BioRisk

BioRisk 24: 133–146 (2026)
DOI: 10.3897/biorisk.24.189621

Research Article

Farmers' perception of pest status and management of rodents in small-scale farming systems in East Gojjam, Ethiopia

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Abstract

Data on farmers' perception of rodent pest status and management intervention are limited in Ethiopia. The study aimed to explore farmers' perceptions of crop yield loss due to rodents, management interventions and factors influencing their perceptions. Data were collected using a semi-structured questionnaire and analysed in R. The result showed that rodents were important agricultural pests, responsible for an average of 231.7 kg/ha crop yield loss per household annually. Farmers' perception was significantly influenced by family size, farmland size, age, education and location of the farmlands. With an increase in farmers' family size, age and farmland size, perceived crop yield loss/kg significantly decreases. Similarly, farmers with informal education experience significantly higher crop yield loss than those with grades 1–5 completed. However, farmers with grade six and above completed experience significantly lower yield loss than those with grades 1–5 completed. Wheat and teff were more susceptible to rodent damage at the growth stage, while maize was at the threshing (harvesting) stage. Most farmers believed that rodent interventions were effective when applied at these crop developmental stages, and rodenticide was the most effective method. Farmers have substantial knowledge to identify the most vulnerable crop developmental stage and management techniques against pest rodents. However, authors recommend that farmers should adopt ecologically-based rodent pest management to reduce crop yield loss and environmental concerns of rodenticides.

Key words: Attitude, Chimit Kola, damage, intervention, yield

OPEN ACCESS

Academic editor: Josef Settele
Received: 24 February 2026
Accepted: 26 May 2026
Published: 11 June 2026

Citation: Wale M, Bekele A, Yihune M (2026) Farmers' perception of pest status and management of rodents in small-scale farming systems in East Gojjam, Ethiopia. BioRisk 24: 133–146. https://doi.org/10.3897/biorisk.24.189621

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Introduction

The livelihood of most rural communities depends on small-scale subsistence farming. Small-scale farmers play a great role in food security in most developing countries (Swanepoel et al. 2017). In Ethiopia, agriculture accounts for 37% of the gross domestic product (Abebaw et al. 2019). Most of the farmers in Ethiopia, including those in the study area, practised small-scale subsistence farming, which is the primary income-generating activity. However, small-scale farming is fragmented and too small to meet households' subsistence demand (Abebaw et al. 2019).

In Ethiopia, farmers grow a mixed type of crops, which include cereals, pulses and other crop types. Likewise, in the East Gojjam zone, the most important crops grown are cereals (78%), followed by pulses (11%), and the remaining accounts for only 11% (Sitotaw et al. 2020). Amongst cereals, wheat, teff, maize and barley are the most commonly cultivated crops. However, crop production in Ethiopia is constrained by several agricultural pests (Afework et al. 2003; Sitotaw et al. 2020). In general, quantitative information on economic losses due to rodent pests is relatively limited in East Africa (Makundi et al. 1999). It has been reported that crop yield loss in East Gojjam, Ethiopia, is mainly associated with insect damage, disease and weeds (Sitotaw et al. 2020). However, recent perception studies carried out in some parts of Ethiopia reported a considerable amount of yield loss due to rodents. For example, 26.4% maize yield loss in Ziway (Afework et al. 2003), 9–44% pre-harvest yield losses of cereal crops in the highlands of Tigray (Meheretu et al. 2010) and 13% annual maize losses in southern Ethiopia (Zewdneh et al. 2020) were reported. One piece of evidence also showed the existence of crop damage due to rodents in the East Gojjam zone (Getachew 2016), but no previous studies were carried out to document the problem in Chimit Kola, this being the subject of the study.

Some crops are more susceptible to rodent damage than others. A study in central Ethiopia and Tanzania showed that maize was more susceptible to rodent damage than other crops (Makundi et al. 2005). Similarly, maize was the most susceptible crop to rodent damage in southern Ethiopia (Zewdneh et al. 2020), but in the highlands of Tigray, wheat and barley were the most susceptible (Meheretu et al. 2010). However, whether the susceptibility of the crop to rodent damage is associated with the frequent occurrence of crops or pest preference needs further investigation.

Not all rodents are agricultural pests. Amongst 104 rodent species recorded in Ethiopia (Bryja et al. 2019), only some of them are potential agricultural pests. The most important agricultural pest rodents in sub-Saharan Africa include *Mastomys*, *Arvicanthis* and *Gerbilliscus* species (Makundi et al. 2005; Mulungu 2017), which are widely distributed pest rodents in Ethiopia (Afework et al. 2003). These pest species are also common in study areas, in Chimit Kola (Mengistu Wale, unpublished), indicating the possibility of potential problems.

In response to crop damage, farmers use different rodent control interventions (trapping, poisoning, clearing rodent hiding places (e.g. weeds) and predation by cats (Schiller et al. 1999; Buckle and Eason 2015**;** Mulungu 2017). The effectiveness of these methods depends on farmers' knowledge, socio-demographic, socio-economic and other factors (Makundi et al. 2005; Tsegaye and Asfawosen 2016). Some farmers preferred a particular type of rodent control method, while others used a combination. Rodenticide poisoning is extensively used in Africa (Mulungu 2017). Few studies in Ethiopia also showed rodenticide as the most preferred rodent intervention (Makundi et al. 2005; Meheretu et al. 2010; Tsegaye and Asfawosen 2016). However, this method impacts non-target species, including humans (Mulungu 2017). Thus, we need to shift from poison-based rodent management to sustainable, ecologically based and environmentally sound methods, such as biological control, non-toxic deterrents, physical and mechanical control, habitat manipulation, crop management and others (Smith and Meyer 2015; Mulungu 2017).

In Ethiopia, farmers applied rodent-control activities individually rather than working in groups (Makundi et al. 2005). Sometimes rodents migrate between

crop fields or live in a particular area with high human population density. In such cases, working in a group is better than working individually (Schiller et al. 1999; Brown et al. 2008). In poor rodent management intervention, crop damage due to rodents may be more serious than expected.

In general, there is limited information regarding the crop damage associated with rodents in Ethiopia (Afework et al. 2003), especially in the study area. The study aimed to explore farmers' perceptions of crop yield loss due to rodents and the management interventions they practised. The finding can be used as a baseline for rodent crop damage surveys and to design effective ecologically based rodent management interventions.

Materials and methods

Description of the study area

The study area includes four adjacent rural Kebeles, located within two districts, Gozamin (Chimit, May Angetam and Denba) and Baso-liben (Dinguabe), in the East Gojjam zone, Amhara regional state (Fig. 1). The study sites were selected because of their proximity to Chimit Kola, where pest rodents are widely distributed (Getachew 2016). The community's livelihood in the study

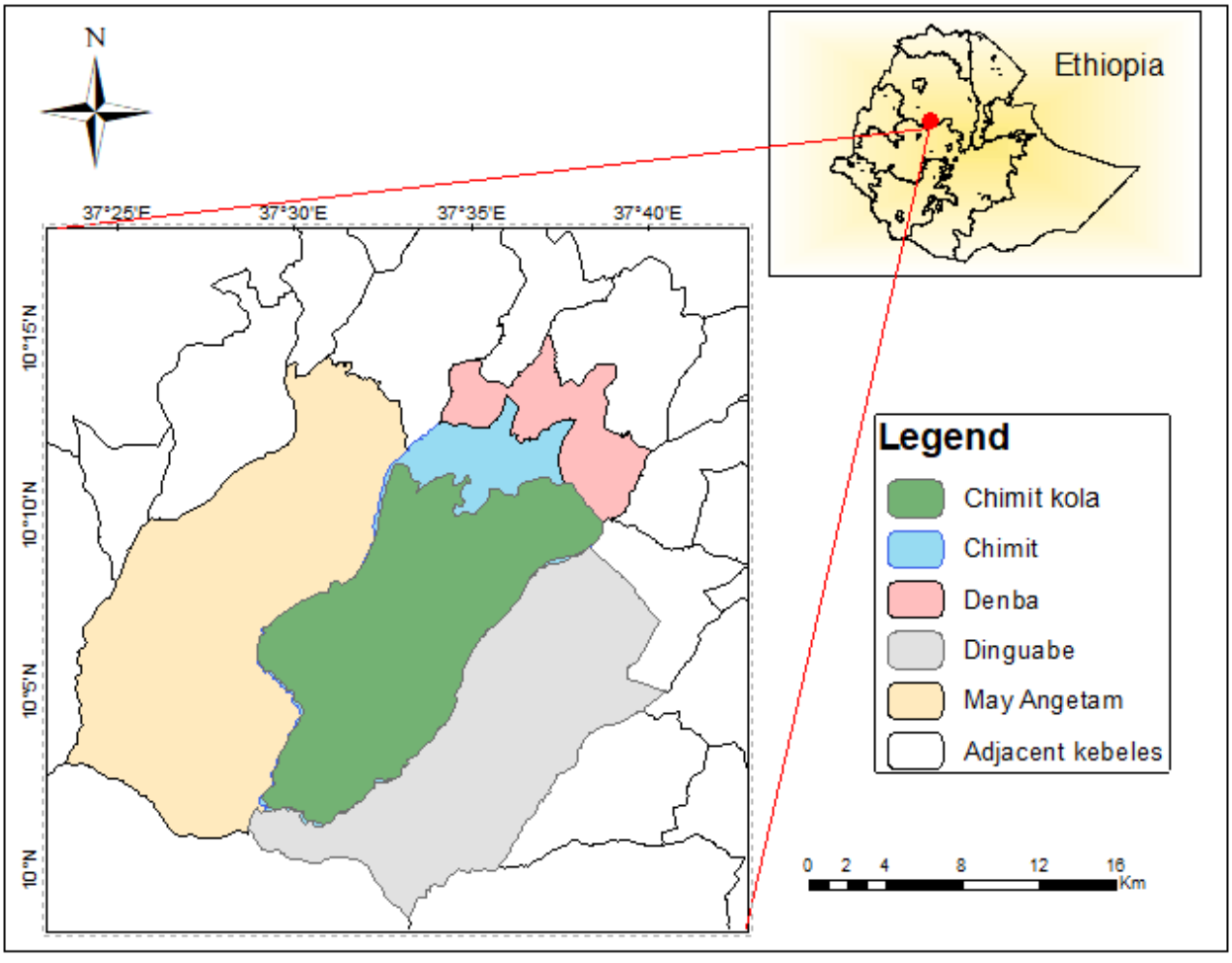

Figure 1. Map of study areas.

area is dependent on rain-fed small-scale agriculture. Wheat, maize, teff, barley and some pulses are the most frequently grown crops (Sitotaw et al. 2020). A few farmers also cultivate oilseeds, fruits and vegetables (Abebaw et al. 2019). Productivity of cereal crops differs in the East Gojjam zone, and maize has the highest average yield (5.8 tons/ha), followed by wheat (4.2 tons/ha) (Sitotaw et al. 2020). The rainfall distribution in the study area is of a 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 (dry season) is often characterised by hot and dry weather and covers the period from October to February (Sitotaw et al. 2020). The topography of the study area is characterised by mountains, slopes and valleys with an altitudinal range of 920–2275 m. The mean temperature and total annual precipitation are 21.9 °C and 1222 mm, respectively. The vegetation of the study areas is categorised as a *Combretum Terminalia* ecosystem and is dominated by woody plants, shrubs and savannah grasslands.

Sampling techniques

Four Kebeles were purposively selected because of their proximity to Chimit Kola, where pest rodent species (*Mastomys* and *Arvicanthis*) are common. A total of 384 household farmers from Chimit (109), May Angetam (115), Denba (82) and Dinguabe (78) Kebeles were selected in this study. The sample size was determined following the Cochran formula (Cochran 1977) by proportional allocation to the population size of the Kebeles.

$$n = \frac{Z^2 qp}{e^2},$$

where: n = sample size, Z = is the critical value at 95% confidence level, p = estimated proportion, q = 1-p and e = desired level of precision at 0.05. Since there were no previous data regarding farmers' perception of rodent damage in the study area, the value of p was assumed to be 50% (Cochran 1977).

Farmers were selected using the Kebele household master list as the sampling frame. Then, the total number of households in each Kebele was divided by the sample size of each Kebele and the quotient was used as a sampling interval until the required sample size was achieved (Zewdneh et al. 2020).

Data collection

Data on farmers' perception of rodent damage and management interventions were collected using a semi-structured questionnaire from 384 farmers and focus group discussions (consisting of 5–10 individuals). Selected household farmers were interviewed face-to-face to explore major rodent pests, the extent of crop yield loss and their management practices. A questionnaire with similar surveys in Southeast Asia (Brown et al. 2008), northern Ethiopia (Meheretu et al. 2010) and southern Ethiopia (Zewdneh et al. 2020) was used as a starting format to prepare the questionnaire for the present survey. The questionnaire was prepared in English and then translated into the community's mother tongue language (Amharic) and pre-tested to contextualise with the community before the actual interview. The questionnaire data were supplemented with

direct observation in the field to strengthen their validity. The questionnaire has three parts: socio-demographic and socio-economic, perception of crop damage and management intervention.

Data analyses

Data were entered and compiled using a Microsoft Excel worksheet. Statistical analyses were computed using R software version 4.2.2. Chi-square tests were used to establish associations of farmers' perceptions with the type of agricultural pests, level of crop yield loss, management interventions and crop developmental stages. Multiple regression models were used to explore socio-demographic and socio-economic predictors of farmers' experiences to estimate crop yield loss due to rodent damage. Estimated annual yield loss was taken as the dependent variable, while household family size, farmland size, ages of farming, educational background and location were the predictor variables. Model selection was based on the Akaike Information Criterion (AIC). The best-fitting model was selected step by step, excluding the predictor variables from the full model until the lowest AIC value of the model was achieved. The linearity of data and normality of residuals were checked using the residuals vs. fitted plot and Q-Q plot, respectively. Graphical illustrations were constructed using R software.

Results

Socio-demographic and farming characteristics of farmers

Out of 384 respondents, 294 were males and 90 were females. The average farming age of respondents was 38.9 years. The average family size of the respondents was 4.85 individuals (± 0.09 SE, range from 2–9) (Table 1). Regarding educational background, the majority of respondents, 232 (60.4%), did not complete a formal education, followed by grades 1–5 complete, 99 (25.8%), grades 6–8 complete, 35 (9.1%) and least was grade 9 and above complete, 18 (4.7%).

Agriculture is the main economic activity of the community in the study area. The average farmland size of the respondents was 1.4 ha per household (± 0.6 SE, range from 0.2 to 4). Farmers cultivated different crops, which include cereals, pulses and oil crops. Cereal crops such as wheat (*Triticum aestivum*), teff (*Eragrostis tef*) and maize (*Zea mays*) were the most commonly grown crops. Pulse crops such as faba bean (*Vicia faba*) and pea (*Pisum sativum*) and oil seeds, such as mung bean (*Vigna radiata*), sesame (*Sesamum indicum*) and others were also cultivated by some farmers. The average annual crop yield per household was 1746 kg (± 0.48 SE, ranging from 8–60) (Table 1).

Table 1. Socio-demographic and farming characteristics of respondents (SE = standard error).

Kebeles		Age lived (years)	Farmland size (per ha)	Family size	Annual crop yield/kg	Perceived annual crop yield loss/kg
Chimit (109)	Mean ± SE	38.5 ± 0.87	1.6 ± 0.08	4.4 ± 0.15	1953 ± 0.85	247.9 ± 6.9
	Min	18	0.5	2	8	34
	Max	65	4	8	60	300

Kebeles		Age lived (years)	Farmland size (per ha)	Family size	Annual crop yield/kg	Perceived annual crop yield loss/kg
Denba (82)	Mean ± SE	37.6 ± 0.23	1.04 ± 0.23	5.1 ± 0.17	1550 ± 0.76	200 ± 4.9
	Min	16	0.5	2	10	30
	Max	66	3	9	40	270
May Angetam (115)	Mean ± SE	40.1 ± 0.84	1.5 ± 0.11	5.1 ± 0.17	1751.2 ± 1.2	237.9 ± 7.3
	Min	23	0.2	2	8	33
	Max	59	4	8	56	290
Dinguabe (78)	Mean ± SE	40.7 ± 1.2	1.3 ± 0.16	4.8 ± 0.19	1730.1 ± 0.98	241 ± 8.9
	Min	18	0.5	2	10	37
	Max	57	4	8	49	297
Overall (n = 384)	Mean ± SE	38.9 ± 0.5	1.4 ± 0.1	4.85 ± 0.1	1746 ± 0.48	231.7 ± 3.5
	Min	16	0.2	2	5	30
	Max	66	4	9	60	300

Agricultural pests and perceived crop damage

Crop production is often constrained by different pest animals. Most respondents perceived primates, 134 (34.09%), as major crop pests, followed by rodents, 90 (23.5%), birds, 23 (15.6%), insects and worms 57 (14.8%) and the least was other animals, 43 (11.2%) (Fig. 2).

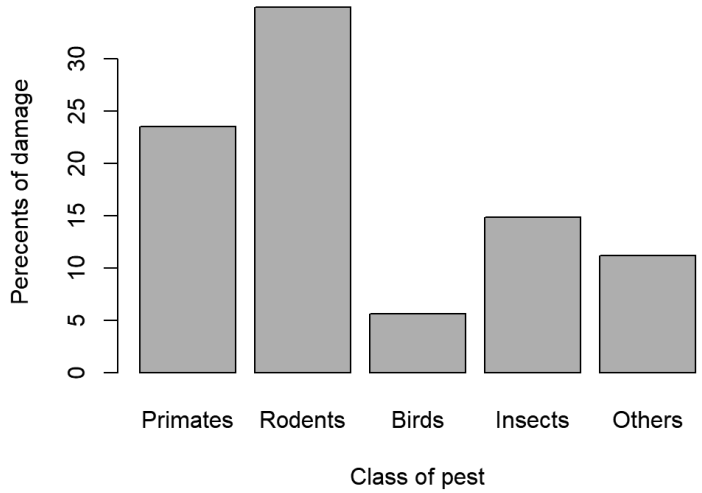

Figure 2. Frequency of respondents' perception on major agricultural pest animals in the study area.

Farmers were asked whether rodent-caused crop damage was a problem for agriculture. About ninety percent, 343 (89.3%), of the farmers believed crop damage by rodents was a problem for their farming in the community, while 23 (6%) of them did not consider it a problem. The remaining 18 (4.7%) responded maybe ($x^2 = 541.8$, df = 2, $p < 0.05$).

The susceptibility of crops to rodent damage differed amongst crop types. Farmers identified maize (49%) as being more susceptible to rodent damage, followed by wheat (21.1%), barley, (15.1%), teff (13.5%), and other crops were the least affected (1.3%). Farmers were also asked to estimate the annual crop

yield loss due to rodent damage. The average perceived annual crop yield loss due to rodents was 231.7 kg/ha (ranging from 30–300) per household. Most of the farmers ranked the level of crop damage as medium, 144 (37.5%), while 116 (30.2%) ranked it as high, and the least 11 (2.9%) very high (Fig. 3). The perception was significantly associated with the level of ranks (x^2 = 173.4, df = 4, p < 0.05).

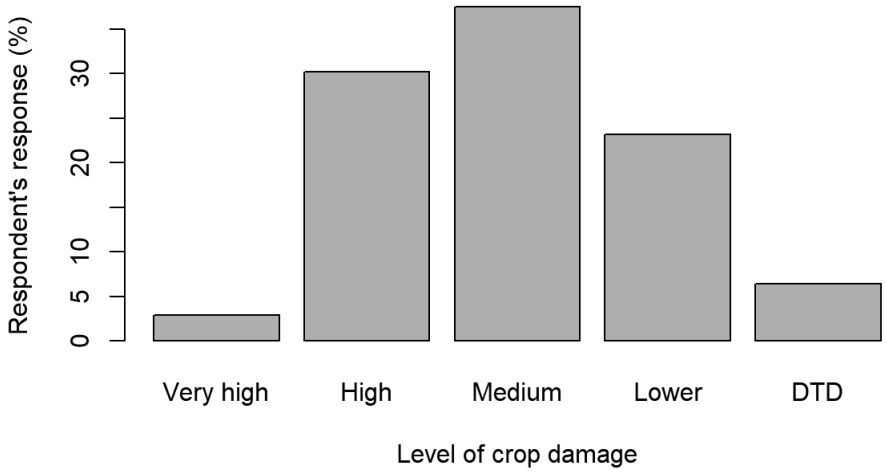

Figure 3. Respondents' perceived level of crop damage due to rodents (DTD = Difficult to determine).

Determinants of farmers' perceived estimated crop yield loss due to rodents

The perceived estimated crop loss due to rodents was significantly influenced by family size, farmland size, age, education and location of the farmers (Overall Multiple regression analysis: F (9,374) = 51.07, p < 0.05). About 54% of the variance in the perceived crop yield loss was predicted by family size, age, farmland size, educational background and location of farmers. For an increase in the farmers' family size, age and farmland size, the average perceived crop yield loss/kg was likely to decrease by 0.08, 0.015 and 0.13 times, respectively (Table 2). Regarding educational background, the average crop damage perceived by farmers with informal education was 0.16 times higher than grade 1–5 completed (p < 0.05). However, the average crop damage perceived by farmers with grades 6–8 and grade 9 and above completed was 0.2 and 0.31 times lower than grades 1–5 completed, respectively (p < 0.05). The average crop damage perceived by farmers from Denba Kebele was 0.29 times lower than that from Chimit Kebele (p < 0.05). However, there was no statistically significant difference in the average crop damage/kg between Chimit and farmers from the remaining Kebele (p > 0.05) (Table 2).

Table 2. Parameters affecting the estimate of farmers' perception of crop yield loss with family size, farmland size, age, education and location.

Parameters	Estimates	SE	t- value	p
Intercept	5.836	0.105	58.27	< 0.0001
Family size	-0.083	0.012	-6.45	< 0.0001*
Farmland/ha	-0.131	0.019	-6.88	0.002*

Parameters	Estimates	SE	t- value	p
Age (years lived)	-0.015	0.002	-6.56	< 0.0001*
Informal education	0.156	0.045	3.44	0.001*
Grades 6–8 complete	-0.204	0.075	-2.69	0.007*
Grade 9 ≥ complete	-0.305	0.098	-3.12	0.002*
Denba	-0.285	0.051	-5.63	< 0.0001*
Dinguabe	0.048	0.060	0.811	0.418
May Angetam	0.008	0.054	0.14	0.887

Multiple regression model: R^2 / R^2 adjusted: 0.551 / 0.541, residual standard error = 0.375, AIC = 348.8, SE = standard error, * = significant at 5% level.

Farmers' experience in rodent management

Farmers used different techniques to identify crops damaged by rodents. More than half of the farmers, 208 (54.2%), identified crop damage by observing rodent feeding, the presence of faeces, parts of plants eaten and the presence of rat holes, while 60 (15.6%) when they observed rodents feeding the crop, 48 (12.5%) when parts of the plant were eaten, 40 (10.4%) presence of faeces and 28 (7.3%) presence of rat hole.

Crops' susceptibility to rodent damage differed amongst crop developmental stages and crop variants (Fig. 4). Both wheat and teff were significantly more susceptible to rodent damage at the growth stage (tillering to booting) (27%) and least in the maturation stage (15%) as perceived by respondents (x^2 = 20.95, df = 4, $p < 0.05$). On the other hand, maize was significantly more susceptible at the threshing (harvesting) stage (29%) and less susceptible at all stages (9%) (x^2 = 68.10, df = 4, $p < 0.05$). Most farmers believed that rodent-controlling activities were more effective when they were applied at the growth stage (30.5%) and followed by the threshing stage (21.4%) than when applied in all developmental stages (Fig. 4). The association of rodent management practice effectiveness to specific crop developmental stages was significant (x^2 = 31.13, df = 4, $p < 0.05$).

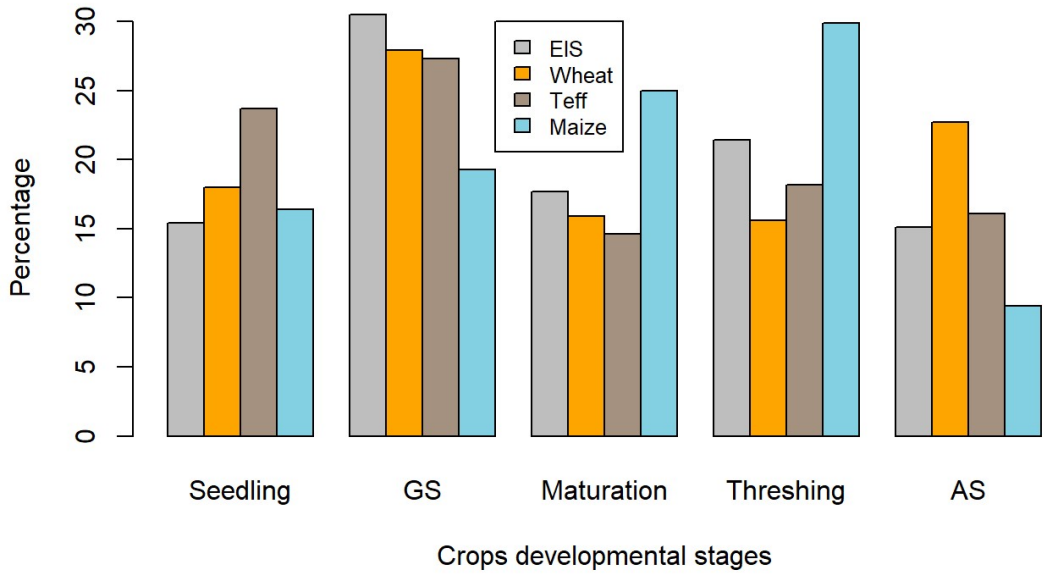

Figure 4. Crop developmental stages and their susceptibility to rodent damage and effective intervention stages (GS = Growth stage, AS = All developmental stages, EIS = Effective intervention stages).

To control rodent outbreaks, nearly half of the farmers, 177 (46.1%), used a combination of trapping and rodenticides, followed by rodenticides alone, 97 (25.3%) and the least applied trapping only, 50 (13%) (Fig. 5). However, about half of the farmers, (48%) believed that using rodenticide was the most effective method for controlling rodent crop damage followed by a combination of both rodenticides and trapping (30%), trapping (11%) and the least was clearing weeds and chasing (10.4%) (Fig. 5). The effectiveness of these controlling methods was significantly different ($x^2 = 37.6$, df = 3, $p < 0.05$).

More than half of farmers significantly protect their crop from rodent damage alone, 223 (58.1%), followed by working in groups with other farmers, 83(21.6%), both in group and alone, 71(18.5%) and few farmers, seven (1.8%), did not protect at all ($x^2 = 258.8$, df = 3, $p < 0.05$). Despite farmers using different techniques, half of them (50.5%) believed that rodent crop damage could not be easily controlled, while 43.8% could be controlled and the rest 5.7% responded maybe.

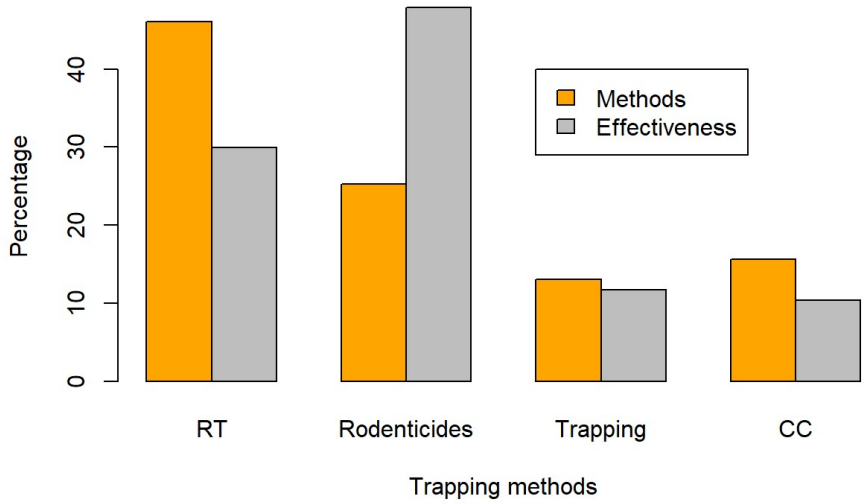

Figure 5. Types of rodent interventions used and their perceived effectiveness (RT = Rodenticide and Trapping, CC = Clearing weeds and chasing rodents).

Discussion

In the rural community farming system, farmers cultivated a variety of crops. However, agricultural production is often constrained by different pest animal species. Rodents are the second most important pest animals after primates in the present study. A similar finding was reported in Laos upland rice production (Schiller et al. 1999) and Myanmar (Brown et al. 2008), where rodents were identified as the second most important pest animals. Other studies in Tigray (Meheretu et al. 2010) and northeast India (Ngaomei and Singh 2016) identified rodents as the main pest in crop production. Rodents had particular preferences for a certain crop type and the amount of crop yield loss varied amongst crop species (Arlet and Molleman 2007). Amongst crops, maize was the most susceptible crop in this study. In agreement with the present finding, maize was the most susceptible crop in southern Ethiopia (Zewdneh et al. 2020), southwest Ethiopia (Tsegaye and Asfawosen 2016), Tanzania and central Ethiopia (Makundi et al. 2005).

Crop yield loss due to rodents is an important economic problem in small-scale farming communities that have no alternative income (Makundi et al.

2005). In the present study, the annual crop yield loss due to rodents was 13.3% as perceived by farmers. However, the level of severity of crop damage was ranked as medium level by most farmers. The perceived crop loss was comparable with others reported from southern Ethiopia, 13% (Zewdneh et al. 2020) and 8.9–44.7% Tigray highlands (Meheretu et al. 2010). On the contrary, a higher estimated annual yield loss was reported in north-east India, 19.9% (Ngaomei and Singh 2016), 23.5% in barley field, Choke Mountain, Ethiopia (Getachew 2016) and even much higher during the rodent outbreak in Tanzania, 86.7% (Mulungu et al. 2015). The difference in the amount of yield loss between studies might be attributed to the variation in farmers' perceptions and the abundance of pest species. Such a high yield loss in this study might be a problem for food security for such small-scale farming households with small farmland sizes.

The amount of crop yield loss due to rodents is influenced by several factors. Family size, farmland size, age, educational background, and location of the farmers significantly determined the amount of perceived crop yield loss in this study. Older farmers are likely to have a lower average perceived crop yield loss than younger ones. In agreement with the present case, Zewdneh et al. (2020) reported that annual maize yield loss due to rodents decreased for farmers who have more farming experience. A similar finding was also reported elsewhere (Zhang et al. 2018). The possible reason might be that older farmers have better experience in increasing their crop production by minimising yield loss due to rodent damage than younger ones. Similarly, households with large family sizes experience lower average perceived crop yield loss than those that have smaller family sizes. This may be explained by the fact that having more family members may help the household to protect the crop against rodent pests, resulting in lower estimated yield loss. Farmers with large farmland sizes perceived lower average crop yield loss than those that have small farmland. The possible reason might be that the larger the size of the farmland, the more difficult it is for farmers to accurately estimate crop loss. In addition, it might be attributed to the concealing effect of higher production for the amount of yield lost due to rodent damage. Educational background is an important tool in changing human perception. In the present study, the average crop yield loss perceived by farmers with informal education was higher than that of those who completed grades 1–5. A similar finding was reported by Zewdneh et al. (2020), where farmers lacking formal education experience the highest average annual storage loss of maize. The possible explanation for this might be that educated farmers are expected to have better experience in applying both scientific and traditional rodent pest-controlling methods to reduce the amount of crop loss than informally educated farmers. There was a lower average perceived annual crop loss from Denba Kebele than from Chimit Kebele. Similar trends of crop loss were reported in other studies (Brown et al. 2008). The location of farmland compared to natural habitats might affect crop damage (Getachew 2016). The location of farmland in Denba Kebele was relatively further away from natural forest and bushland than the other Kebele farmlands. These non-cropping areas (natural forest and bushlands) possibly provide refugia habitats for rodent pests, which contributed to higher crop damage estimates in the three Kebeles in comparison with Denba Kebele.

Farmers use a variety of techniques to differentiate whether rodents damage a crop or not (Mulungu 2017). In this study, most farmers used a combination

of methods, including observing rodent feeding, the presence of faeces, parts of plants eaten and the presence of rat holes to identify crop damage caused by rodents, and they used different rodent control techniques. The most effective rodent control method was poisoning using rodenticides. Several studies reported similar trends of rodent management in Tanzania (Cochran 1977; Makundi et al. 2005) and Ethiopia (Meheretu et al. 2010; Getachew 2016; Tsegaye and Asfawosen 2016; Zewdneh et al. 2020). The possible explanation might be attributed to rodenticides killing many rodent pests in a short period with less labour investment than other methods. However, the use of rodenticides becomes a focus of human health concern and killing non-target animal species (Buckle and Eason 2015; Mulungu 2017).

Crop damage due to rodents differs among crop developmental stages and crop types (Mulungu 2017). Wheat and teff were more affected by rodent damage at the growth stage (tillering to booting) than maize, which was more susceptible at the threshing (harvesting) stage in this study. This is in agreement with higher wheat and barley damage at the booting stage reported in Tigray (Meheretu et al. 2010), Choke Mountain (Getachew 2016) and maize after the seedling stage (Afework et al. 2003). In contrast to the present finding, Zewdneh et al. (2020) reported that maize was highly susceptible to rodent damage at the seedling stage, while Makundi et al. (2005) reported susceptibility at the seedling and germination stages. The susceptibility of wheat and barley to rodent damage at the vegetative stage might be attributed to the development of soft stem and leaves might attract pests. In addition, as the growth of wheat and barley plants progressed, it created hiding sites for rodents, favouring higher rodent abundance at this stage than maize plants. On the contrary, the more serious damage at the harvesting stage in maize might be that the fruit provides better nutritional quality than the vegetative stage and with a larger quantity than other crops.

Farmers identified plant developmental stages where the most effective intervention to rodent damage is to be carried out. Most farmers believed that rodent-controlling activities were effective when applied at growth stages (tillering and booting). Several studies identified booting as the most effective intervention stage to control rodents (Meheretu et al. 2010; Ngaomei and Singh 2016). This might be attributed to the presence of a lot of food sources (soft stems, shoots and leaves) and shelter attracts more rodents at the booting stage. Thus, high rodent abundance at the booting stage might result in more damage, which may trigger farmers to apply rodent management interventions at this stage. In addition, proactive controlling, including frequent site inspection and clearing of refugia habitat, may reduce rodent encroachment into the crop field.

Rodent outbreaks have been recorded in many African countries, including Ethiopia (Leirs et al. 2010). In the present study, most farmers believed that rodent outbreaks occur occasionally, often every two-year interval. In contrast, several studies reported regular (yearly) occurrences of rodent outbreaks (Meheretu et al. 2010; Mulungu 2017; Zewdneh et al. 2020). Rodent outbreaks in Africa are limited to certain rodent pests that belong to *Mastomys*, *Arvicanthis* and some *Gerbilliscus* species (Leirs et al. 2010), which are also common in the present study area. Outbreaks for rodent species such as *Mastomys* may occur when there is high continuous rainfall or during bimodal rainy seasons (Mulungu 2017). The newborn rodents in the first rainy season could be ready to give

birth (together with their parents) in the next breeding season, which leads to a sudden population eruption and more crop damage (Singleton et al. 2010). The difference in the occurrence of rodent outbreaks between studies might be due to variations in farmers' observations and the availability of a suitable environment (rainfall) for breeding.

During the occurrence of higher pest populations and associated crop damage, most farmers protect their crops from rodent damage alone. Similar perception studies conducted in Ethiopia and elsewhere support the present finding (Brown et al. 2008; Tsegaye and Asfawosen 2016). Although farmers used different techniques and worked alone or in groups, most of them perceived that crop damage due to rodents could not be controlled at all, but could be minimised. This is consistent with Brown et al. (2008), who reported that many farmers believed rats could not be controlled. Unlike large animals, the smaller size of rodents might help them to hide in small holes or shelter sites, making it difficult for farmers to chase away or hunt them easily.

Conclusions and recommendations

The study shows that farmers in East Gojjam suffered from pest damage. Rodents were amongst the most important crop pests in the study area. Socio-demographic and socio-economic characteristics, such as family size, age, farmland size, education and location of the farming area, were important determinants of farmers' perception of crop yield loss due to rodents. Farmers have substantial knowledge to identify the most susceptible crops and the most vulnerable crop developmental stage (tillering and booting) to rodent damage (Singleton et al. 2010; Mulungu 2017; Singleton et al. 2021). They used different rodent control measures to control rodents, where poisoning with rodenticide is believed to be the most effective method.

Based on the current findings, crop yield losses from rodent damage may pose a serious problem for most subsistence farmers. Thus, both governmental and non-governmental organisations should give more emphasis on rodent control measures by forecasting potential rodent outbreak periods and conducting a consistent awareness-raising programme. The dependency of farmers on rodenticide requires an assessment, as this method has serious health, environmental and other concerns. Therefore, farmers must be aware of the consequences of crop damage due to rodents through training and be recommended to use ecologically friendly and environmentally sound rodent management methods which includes the synchrony of cropping, conducting community management before the onset of breeding, using biological control, fertility control, non-toxic deterrents, physical and mechanical control, habitat manipulation and others (Smith and Meyer 2015; Mulungu 2017; Singleton et al. 2021).

Acknowledgements

The authors acknowledge Mr Tegbar Sibahat for his guidance, participation in fieldwork and facilitation of the interview during the entire data collection process in Chimit Kola. We also thank the local communities living around Chimit Kola and the agricultural research extension experts who participated in this research.

References

Abebaw A, Atzberger C, Seher W, Mansberger R (2019) Farmer's Willingness to Participate in Voluntary Land Consolidation in Gozamin District, Ethiopia. Land 8(10): 148. https://doi.org/10.3390/land8100148

Afework B, Leirs H, Verhagen R (2003) Composition of rodents and damage estimates on maize farms at Ziway, Ethiopia. In: Singleton DR (Eds) Rats, Mice and People: Rodent Biology and Management. ACIAR Monograph No. 96, 262–263.

Arlet ME, Molleman F (2007) Rodents damage crops more than wildlife in subsistence agriculture on the northern periphery of Dja Reserve, Cameroon. International Journal Pest Management 53: 237–243. https://doi.org/10.1080/09670870701418994

Brown PR, Yee N, Singleton GR, Kenney AJ, Htwe NM, Myint M, Aye T (2008) Farmers' knowledge, attitudes, and practices for rodent management in Myanmar. International Journal Pest Management 54(1): 69–76. https://doi.org/10.1080/09670870701474047

Bryja J, Meheretu Y, Sumbera R, Laverenchenko L (2019) Annotated checklist, taxonomy and distribution of rodents in Ethiopia. Folia Zoologica 68(3): 117–213.https://doi.org/10.25225/fozo.030.2019

Buckle AP, Eason CT (2015) Rodent Control Methods: Chemical. In: Buckle, Smith (Eds) Rodent Pest and their Control, 123–154. https://doi.org/10.1079/9781845938178.0123

Cochran W (1977) Sampling Techniques, 3rd edition. John Wiley and Sons, Inc. Canada.

Getachew M (2016) Species Composition, Distribution, Abundance and Economic Importance of Rodents in Choke Mountains, East Gojjam, Ethiopia. PhD Dissertation, Addis Ababa University, Addis Ababa.

Leirs H, Sluydts V, Makundi R (2010) Rodent outbreaks in sub-Saharan Africa. In: Singleton GR (Ed.) Rodent Outbreaks: Ecology and Impacts. International Rice Research Institute, Los Banos, 269–280.

Makundi R, Guge N, Mwanjabe PS (1999) Rodent pest management in East Africa: an Ecological Approach. In: Singleton C, Hinds LA, Leirs H, Zhang Z (Eds) Ecologically-based management of rodent. ACIAR Monograph No. 59: 460–476.

Makundi RH, Afework B, Leirs H, Massawe W, Rwamugira W, Mulungu LS (2005) Farmers' Perceptions of rodents as crop pests: knowledge, attitude and practices in rat management in Tanzania and Ethiopia. Belgian Journal of Zoology 135: 153–157.

Meheretu Y, Kiros K, Deckers S, Raes D, Makundi R, Leirs R (2010) Farmers' perspectives of rodent damage and management from the highlands of Tigray, Northern Ethiopia. Crop protection 29(6): 532–539. https://doi.org/10.1016/j.cropro.2009.12.006

Mulungu LS (2017) Control of rodent pests in maize cultivation: The case of Africa. In: Mexico, Watson D (Eds) Burleigh Dodds Series in Agricultural Science. Burleigh Dodds Science Publishing, 317–338. https://doi.org/10.19103/as.2016.0002.18

Mulungu LS, Mrosso FB, Katakweba A, Mdangi AM, Tesha PH, Ngowo VP, Mchomvu B, Kilonzo BS (2015) Farmers' knowledge, attitude and practice on rodent management in lowland irrigated rice in Central-eastern Tanzania. International Research Journal Plant Science 6(1): 7–14. https://doi.org/10.14303/irjps.2014.016

Ngaomei J, Singh EJ (2016) Farmers' knowledge, attitudes and practices with respect to rodent management in the agricultural ecosystem of Tamenglong district, Manipur, North-East India. International Journal of Applied Research 2(4): 536–540.

Schiller LM, Boupha BD, Bounnaphol O (1999) Rodents in Agriculture in the Lao PDR – a Problem with an Unknown Future. In: Singleton C, Hinds HA, Leirs H, Zhang Z (Eds) Ecologically-based management of rodent. ACIAR Monograph No. 59: 372–387.

Singleton GR, Belmain SR, Brown PR, Hardy B (2010) Rodent outbreaks: ecology and impacts. Los Baños (Philippines): International Rice Research Institute.

Singleton GR, Lorica RP, MeHtwe N, Stuart AM (2021) Rodent management and cereal production in Asia: Balancing food security and conservation. Wiley Online Library, https://doi.org/10.1002/ps.6462

Sitotaw F, Getachew A, Aemiro K, Tesfahun A, Chilot Y (2020) Farming Systems Characterization and Analysis in East Gojjam Zone: Implications for research and development intervention. Research Report No. 127. EIAR, Addis Ababa.

Smith RH, Meyer AN (2015) Rodent Control Methods: Non-Chemical and Non-Lethal Chemical, with special reference to food stores. In: Buckle, Smith (Eds) Rodent Pest and their Control, 102–154. https://doi.org/10.1079/9781845938178.0123

Swanepoel L, Swanepoel C, Brown PR, Eiseb SJ, Goodman SM (2017) A systematic review of rodent pest research in Afro-Malagasy small-holder farming systems: Are we asking the right questions? PLOS ONE 12(3). https://doi.org/10.1371/journal.pone.0174554

Tsegaye G, Asfawosen B (2016) Farmers' perceptions of rodents as crop pests: Knowledge, attitude and practices of farmers about rodent pest management in Southwest Ethiopia. Journal of Agricultural Extension Rural Development 8(3): 39–46. https://doi.org/10.5897/jaerd2015.0739

Zewdneh T, Simon S, Meheretu Y, Leirs H (2020) Farmers' perspectives of rodent damage and rodent management in smallholder maize cropping systems of Southern Ethiopia. Crop protection 136: 105232. https://doi.org/10.1016/j.cropro.2020.105232

Zhang W, Kato E, Bianchi F, Bhandary P, Gort G, Werf W (2018) Farmers' perceptions of crop pest severity in Nigeria are associated with landscape, agronomic and socio-economic factors. Agriculture Ecosystem and Environment 259: 159–167. https://doi.org/10.1016/j.agee.2018.03.004

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

The study was approved by the Department of Zoological Sciences, Addis Ababa University (SF-ZS-131-13-2020). Written permission was obtained from the local district administration. In addition, verbal consent was obtained from local communities living around the study areas.

Artificial Intelligence (AI) use

The authors accept full responsibility for the content of the manuscript, including the disclosure of any use of AI.
No AI tools were used in the preparation of this manuscript.

Funding

The authors have no support for this research work.

Author contributions

Mengistu Wale was responsible for data collection, analysis and writing manuscripts, while Afework Bekele and Mesele Yihune participated in the supervision and editing processes. All authors have read and agreed to the published version of the manuscript.

Data availability

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