were carried out using R software version 4.1.3 (R Developmental Core Team 2019).

3. Results

3.1. Abundance of rodent species

A total of 166 stomachs that belong to six rodent species from six habitats were investigated for dietary analysis (Table 1). The overall trap success of trapping was 11.5% for 1440 trap nights (12.5% wet and 10.5% dry season). The most encountered rodent species captured was *M. awashensis* (32%) followed by *A. louisae* (27%) and the least was *L. macculus* (6.6%). A relatively higher abundance of rodents was captured in grassland (25.3%) and the least was recorded in fallowland (12%). None of the rodent species was captured in all habitats. For instance, *L. simensis* was captured only in the mixed shrub. *Mastomys awashensis* and *L. simensis* are endemic species whereas *Gerbilliscus* sp. is also possibly endemic but waiting for a full scientific description. Except *Gerbilliscus* sp. and *A. raffertyi* which are not evaluated the remaining species were listed under the Least Concern category by IUCN 2016.

3.2. Frequency and mean proportion of food fragments

Despite some variations in the occurrence of food types, all of the six rodent species consumed leaves, fruits, seeds and invertebrates (Table 2). Invertebrates (mainly insects) and leaves were the most commonly encountered food types, occurring in 78–100% of the stomachs of rodents. Seeds and fruits were recorded in 73–87% and 20–65% of rodent stomachs, respectively. Hairs and unidentified food matters also occurred in 0–64% and 20–47% of rodent stomachs, respectively. There were no hairs recorded in the stomach of *Gerbilliscus* sp.

All of the six rodent species consumed leaves and stems, fruits, seeds and invertebrates with different proportions (Fig. 2). The mean relative abundance of leaves and stems consumed was significantly different among rodent species ($F = 13.39$, df = 5, $P < 0.05$). The proportion of leaves and stems identified in each stomach of *A. raffertyi* (49.6%) and *L. macculus* (46.7%) was higher than *M. awashensis* (29.0%), *A. louisae* (23.9%) and *L. simensis* (26.7 %) ($P < 0.05$, Tukey post hoc comparisons). The mean relative abundance of invertebrates was significantly different among rodent species ($F = 10.78.6$, df = 5, $P < 0.05$). There was a greater proportion of invertebrates in each stomach of *L. simensis* (46.1%), *A. louisae* (42.8%), *Gerbilliscus* sp. (33.3%) and *M. awashensis* (28.7%) than *A. raffertyi* (14.6%) ($P < 0.05$, Tukey post hoc comparisons). Similarly, *L. simensis* (46.1%) and *A. louisae* (42.8%) also differed from *M. awashensis* ($P < 0.05$). The mean relative abundance of seeds also showed a significant difference among rodent species ($F = 2.57$, df = 5, $P < 0.05$) and *M. awashensis* (30%) consumed more seeds than *L. macculus* (14%) ($P < 0.05$).

Although the proportion was very small, most of the rodent species had fruits, hairs and unidentified food matter in their stomachs (Fig. 2). The abundance of fruits in the stomach contents was significantly different among the rodent species ($\chi^2 = 15.96$, df = 5, $P < 0.05$) whereas *A. raffertyi* (9.1%) had a greater mean difference than *A. louisae* (4.1%) ($P < 0.05$), *L. simensis* (2.2%) ($P < 0.05$) and *L. macculus* (2.8%) ($P < 0.05$). Similarly, hairs were recorded in greater abundance in the stomachs of some rodent species ($\chi^2 = 22.53$, df = 5, $P < 0.05$). *Mastomys awashensis* also consumed more fruits (7.2%) than *A. louisae* and *L. simensis* ($P < 0.05$ for each Dunn's multiple comparison test). There was a greater proportion of hairs in the stomach of *A. louisae* (4.1%), *L. macculus* (3%) and *M. awashensis* (2.8%) than each *A. raffertyi* (0.7%) stomach ($P < 0.05$). However, the mean relative abundance of unidentified food matters in the stomach contents was not significantly different among rodent species ($\chi^2 = 8.16$, df = 5, $P = 0.14$).

3.3. Seasonality of rodent diet

Some rodent species showed a seasonal change in their diet. The abundance of leaves and stems in the stomach content of *A. louisae* was significantly higher during the dry season ($F = 8.93$, df = 1, $P < 0.05$) while the invertebrates ($F = 8.79$, df = 1, $P < 0.05$) and unidentified food matter ($\chi^2 = 6.92$, df = 1, $P < 0.05$) were more abundant during the wet season (Table 3). However, there was no significant seasonal difference in the abundance of seeds, fruits and hairs ($P = 0.423$) for this species. Similarly, *A. raffertyi* significantly consumed more leaves and stems ($F = 7.51$, df = 1, $P = 0.012$) and seeds ($F = 9.50$, df = 1, $P < 0.05$) during the wet and dry seasons, respectively. However, the proportion of invertebrates, fruits, hairs and unidentified food matter in the stomachs of this species was similar between seasons ($P = 0.166$). There was no significant difference observed in the proportion of *M. awashensis* diet between seasons ($P = 0.312$). However, it consumed relatively more seeds (30.8%) and leaves and stems (29.8%) during the dry seasons than in the wet season (29%) and (27.9%), respectively, and a slight shift in feeding preference into invertebrates (31%) during the wet than

Table 1
Relative abundance (RA in percent) of rodent species captured and their distribution in the studied habitats.

Species	Study habitats						Total	RA (%)
	Grassland	FD	RF	Forest	Bushland	MS		
Mastomys awashensis	19	11	12	8	3	0	53	32
Acomys louisae	0	0	11	10	11	13	45	27
Arvicanthis raffertyi	9	6	2	0	6	0	23	14
Lophuromys simensis	0	0	0	0	0	19	19	11
Gerbilliscus sp.	8	0	2	5	0	0	15	9
Lemniscomys macculus	5	3	3	0	0	0	11	7

RF = Riverine forest, MS = Mixed shrub, FD = Fallowland.

Table 2
Percentage occurrence of food types identified from the stomach of rodent species.

Species	n	Food types					
		LS	Fruits	Seeds	Invertebrates	Hairs	UF
M. awashensis	53	85	49	85	98	43	45
A. louisae	45	78	20	84	91	42	47
A. raffertyi	23	100	65	83	78	4	26
L. simensis	19	89	21	79	100	26	26
Gerbilliscus sp.	15	87	53	87	100	0	20
L. macculus	11	91	36	73	82	64	27

n = number of stomachs investigated, LS = leaves and stems, UF = unidentified food matter.

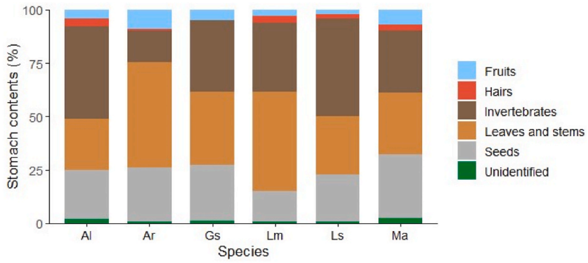

Fig. 2. The mean relative abundance (%) of food types identified in the stomach content of rodent species (Al = *A. louisae*, Ar = *A. raffertyi*, Gs = *Gerbilliscus* sp., Ls = *L. simensis,* Lm = *L. macculus* and *Ma* = *M. awashensis*).

Table 3
Mean relative abundance (%) of food types identified in the stomachs of rodent species during the wet and dry seasons.

Season	Species	N	Food types identified					
			LS	Seeds	Invertebrates	Fruits	Hairs	Unidentified
Dry	*M. awashensis*	29	29.8	30.8	27.0	7.3	2.8	2.3
	A. louisae	18	32.8	25.2	31.9	3.6	5.6	0.9
	L. simensis	7	35.1	23.4	41.5	0	0	0
	A. raffertyi	14	41.6	31.5	14.1	10	1	1.8
	Gerbilliscus sp.	5	49.2	21.4	24.2	4.3	0	0.9
	L. macculus	3	59	23.5	15.2	0	1.1	1.2
Wet	*M. awashensis*	24	27.9	29.0	30.9	7.1	2.7	2.4
	A. louisae	27	17.9	20.8	50.0	4.3	3.3	3.7
	L. simensis	12	21.8	21.5	48.8	3.5	2.6	1.8
	A. raffertyi	9	62.1	14.5	15.4	7.7	0	0.3
	Gerbilliscus sp.	10	26.6	28.4	37.7	5.9	0	1.4
	L. macculus	8	42.1	10.5	38.6	3.8	3.8	1.2

n = number of stomachs investigated, LS = leaves and stems.

the dry seasons (26.9%).

A diet shift was observed in *L. simensis* where a significant proportion of its diet was composed of leaves and stems ($F = 6.61$, $df = 1$, $P < 0.05$) during the dry season but this shifted to invertebrates during the wet season ($F = 5.07$, $df = 1$, $P < 0.05$). However, none of the remaining stomach contents (seeds, fruits, hairs and unidentified food matters) showed variation in the amount between seasons ($P = 0.602$). *Gerbilliscus* sp. had a greater portion of leaves and stems in its stomach during the dry season ($F = 6.61$, $df = 1$, $P < 0.05$) than during the wet season. However, there was no significant difference in the abundance of invertebrates, seeds, fruits, and unidentified food matter between seasons ($P = 0.065$). Despite the variation in the abundance of stomach contents of *L. macculus* between seasons, none of them was significantly different ($P = 0.095$).

3.4. Diet variation across the study habitats

The abundance of most food items identified in the stomach content of rodent species showed variation among the study habitats. Seed fragments comprised the highest proportion in the stomach content of *M. awashensis* in the fallowland habitats (44%) followed by riverine forest (31%) and the least was in the forest habitat (19%). The mean difference in the relative abundance of seeds in the stomach contents of *M. awashensis* was significantly different between habitats ($F = 2.75$, $df = 4$, $P < 0.05$). However, none of the other food items of *M. awashensis* showed significant variations between habitats ($P = 0.3735$) (Fig. 3, A). Similarly, the mean relative abundance of insects in the stomach contents of *A. louisae* significantly differed among habitats ($F = 3.18$, $df = 3$, $P < 0.05$). It consumed more invertebrates in the bushland habitat (53%) followed by riverine forest (47%) and least in mixed shrub habitat (29%). *Acomys louisae* consumed relatively higher leaves and stems in the mixed shrub (33%) and seeds in the forest (26%) than in the bushland habitat with each (19%) but with no significant difference ($P = 0.172$). The contribution of fruits and unidentified food items was limited (Fig. 3, B).

Arvicanthis raffertyi consumed more leaves and stems in the grassland (59%), seeds in fallowland (32%) and invertebrates in riverine forest habitats (18%). The variation in the diet composition of *A. raffertyi* between habitats was not significant ($P = 0.225$) (Fig. 4, A). Similarly, *Gerbilliscus* sp. consumed more leaves and stems in grassland (39%), seeds in the forest (32%) and insects in the riverine forest habitats (46%) with no significant difference between habitats ($P = 0.391$) (Fig. 5). *Lemniscomys macculus* consumed more invertebrates in the riverine forest (48%) than fallowland (43%) and the least in grassland habitat (16%) (Fig. 4, B). Invertebrate consumption was significantly different between habitats ($F = 5.32$, df $= 2$, $P < 0.05$) but there was no significant difference in the abundance of other food items between habitats ($P = 0.112$).

4. Discussion

All six rodent species consumed a variety of leaves, stems, seeds, invertebrates and fruits with different frequencies of occurrence and proportions. They do not show a strict dependency on a single food item instead they incorporate some variety of food items in their diet and are considered omnivores or diet generalist species [2]. Diet studies conducted in different parts of Africa categorized *Lemniscomys*, *Arvicanthis* and *Gerbilliscus* as omnivore rodents which is in agreement with the present finding [10,23,24].

In the present study, invertebrates, leaves and stems, and seeds account for more than 73% of all rodent stomach contents. Similar studies showed the occurrence of these food fragments in the greatest frequency in the stomach content of different rodent species [10, 25,26]. Mulungu et al. [27] reported the occurrence of plant materials and seeds in 98.9% and 100% *M. natalensis* stomach which is *a* sister species of *M. awashensis*, respectively. Similarly, invertebrates occurred in more than 77% of *Lophuromys* and seeds in 87% of *Lemniscomys* stomachs [28]. The occurrence of fruits, hairs and unidentified food matter was relatively small in this study which is consistent with other studies [24–26]. A high percentage occurrence of food items in the rodent stomachs in the present study may be attributed to diversified feeding behavior and less diet preference of these species.

The mean relative abundance of each food item consumed differed among species. Leaves and stems account for the greatest proportion of both *A. raffertyi* and *L. macculus* diet in this study. Rabiu and Rose [8] stated leaves and stems are the predominant food items of *Arvicanthis* in natural savanna fields. Elsewhere in Ethiopia, Mulungu et al. [26] and Ashetu and Afework [25] reported that plant leaves as the main food items of *Arvicanthis* and *Lemniscomys* species, respectively. On the contrary, seeds account for a greater proportion of *Arvicanthis* diet than leaves and stems in the irrigated fields [8]. In natural savanna, grass leaves and stems are abundant whereas in farmland seeds dominate. The consumption of more leaves and stems in grassland and seeds in farmland by *Arvicanthis* possibly suggests its opportunistic feeding behavior dictated by food availability.

Invertebrates accounted for the greatest proportion of *L. simensis* and *A. louisae* diet. This finding is consistent with other studies reported by Ashetu and Afework [25], Torres-Contreas and Bozinovic [29] and Rabiu and Rose [8] where invertebrates are predominant in the diet of *Lophuromys*. Similarly, invertebrates constituted the greatest proportion of *Acomys* diet in the deserts of Israel

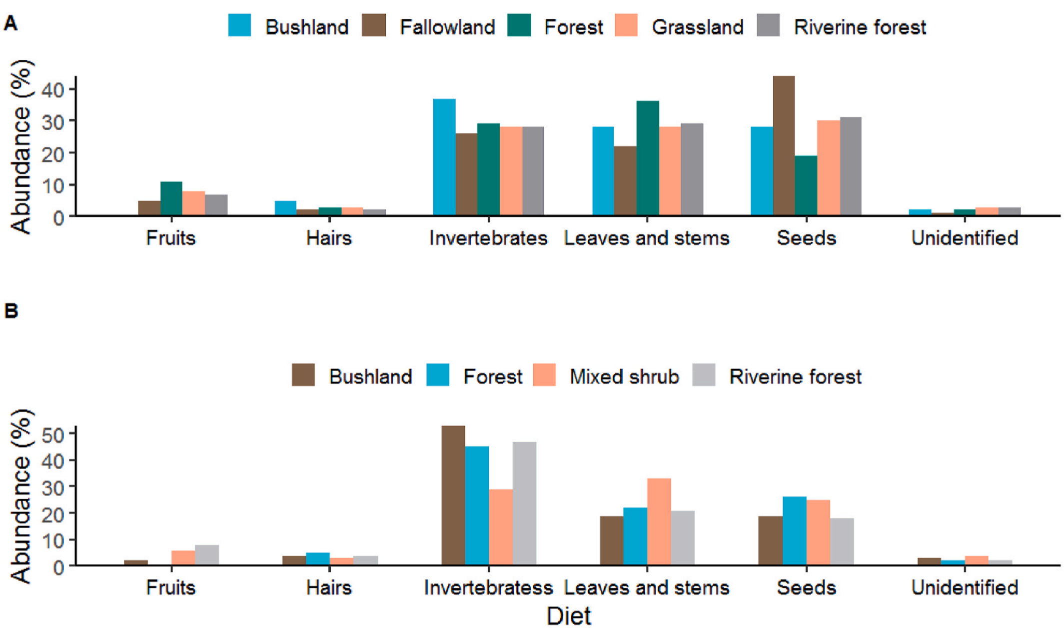

Fig. 3. The abundance of food items in the stomach content of *M. awashensis* (A) and *A. louisae* (B) among habitats.

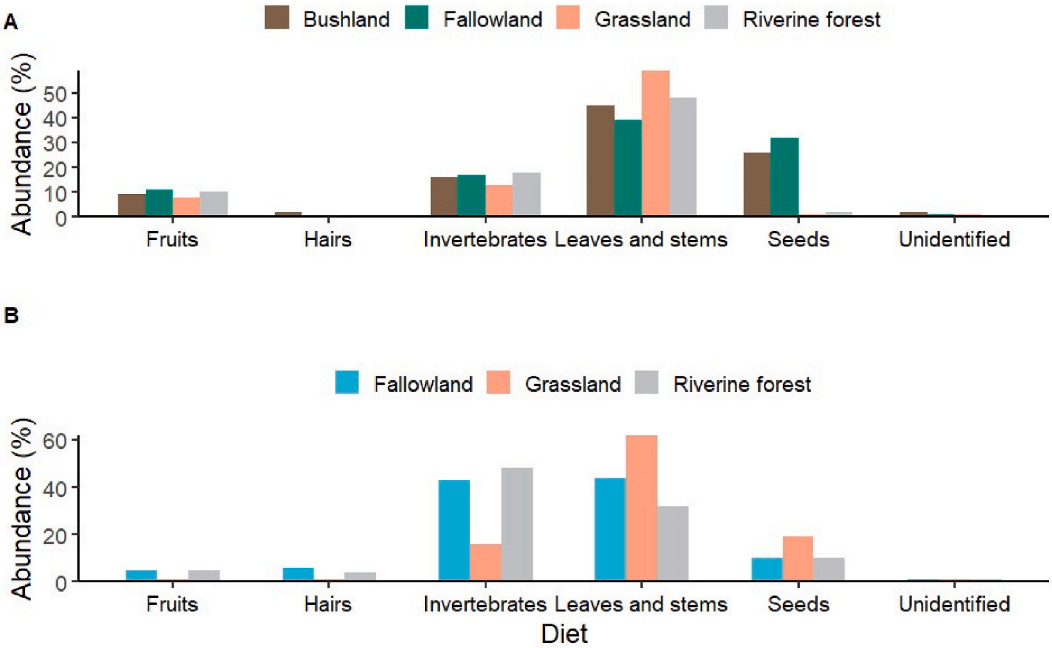

Fig. 4. The abundance of food items in the stomach content of *A. raffertyi* (A) and *L. macculus* (B) among habitats.

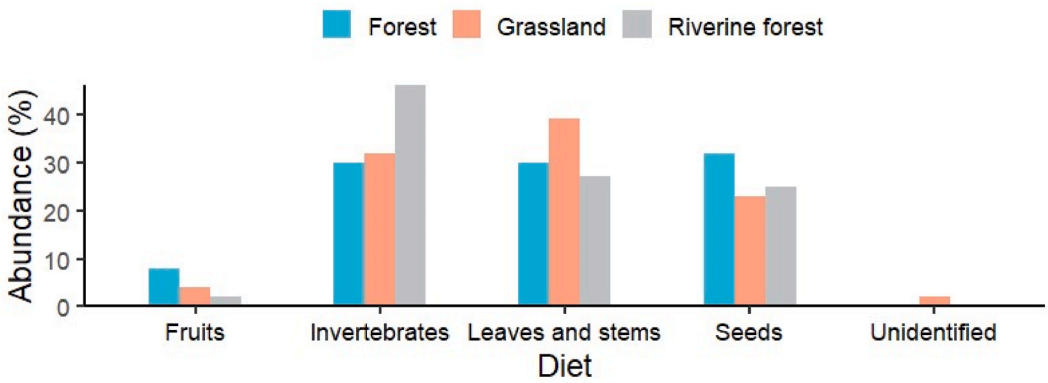

Fig. 5. The abundance of food items in the stomach content of *Gerbilliscus* sp. among habitats.

[6] and northern Kenya [30]. Rodents prefer a certain food item for different aspects [31]. For instance, *Acomys* species in a dry environment prefer invertebrates from a variety of food types to fulfill their first choice of requirements such as energy and water [32]. The preference of invertebrates by *A. louisae* and *L. simensis* in this study may be attributed to their specific physiological requirements.

Mastomys awashensis feeds on relatively more seeds than other rodent species. Mulungu et al. [11] also reported that *Mastomys* predominantly consumed seeds more than other rodent species in central Tanzania. The reason for the difference in seed consumption among rodent species may be due to the difference in foraging behavior and diet preference of the species. The overall proportion of seeds consumed by *M. awashensis* was similar to leaves and stems, and invertebrates. Mlyashimbi et al. [33] reported a similar proportion of seeds and plant material for *Mastomys* species. This finding contradicts the report of Rabiu and Rose [8], in Nigeria and Ademola et al. [27], in Tanzania where they identified seeds as the main food habits of *Mastomys*. The variation in seed consumption of *Mastomys* is related to the difference in the type of habitat investigated [27]. For example, in maize/crop fields a significant proportion of the *Mastomys* diet is composed of seeds but relatively less in natural or woodland habitats.

Arvicanthis raffertyi consumed relatively more fruits than other species. In agreement with the present finding, a smaller contribution of fruits to the diet of rodents was reported in semi-arid areas in Tanzania [33]. In this study, hairs were observed in all rodent species except *Gerbilliscus* sp. stomachs. Hairs were also observed in the stomachs of *M. awashensis*, *L. macculus* and *L. simensis* elsewhere in Ethiopia [25,29]. Unfortunately, none of the hairs observed were attached to meet which makes it difficult to suggest the presence of hairs as a result of meat consumption. Thus, hairs may be a result of accidental ingestion during grooming and other activities as suggested by Shiels et al. [17]. Some stomach contents were difficult to identify and encountered in all rodent species but with relatively more in the stomach of *A. louisae* and *M. awashensis*. Mulungu et al. [34] stated a large percentage of the unidentified food matter in the sister species, *M. natalensis*. The reason for the variation in the percentage of unidentified food matter may be attributed to the digestive process that hinders identification.

Several factors may influence the feeding preference of animals such as seasonal change and temporal physiological requirements of the animal (breeding time) [31]. In the present study, both *A. louisae* and *L. simensis* consumed more leaves and stems during the dry season but this shifts into invertebrates during the wet season. This finding is consistent with Kronfield-Schor and Dayan [6] and Bewketu et al. [10] who stated that *Acomys* and *Lophuromys* feed more on invertebrates during the wet seasons than during the dry seasons, respectively. The moist environment during the wet season creates a suitable condition for the reproduction of most invertebrate animals which increases in their relative abundance. Thus, an increase in the abundance of invertebrates results in a chance of frequent encounters of prey with predatory (rodent species) thereby the diet of rodents will predominate invertebrates.

The diet of *A. raffertyi* showed seasonal variation. It consumed more leaves and stems during the dry season and shifted to more seeds during the wet season. This is in agreement with Rabiu and Rose [8] who reported plants predominated in the diet of *Arvicanthis* species during the dry season while seeds and insects were replaced during the wet season. An increase in the consumption of more seeds during the wet season for this species may be related to the increased productivity of plants in the rainy seasons. There was no significant variation in the abundance of food items consumed by *M. awashensis* between seasons. However, it tends to feed more on seeds during the dry season, leaves and invertebrates during the wet season. A similar finding was reported by Ademola et al. [27] in Tanzania and Swaziland, and Rabiu and Rose [8] in Nigeria where the proportion of seeds was similar between seasons. Mlyashimbi et al. [33] also reported a similar composition of stomach contents such as fruits, hairs, or invertebrates between seasons which is in agreement with the present finding. In contrast, a significant seasonal variation in the diet of this species was reported in other studies [33]. The possible reason for the diet variation between seasons is related to the generalist feeding behavior of the species and the influence of the season and habitat on the availability of food resources.

Leaves and stems account for the greatest proportion of the diet of *Gerbilliscus* sp. during the dry season than during the wet season. Odhiambo et al. [24] reported plant materials become the main food item for other gerbil species during the dry season. However, none of the *L. macculus* diet was statistically significant. A similar consumption of arthropods by *Lemniscomys* was reported by Ashetu and Afework [25]. The possible reason may be associated with the feeding behavior of species and diet distribution.

In the current study, most of the rodent species consumed a similar proportion of food items among the study habitats. However, *A. louisae* consumed a significantly higher proportion of invertebrates in bushland habitats than those found in mixed shrubs. *Mastomys awashensis* consumed significantly more seeds in fallowland than those found in the forest. Unlike the present study, *Mastomys* seed consumption was similar between habitats; fallow and maize fields in Tanzania [33]. The possible reason for the variation in seed consumption between habitats may be related to the variation in the productivity of habitats. In the present study, fallowland was located close to farmland which enhances the accessibility of more seeds to this species. *Lemniscomys macculus* consumed a significantly higher proportion of invertebrates in the riverine forest than in other habitats but it consumed more of leaves and stems in the grassland habitat. This is probably due to the opportunistic feeding behavior of this species that depends on the availability of resources in the environment. We observed the amount of food resources variations between seasons and habitats but not quantified due to time and budget constraints and this could be taken as a limitation of the study.

In conclusion, all of the rodent species consumed leaves, stems, seeds, invertebrates and fruits in different occurrences and proportions and they are generally opportunistic diet generalist species. Hairs were common in most rodent stomach contents but further investigation is needed to conclude whether it is a result of cannibalism or accidental ingestion during grooming behavior. The dietary composition of some rodent species is influenced by seasonality and productivity of the habitats. Thus, the management and conservation of these rodents should consider their feeding habits. The study documents the diet composition and feeding behavior of endemic rodent species (*M. awashensis*, *L. simensis* and *Gerbilliscus* sp.) for the first time and other non-endemic species. Further investigation is recommended for some food items named “unidentified food matters” which are difficult to identify using these methods.

Ethical statement

The study was approved by the Department of Zoological Sciences, Addis Ababa University (SF-ZS-131-13-2020) on November 18, 2020. In addition, verbal consent was obtained from local communities living around the study areas. Animal handling was carried out in accordance with the European Communities Council Directive 2010/63/EUon the protection of animals used for scientific purposes.

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Data availability

Data will be available immediately upon request of the corresponding author.

CRediT authorship contribution statement

Mengistu Wale: Molalign, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization.

Afework Bekele: Simegn, Writing – review & editing, Visualization, Supervision, Funding acquisition, Conceptualization. **Mesele Yihune:** Tamene, Writing – review & editing, Supervision, Resources, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper and also, they are not members of Heliyon journal Editorial Board or guest editors.

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