**The Rodent Pest Species Infesting Maize (*Zea mays* L) and Wheat (*Triticum aestivum* L) Farms at University of Eldoret, Uasin Gishu County, Kenya**

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**Abstract**

*Rodents are pests of concern in Kenya, as they cause considerable damage to cereal during pre harvest and post-harvest period and therefore affecting food security by impacting on both food availability, quantity and quality. However, knowledge on rodent pests and cereal crops infested in Kenya is limited. The objectives of the research were to investigate the rodent pest species that infest maize and wheat farms, determine the rodent species, gender (males and females) and population distribution in maize and wheat farms at University of Eldoret. Two habitats (Maize and wheat farms) were selected for the study. Grids of 70mx70m crop cuttings were done in commercial fields of maize and wheat. The grid was subdivided into four quarters each with 4 Sherman's live traps and 4 locally woven live traps, a total of 32 trapping points were established. Peanut butter and sun dried Omena (Rastrineobola argentea) were used as baits. Rodents captured were identified up to species level using keys for classifying rodents. The SPSS statistical package version 22.0 was used to analyze the data. Chi square test was used to compare the populations of myomorph rodents captured during the cropping period in both farms, independent sample t-test was used to compare the variation in infestation between the two habitats, gender and species distribution, Autoregressive Integrated Moving Average (ARIMA) [1, 1, 1] [2, 0, 0] Time series model was used to forecast the trend of rodent incidences. The results were presented in tables and figures. Three myomorph rodent species were recorded during the three-year study period. They included Mastomys natalensis (M. natalensis), Arvicanthis niloticus (A. niloticus) and Lemniscomys striatus (L. striatus). A total of 924 myomorph rodents were captured during study period with 50.97%, 19.48% and 29.54% captured in year one, two and three respectively. Mastomys natalensis represented the highest captures 60.61% followed by Arvicanthis niloticus 38.42% and then Lemniscomys striatus 0.97%. There was variation in infestation between the two fields with rodents showing preference to maize than wheat farms. There were more M. natalensis and A. niloticus in maize compared to wheat farms and L. striatus was a rare species during this study. There was a significant variation in infestation in year one (P =.001) and no significant variation in distribution of myomorph rodents in year two (P = .499) and year three (P = .127) cropping period. Species displayed variation in distribution with negative relationship in terms of species incidences and habitat in year two (t = -0.677; P =.499) and positive relationship (t = 1.529; P = .127) for year three. There was a significant difference in distribution of gender (males and females) in second year of study (t = -2.625, P = .009) and overall, no significant variation in distribution of gender (t = 0.525, P = .600) in the two habitats. ARIMA (1, 1, 1) model depicted that there was abundance of the rodent pests between the months of March and July, with decline in the months of November to January for the forecasted year with minimal variations. The findings (t = 3.523, P = .001) also revealed that there was a statistically significant difference in species distribution between the rodents in maize and wheat fields. In conclusion, the three myormoph rodent pests' species distribution varied in maize and wheat farms and the population varied from year to year with higher incidences of pests in maize than wheat fields. Despite the varying numbers of either species in both maize and wheat, the types of species did not vary in both fields. There* *was no significant difference between gender (male and female) of rodent species in maize and wheat farms. The abundance could increase to cause loss and therefore needs to determine rodent pest control strategies to minimize the numbers and population of these rodent species in the study area and other regions that grow maize and wheat.*

**Keywords:** *Arvicanthis niloticus*, *Mastomys natalensis, Lemniscomys striatus,* population distribution.

## INTRODUCTION

Rodents are recognized as one of the most destructive pests. They cause great economic loss to farmers by damaging growing crops, stored products, poultry, and animal farms. They damage structure and fabric of buildings because they gnaw through almost every object to obtain food and shelter (Desoky, 2018). Rodentia which is the most important mammalian order with greatest number of rodents have their effect on environment directly through feeding and foraging habits being primary consumers feeding on grains and vegetation there by reducing potential production of grains or indirectly through their position in the food chain whereby they are used as prey (food) for predators.

Rodents are the most diverse and abundant groups of mammals accounting for approximately 2200 species and new species are being described (Monadjem *et al*., 2015). Rodents occur in a wide range of terrestrial habitat, they are diverse and form an integral part of the ecosystem functioning (Fischer *et al.*, 2017; Mayamba, 2020). Rodents are also of biogeographic, systematic, and conservation interest (Happold 2013; Monadjem *et al.*, 2015). According to Royer *et al.* (2016) rodent immigrations and emigrations take place, which results in new regional populations being established in order to occupy the fundamental niche which is a potential role that could be filled and is affected by among other factors the ability of individual organism to disperse, their tolerance to different environmental conditions and how the organism interact with other species. The rodents fulfill this role in terms of resource use due to presence of other species competing for resources like predation, competition and environmental stresses which prevents the acquisition of the resource.

Rodents have been grouped into three suborders (Nowak, 1999; Vaughan *et al.*, 2000), based largely on jaw musculature and associated structure of the skull being, Sciuromorpha (squirrel-like), Myomorpha (rat-like) and Hysticomorpha (porcupine-like) rodents respectively. These sub-orders are grouped into 29 living families, 426 genera, and 2,000 species. So, rodents are the most ubiquitous of all orders of mammals (Nowak, 1999). Among these, most of the rodent species belong to sub-order Myomorpha and two-third of the living rodent species belong to a single family Muridae. The number of rodent species keeps increasing from time to time as a result of the development of new techniques of identifying siblings and cryptic species (Kingdon, 1997).

The habitat and behavior of rodents have been reported to be highly diversified (Kingdon, 1997; Nowak, 1999). Rodents are quite intelligent and can master simple tasks when conditioned. They have an acute sense of smell, hearing, taste and touch. Rodents are highly social animals and use many of their senses to communicate. According to Nowak, (1999) rodent's behavior is highly adaptable. They have high reproductive rates and ability to invade varied habitats and therefore they are able to spread and multiply very quickly. The rats actively begin to search for food and water shortly after sunset. The signs of the presence of rats are tracks; rub marks, droppings, gnawing and burrows (Aplin *et al*., 2003).

Rodents are known to be pests of concern in that some species constitute pests, which cause damage to a variety of crops before and after harvest. Odhiambo and Oguge (2003) reported a 90% loss of crops due to rodents in Kwale County in Kenya. Rodent species reported by

Oguge *et al*. (1983) included, *Arvicanthis niloticus* (Desmarest), *Pumilio natalensis* (Smith), *Rhabdomys pumilio* (Smith), *Lemniscomys striatus* (Linnaeus), *Rattus rattus* (L) and *Mus sp.* All these species are pests of stored cereal and grains as reported by Vaughan (1986). Also, Taylor (1968) had reported rat outbreaks in Kenya, and he recorded eight species, the most serious pests being, *Mastomys natalensis*, *Arvicanthis niloticus* and *Rhabdomys pumilio.* As Taylor, (1968) found out, the species targeted wheat, maize, and barley among other crops. The *A. niloticus* has been reported to infest and feed on both the lodging and standing maize plants and cause damage to stalks and spikes of cereal plants. They cause more damage to seed bearing heads or spikes of cereal plants and grains, (Desoky, A.E.A.S.S., 2018). In addition, Meheretu *et al*. (2013) identified and cited rodents as pests of agricultural crops in central Ethiopia whereby, out of 34 recorded species, 12 were rodents that cause damage to crop both as pre harvest and post-harvest pests. Rodents have been identified as pests of wheat by Kamwaga *et al*. (2016) and *Rattus* species is identified for being a menace especially during post-harvest and storage stage where their sign of infestation is noticed by presence droppings and nesting sites, grains scattered around droppings or footprints, unconsumed grain contaminated with urine and droppings. the reason behind the partially consumed grains is because rodents feed on endosperm part of the seed that has highly concentrated and localized nutrient source of lipids than other parts of the plants while the starchy carbohydrate part is left behind as left overs plus the presence of dirty marks in places through which they pass.

Anthropogenic environmental changes have been shown to be crucial determining factor in the increase of rodent’s ubiquity through time when rodents are attracted to food in villages and fields (Dean, 2005). As Dean (2005) also observed, kangaroo rat population increased due to the weedy annuals around human habitation. Different species of rodents vary in their ecology and behavior, in the type of damage they cause and in their response to various control measures according to Oguge *et al.* (1983). Rodent pests have been reported as a serious problem for agricultural production in China by Zhi-Bin Zhang (1999) where he reported rodents being more abundant during heavier droughts and warmer winters. Further, Zhi-Bin Zhang (1999) reported broad-scale out breaks of rodents in China with a 24.9% arable land and 14% of grassland being infested annually. He further noted that the population dynamics and management strategies varied greatly and are dependent on the species and its ecosystem. Most field rodent pests display irregular population outbreaks during which damage to standing crops can be very devastating. The irregular population outbreaks may be due to animals being residents or passer-by. Rodents infest areas or land offering harborage to them and damage in the field is either random or regular (Mulungu, 2017). In the same view, Kasso (2013) reported that rodents are pests that cause substantial damage to agricultural crops, household items and human health through mechanisms like feeding, contaminating food, mechanical damage, and disease transmission. Rats usually feed on embryo part of the grain because of the lipid content that is easier to digest and provides energy for the rodents instead of starchy carbohydrates which is left as waste not fit for human consumption. The grains left overs are not palatable and are easily prone to infection by aflatoxins. High populations of rodents with their wasteful, destructive eating cause loss in production of maize and wheat. Rodents in general prefer grains with low protein, high carbohydrate and fat contents or seeds of low carbohydrate, high protein and high fat (Asran *et al*., 2014). This study investigated the type of rodent pest species, their population abundance and distribution in maize and wheat farms in the study area.

## MATERIALS AND METHODS

### Study area

The study was carried out at the University of Eldoret maize and wheat farms. University of Eldoret is in Uasin Gishu County. The county of Uasin Gishu is situated in the Kenyan Great Rift Valley. Its neighbors are Kakamega County to the northwest, Kericho County to the southeast, Elgeyo Marakwet County to the east, TransNzoia County to the north, and Nandi County to the south (County Integrated Development Plan CIDP, 2018). The six sub counties that make up Uasin Gishu County are Kesses, Kapseret, Moiben, Ainabkoi, Soy, and Turbo (Figure 1).

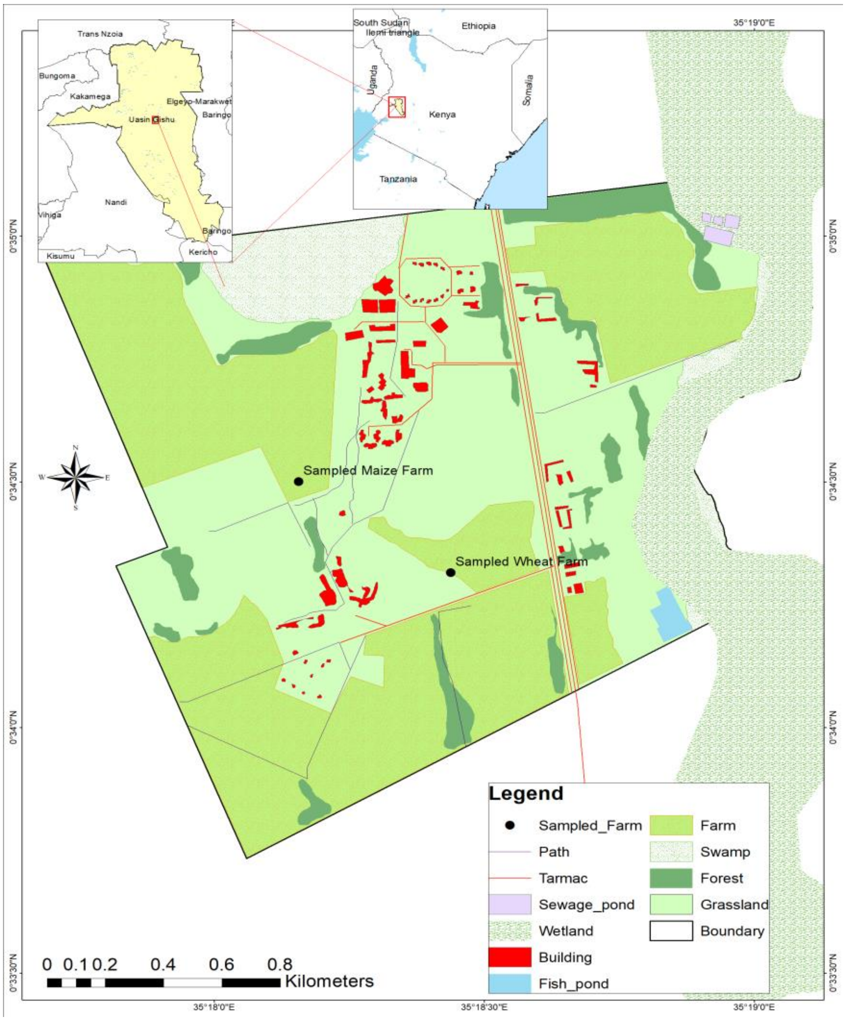


**Figure 1 Map showing Kenya, Uasin Gishu County and University of Eldoret study site of maize and wheat farms**

*Source: Researcher, 2022*

The County has high and reliable rainfall, the main agricultural production system is small scale mixed farming where farmers grow various crops and keep livestock on same land parcel. However, there are a few large-scale farmers who produce maize and wheat on large scale for commercial purpose in rural areas. The major crops in the county are maize grown on 102733 hectares (Ha) of land, wheat (16867 Ha), beans (16210 Ha) and Irish potatoes (1429 Ha) among other crops while the livestock include dairy farming, beef cattle, poultry, sheep, goats, pigs, beekeeping, rabbit farming and fish farming where the county produces about 200million Kgs of milk and about 2.5million Kgs of meat annually (CIDP, 2018). Uasin Gishu County has three main distinct agro-ecological zones (AEZs) namely; lower highlands (LH), Upper midlands (UM) and upper highlands (UH). Lower highlands constitute LH2, LH3 and LH4. Upper midlands have UM3, UM4 and upper highlands is represented by UH1 and UH2 (MoALF. 2017).

The University of Eldoret is situated 9 km to the north of Eldoret town at latitude $0^{0}34'36''$N and longitude $35^{0}18'20''$E along Eldoret –Ziwa road off Iten road in Moiben sub-County. The University occupies 414.8 hactare( Ha) of land at an altitude of 2140M above sea level.The area experiences one long rainy season commencing in March to September with two peaks in March and August.The mean daily temperature is about $18^{0}$C (range $9^{0}$C - $25^{0}$C). Usually the highest and lowest temperatures occur in February and July respectively which can be categorised under low highland agro- ecological zone LH4 (MoALF, 2017).

University of Eldoret is a learning institution where students are engaged in learning and research. University farms are used as research experimental plots where new wheat varieties have been developed. They practice large scale mixed farming where animals and crops are grown.The maize variety grown is not only for food but the institution keeps livestock for dairy and thus large scale maize production on farms are utilized for production of silage and maize stalks used to feed the cattle. Although pest managenent is intense on University of Eldoret farms, the university farms are still appropriate study plots on ecology of myomorph rodent pests because of the incidences of rodent pests from the areas bordering the University of Eldoret farms which may form hiding sites and which can facilitate rodent movements in and out of the study grid (maize and wheat farms). Availability of large quantity of feed on the farms as a result of highly improved means of production could influence the feeding and movement of various rodent pests.

**Research Design**

A quantitative and longitudinal research design was employed in this study, where repeated primary data from selected maize and wheat fields were collected over a period of three years. The protocol variables were time, three cropping years and two sites maize and wheat. Discrete variables of numbers of rodents captured, type of species and number of gender (males and females) captured in maize and wheat were used to investigate their population abundance and variation in distribution during the three years of study. The study was based on empirical field data (Pandey and Pandey 2015). Models of correlations and regression were used to test variance and relationship in distribution.

**Materials and methods**

Materials and tools used in this study included; traps, data sheets, tape measure, waterproof markers, field note books, leather gloves and surgical gloves, trap baits and animal field guides.

**Trapping Techniques and Data Collection**

There are several traps used for trapping small mammals. In the present study Sherman live-trap (7.5 × 9.0 × 23.0 cm, HB Sherman Trap Inc., Tallahassee, USA) Sourced from 3731 Peddie Drive Tallahassee, FL 32303 and locally woven live traps bought from a market in Eldoret town were used. The Sherman live traps are light aluminium box traps and are designed to capture live animals. They are collapsible and easy to transport. Locally woven live traps are woven wires with an entrance in which trapped rodents cannot escape also designed to capture live animals. The rodents captured by live traps were ear marked by permanent ink marker after shaving on the ear and released. The number of rodents captured was used to determine the populations. Peanut butter and raw sun dried Omena (*Rastrineobola argentea*) were used as bait. Bait (Peanut butter) was obtained from Tuskys and Uchumi supermarkets in Eldoret town and raw sun dried Omena (*Rastrineobola argentea*) was sourced from municipal market in Eldoret. The peanut butter bait was kept in a closed air tight container with a cover lid while Sun dried Omena were kept in a closed polythene bag and put in a locked clean cool dry laboratory cabinet for storage.

Study fields of maize and wheat were chosen with the help of farm managers and crop cutting was done in the commercial fields. The Linzey and Kesner (1997) standard grid trapping design was adopted in this study. In each farm, trapping grid of 70m x 70m crop cutting was established, a total of 16 Sherman traps where 4 Sherman's traps and 4 locally woven traps per quadrat were set randomly. The traps were baited to attract rodent pest for capture. The traps were checked twice a day early morning before 10am and late afternoon before 6pm on daily basis to maintain consistency in collection of data by both traps and detect if there is any variation in captures by traps. Rodents are known to be active early evening and at dawn so the traps were checked at 8am in the morning for those captured at night to be recorded and 6pm in the evening for those that could be caught during the day to be recorded. Each trapped rodent was marked on the ear with a permanent ink marker after shaving, identified and released, as per Linzey and Kesner (1997), in order to identify the animals that were captured in initial sample. In addition, data of gender, species, and habitat where the rodents were captured were recorded.

**Data Analysis**

Descriptive statistics (Pandey and Pandey, 2015) was used in form of means, standard deviations and percentages. Data then were analyzed using SPSS version 20.0 software. Autoregressive time series model was used to determine the future rodent population which can be used to predict future rodent outbreak. The Chi-Square test ($\chi^2$) was used to test the association between relative abundance of rodent's population in maize and wheat farms during the three years of study. Independent t test was used to compare their distribution in the two habitats. To investigate species distribution in maize and wheat fields and gender, all captured rodents were separated into male and females and their numbers recorded means calculated and then independent t-test was used to compare the distribution of gender (males and females) in the two farms of maize and wheat.

## RESULTS

Three myomorph rodent pest species were captured during the study period in maize and wheat farms. These were *Mastomys natalensis*, *Arvicanthis niloticus*, and *Lemniscomys striatus*. *Mastomys natalensis (M. natalensis)* a multimammate rat, which have soft grey /black hair with cream to white under the belly was captured throughout the three cropping years in both fields. *Arvicanthis niloticus* the grass rat (*A. niloticus)* have brown tough rough fur (hair) skin cover and *Lemniscomys striatus* striped grass rats (*L. striatus*) have black/whitish stripes especially on the back.

**Table 1a: Rodent population% in maize and wheat fields during study period**

| Habitat | Year1 | Year2 | Year3 | Totals captures | Percentage % |
|---|---|---|---|---|---|
| Maize | 288(31.17%) | 99(10.71%) | 146(15.80%) | 533 | 57.68 |
| Wheat | 183(19.80%) | 81(8.77%) | 127(13.74%) | 391 | 42.32 |
| Total captures | 471 | 180 | 273 | 924 | 100 |

**Table 1b: Rodent pest population in University of Eldoret farms for the three cropping years**

| Species | Total rodents captured | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Maize | | | | | | Wheat | | | | | |
| | Year 1 | | Year 2 | | Year 3 | | Year 1 | | Year 2 | | Year 3 | |
| | T.c | R.a (%) | T.c | R.a (%) | T.c | R.a (%) | T.c | R.a (%) | T.c | R.a (%) | T.c | R.a (%) |
| *M. natalensis* | 136 | 47.22 | 71 | 71.72 | 87 | 59.59 | 122 | 66.67 | 57 | 70.37 | 87 | 68.50 |
| *A. niloticus* | 149 | 51.74 | 28 | 28.28 | 59 | 40.41 | 58 | 31.69 | 21 | 25.93 | 40 | 31.50 |
| *L. striatus* | 3 | 1.04 | 0.00 | 0.00 | 0.00 | 0.00 | 3 | 1.64 | 3 | 3.70 | 0.00 | 0.00 |
| Total | 288 | 100 | 99 | 100 | 146 | 100 | 183 | 100 | 81 | 100 | 127 | 100 |

*T.c = Total captured; R.a = Relative abundance*

Findings on variation in infestation levels of myomorph rodents are shown in Table 1a and Table 1b. It was observed that the numbers of capture of the three species not only varied from year to year but also in maize and wheat farms. The total captures were 924 myomorph rodents, with 50.97% captures in year one, 19.48% showing captures for year two and 29.55% for year three and 57.68% were captured in maize and 42.32% in wheat. Shown in table 1a are myomorph rodent population percentages in maize and wheat fields during the study period. Of the total captures 31.17% and 19.80% were in maize and wheat respectively while for year two 10.71 % were captures in maize and 8.77% in wheat and year three realized a population distribution of 15.80% in maize and 13.74% in wheat. The number of rodents' capture were 57.68% in maize fields and 42.32% in wheat fields. Presented in Table.1b are myomorph rodent population total captures each year and relative abundance in both maize and wheat farms. The *Mastomys natalensis* was more abundant in maize and wheat throughout the study period followed by *A. niloticus* and then *L. striatus*. *Lemniscomys striatus* was captured once in maize in year one and twice in wheat field during the year one and two of study. The *Arvicanthis niloticus* species was the highest with a 51.74% followed by *M. natalensis* species 47.22% and then *L. striatus* 1.04% in maize during year one with a 66.67%, 31.69% and 1.64% for *M. natalensis, A. niloticus* and *L. striatus* respectively in wheat. Out of the rodents captured in year two in maize, 71.72% were *M. natalensis* and 28.28% were *A. niloticus* while in wheat 70.37% were *M. natalensis* and 25.93% were *A. niloticus*. In Year three, more than half of the rodents captured in that given year were *M. natalensis* species accounting for 59.59%) in maize *and 68.50%* in wheat fields, followed by *A. niloticus* 40.41% of captures in maize and 31.50% in wheat. The *M. natalensis* was the most common species among the imprisoned rodent pests in the three cropping years, followed by *A. niloticus,* and L. *striatus* was a rare species during the observations throughout this research period, according to the data.

**Table 1c: Chi-Square test for the rodent pest population in three cropping years**

| Cropping Years | N | $\chi^2$ Value | DF | P-value |
|---|---|---|---|---|
| Year one | 471 | 18.265 | 2 | .001 |
| Year two | 180 | 3.769 | 2 | .152 |
| Year three | 273 | 2.335 | 1 | .126 |
| Overall | 924 | 20.293 | 4 | .001 |

The findings showing variation in rodent pest population between the cropping years and infestation in maize and wheat are presented in Table 1c. The Chi-Square test was used to determine whether there was a statistical variation in distribution of myomorph rodents between the two farms during the three years under the study. The findings show that in year one a statistically significant variation existed ($\chi^2$=18.265, DF = 2 and P-value = .001), P-value = .001 < 0.05, while the subsequent years no statistical variation existed ($\chi^2$= 3.769, DF =2 and P-value = .152, $\chi^2$= 2.335, DF =1 and P-value .126 in year two and year three respectively P > .001). On the overall it was observed that there was statistically significant variation in distribution and abundance of myomorph rodent pest in the two farms ($\chi^2$=20.293, DF = 4 critical value 18.467 less than calculated value and P-value = .001), reject the null hypothesis and infer a significant variation in rodent distribution in maize and wheat farms during the three cropping years of study.

Figure 2 is ARIMA regression model for forecasting rodent population. The forecasting with time series model depicted that there was an increase in population of the rodent pests between the months of March to May, decline May to July then increase from September to November and decline to January during the three year circle. The model predicted that there would be a higher abundance of rodents between the months of May and July and decline to November. The population trends vary from year to year.

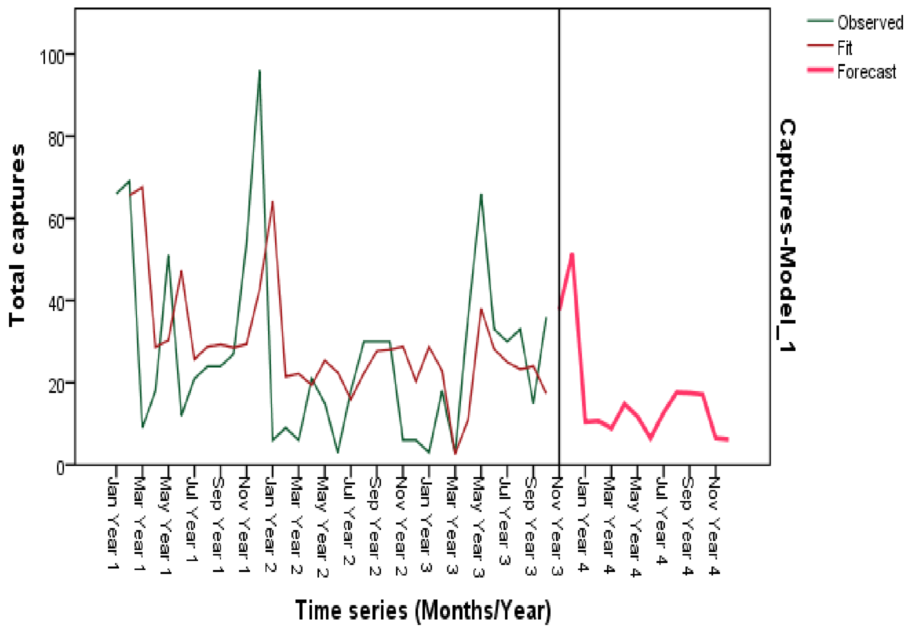


**Figure 2: One year forecast using regression model with ARIMA (1, 1, 1) (2, 0, 0) for rodents' population**

Presented in Table 2a are the findings of distribution of rodent pest species that infested the maize and wheat fields. The most dominant species of the trapped rodent pests was *Mastomys natalensis* which was higher in maize fields than wheat fields, followed by *Arvicanthis niloticus* and then *Lemniscomys striatus* turned out to be a rare species during this particular period of study. *L. striatus* being a typical grass mouse would prefer short wheat grass habitat than maize. The myormoph rodents were randomly distributed in the two fields. *Mastomys natalensis* with 55.16% dispersion in maize and 68.03% in wheat making 60.61% of rodents captured during the study period. *Arvicanthis niloticus* showed 44.28% dispersion in maize and 30.43% in wheat accounting for 38.42% of total rodents captured and least observed rodent was *L. striatus* at 0.56% in maize and 1.54% wheat accounting for only 0.97% of total population captured. There were more incidences of *M. natalensis* than *A. niloticus* and *L. striatus* in maize than in wheat fields. The *L. striatus* was a rare specy compared to the other two species where it was only captured once in maize and wheat fields in year one and year two of study and once in wheat. It was not caught in the final year three of study being least observed during the period of study.

**Table 2a: Rodent species percentage captures in maize and wheat farms**

| Species | **Habitat** | | | | | |
|---|---|---|---|---|---|---|
| | **Maize** | | **Wheat** | | **Total** | |
| | **Count** | **Row N %** | **Count** | **Row N %** | **Count** | **Row N %** |
| *M. natalensis* | 294 | 55.16 | 266 | 68.03 | 560 | 60.61 |
| *niloticus* | 236 | 44.28 | 119 | 30.43 | 355 | 38.42 |
| *L. striatus* | 3 | 0.56 | 6 | 1.54 | 9 | 0.97 |
| Total | 533 | 100 | 391 | 100 | 924 | 100 |

Presented in Table 2b are results of independent t-test to compare if there was any statistically significant difference in distribution of rodent species in maize and wheat habitats. In year one ($t$ (469) = 3.859, $P$ = .001) there was a significant difference in distribution of rodents in maize and wheat habitats. It was observed that in year two of study there was a negative significant difference in relationship ($t$ (178) = -.677, $P$ = .499; $t < -2.0$ with $P > .05$) showing no significant variation in distribution of rodents in maize and wheat fields and in year three there was a positive statistically no significant difference (t (271) =1.529, *P* = .127; t < 2.0 with P >.05) in the rodents species captured in maize and wheat fields. Overall findings (t (922) = 3.523, P = .001) also showed that there was a statistically significant variation in species distribution in maize and wheat fields in University of Eldoret.

**Table 2b: Independent t-test between rodent species and habitat (farms)**

| | t-value | DF | P-value | Mean Difference | S.E Difference |
|---|---|---|---|---|---|
| Year one | 3.859 | 469 | .001 | 0.188 | 0.049 |
| Year two | -0.677 | 178 | .499 | -0.051 | 0.075 |
| Year three | 1.529 | 271 | .127 | 0.089 | 0.058 |
| Overall | 3.523 | 922 | .001 | 0.119 | 0.034 |

Table 3a shows population of species distribution per gender in maize and wheat fields during the three-year study period. The findings indicate that in year one under the maize field, Male *Arvicanthis niloticus* were the most prevalent 52.05% and females 50.72% followed by *Mastomys natalensis* which had males 46.58%and females 49.28% *Lemniscomys striatus* species had the lowest prevalence in year one which entailed 1.37% males only and no females were captured. In year two under the maize field, Male *Mastomys natalensis* were the most abundant 78.69% and females 60.53% followed by *Arvicanthis niloticus* that had Males 21.31% and at 39.47% females. In year three, under the maize field, males of *Mastomys natalensis* were most abundant 53.93% and females 68.42% followed by *Arvicanthis niloticus* males 46.07% and 31.58% females. On the other hand, under the wheat fields, *Mastomys natalensis* had a higher number of female being74.24% of females and males 62.39% of males captured that year, followed by *Arvicanthis niloticus* species that had females 35.04% and 25.76% males and *Lemniscomys striatus* species had the lowest abundance with only females at 2.56% of females captured. In year two of study, *Mastomys natalensis* species was higher with a number being males 76.92% and females 64.29% followed by *Arvicanthis niloticus* species that had males 23.08% and 28.57% females, and *Lemniscomys striatus* species had only female 7.14% captured. In year three *Mastomys natalensis* species was higher with a number being males 66.67% and females70.49% followed by *Arvicanthis niloticus* Males 33.33% and 29.51% females, and *Lemniscomys striatus* species was not captured in wheat during the third year. On overall there were more males 58.45%captured than females 41.55%. There were more males of *M. natalensis* (59.44%) followed by *A. niloticus* (40%) and then *L. striatus* (0.56%) than females *M. natalensis* (62.24%), *A. niloticus* (36.20%) and *L. striatus* (1.56%) as presented in Table 3b.

**Table 3a: Gender and Species of the myormoph rodents in University of Eldoret farms for the three cropping years**

| | Total rodents captured | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Maize | | | | | | Wheat | | | | | |
| | Year 1 | | Year 2 | | Year 3 | | Year 1 | | Year 2 | | Year 3 | |
| Species | Male Count (%) | Female Count (%) | Male Count (%) | Female Count (%) | Male Count (%) | Female Count (%) | Male Count (%) | Female Count (%) | Male Count (%) | Female Count (%) | Male Count (%) | Female Count (%) |
| *M.natalensis* | 102 46.58 | 34 49.28 | 48 78.69 | 23 60.53 | 48 53.93 | 39 68.42 | 49 62.39 | 73 74.24 | 30 76.92 | 27 64.29 | 44 66.67 | 43 70.49 |
| *niloticus* | 114 52.05 | 35 50.72 | 13 21.31 | 15 39.47 | 41 46.07 | 18 31.58 | 17 25.76 | 41 35.04 | 9 23.08 | 12 28.57 | 22 33.33 | 18 29.51 |
| *L. striatus* | 3 1.37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3 2.56 | 0.00 | 3 7.14 | 0.00 | 0.00 |
| Total | 219 100 | 69 100 | 61 100 | 38 100 | 89 100 | 57 100 | 66 100 | 117 100 | 39 100 | 42 100 | 66 100 | 61 100 |

**Table 3b: Myomorph rodent gender in maize and wheat habitats**

| Species | Habitat | | | | | |
|---|---|---|---|---|---|---|
| | Maize | | Wheat | | Total | |
| | Count/males | Row N % | Count/female | Row N % | Count | Row N % |
| *M. natalensis* | 321 | 59.44 | 239 | 62.24 | 560 | 60.61 |
| *niloticus* | 216 | 40.00 | 139 | 36.20 | 355 | 38.42 |
| *L. striatus* | 3 | 0.56 | 6 | 1.56 | 9 | 0.97 |
| Total | 540 | 100 | 384 | 100 | 924 | 100 |

A t-test showed that there was no statistically significant difference in distribution of gender in year one and year three (t (469) = 0.806; P = .421) and t (271) =1.729; P =.085), t < 2.0 with P >.05 respectively. There was a statistically significant difference (t (178) = -2.625, P = .009) in distribution of gender of either species in maize and wheat field in year two leading to rejecting the null hypothesis based on degree of freedom t >2.0 and p < .05 values. The larger the t value the more likely that the two samples are statistically different from each other in maize and wheat fields at University of Eldoret farms as shown in Table 3c. Generally, on the overall, the findings t (922) = 0.525, P = .600) indicated that there was no statistically significant difference in distribution of gender of either species in maize and wheat fields in University of Eldoret farms as shown in Table 3c.

**Table 3c: Independent t-test between gender and species**

| Cropping Years | t-value | DF | p-value | Mean Difference | S.E Difference |
|---|---|---|---|---|---|
| Year one | 0.806 | 469 | .421 | 0.040 | 0.049 |
| Year two | -2.625 | 178 | .009 | -0.193 | 0.073 |
| Year three | 1.729 | 271 | .085 | 0.101 | 0.059 |
| Overall | 0.525 | 922 | .600 | 0.018 | 0.034 |

## DISCUSSION

This study presents the findings of investigations on rodent pest species that infested agricultural commercial farms in University of Eldoret. Three species were recorded in both maize and wheat farms and they included *Mastomys natalensis*, *Arvicanthis niloticus* and *Lemniscomys striatus*. Capturing low number of species is not isolated to present study. Similarly, low numbers of species were captured and identified in cultivated farmland in Ethiopia by Shenkut and Balakrishnan, (2006) where *Mus* species, *Mastomys natalensis* and *Arvicanthis niloticus* were encountered. *Mastomys natalensis* was the most dominant species of the rodents captured in both maize and wheat. Although only these three species were identified in University of Eldoret farms, other researchers reported presence of more species in Kenya, other regions of E. Africa, Africa and other regions of the world (Taylor, 1968; Oguge *et al*., 1983; Singleton, 2003). Same species were reported among others in earlier studies in Kenya where they cause damage to cereals as reported by Odhiambo and Oguge, (2003) in Nakuru area, rift valley Kenya and Ognakossan *et al*. (2018) in Kwale coastal region. The possible low numbers in the study area include reduced number of nesting sites and bushes, reduced agricultural land to residential and intense surveillance in study area with a possibility of elimination of myomorph near settled areas. Human activities especially habitat disturbance for example the use of rodenticides, snap trapping to reduce and eradicate rodents, could be some of the activities deliberately applied to eradicate rodent pest. Similar studies have been carried out in agricultural land where the presence of diverse crops would favor rodents Mayamba, (2020). Each species is usually found where it can derive its basic requirements for food, shelter and mate for reproduction and where a species can be as adaptive as possible to escape predators. Maize and wheat farms provided a habitat or site where the three myomorph rodent pests could reside. These results are in line with other studies done in most parts of sub-Saharan Africa where they have been captured and identified as among important agricultural rodent pest species (Makundi *et al*., 2007; Mulungu, 2017; Swanepoel *et al*., 2017; Mayamba, 2020). In the present study, *A. niloticus* which is a grass rat and *L. striatus* a striped grass mouse was least captured. Rodent pest population infestation and distribution varied in maize and wheat fields from year to year during this study with significant difference in distribution between year one ($\chi^2$ =18.265, P = .001) but no difference in subsequent years ($\chi^2 = 3.769$ $P = .152$, $\chi^2$ =2.335 P=.126) for year two and three, respectively.

Rodents being highly mobile animals move from place to place in search of food, shelter herbage and nesting sites. Lack of sustainable ecological niche could encourage movement of rodents from a given habitat. There being no identifiable barrier to movement there would have been a difference in pattern of distribution in maize and wheat fields because each field provided a unique local ecological environment. This was not observed in this study possibly because of a common trend in surveillance in both maize and wheat fields that could lead to toxic environment for rodent pests since some of the chemicals used as biocides for example herbicides could not only eradicate weeds but are toxic to rodents. Some of the biocides could also be allergens to rodents causing negative impact on rodent species survival. Although the climatic conditions remained almost similar where population was expected to be high due to available resources like food and mate which would have resulted in high fecundity the population remained low. Some of the activities that could have contributed to low populations may be fields, were kept clear of weeds which constituted parts of the components of the habitat used as hiding place and because of frequent weeding, tunnels and burrows which acts as nesting sites were interfered with. This could also be attributed higher surveillance and use of herbicide to clean the fields making environment toxic for rodent survival. Frequent use of biocides used to control weeds and other pests may lead to high toxic levels in maize and wheat grains fed on by myomorphs leading to their mortality thus reducing their populations. Rodent species, according to Jurisic *et al*. (2022), cause a wide range of material losses in agriculture, forestry, storage facilities, and households through their natural feeding activities and behavior that result in damage and a decrease in crop yields. Damage to seeds, seedlings, and grains prompts intensive surveillance and action to reduce rodent population.

These species are not peculiar to the findings of this study because some have been identified as pests of crops (Makundi *et al.*, 1999 and Ochilo *et al.*, 2018) whereby these species caused damage to cereals. Identification of these species in maize and wheat farms during this study agrees with the findings by Ognakossan, (2017) that rats and mice are pests that affect cereals. They have also been cited as most common species responsible for post-harvest crop damage by Fall, (2011). The *M. natalensis* has also been reported as most important agricultural pest in Sub Saharan Africa, by Solveig Vibe-Paterson *et al*. (1999) and in Uganda by Mayamba *et al.* (2019). Rodents are major pests of agricultural crops and *Mastomys* species and *Arvicanthis* species are very common in Africa. The genera *Mastomys* and *Arvicanthis* have been identified by Wondifraw *et al*. (2021) as pests in maize fields of Central and Northern Ethiopia. Also, Wondifraw *et al.* (2021) reported rodent pests in four African countries being Tanzania accounting for 24.69%, Nigeria 8.64%, Ethiopia 8.64%, and Kenya 8.02%. The rodent pest's species captured in this study are not unique as same species have been identified and even classified as evasive species on some Islands (Harper and Bunbury 2015). Likewise, *Arvicanthis* and *Mastomys* genera have been reported as most abundant rodent pests that cause heavy damage on wheat and barley when the crop was at milky and fruiting stage and just before harvest (Meheretu *et al*., 2013).

ARIMA regression model for forecasting rodent population predicted more rodent pests in months of March and July and decline in November to January each year. Higher populations observed in March coincided with planting seasons when maize seeds are in the fields and July when peaks of rainfall that contributes to increased weedy vegetation in fields provided food for rodents. In November, all maize and wheat fields had been harvested and therefore the decline could be attributed to clearance of the fields and absence of grains. Therefore, with predictions and trends of rodent population increase and decrease it can prepare the farmers and scientists to put strategies in place for myomorph rodent species population management especially in anticipation in case of rodent population explosion. These species can be widespread in the surrounding fields and their number could increase and contribute to damage and loss of crop if environmental conditions in university of Eldoret maize and wheat farms could favor their high rate of reproduction and survival.

A total of 924 myomorph rodents were captured during the study period with 50.97%, 19.48% and 29.54% captures in year one, two and three respectively. *Mastomys natalensis* was most abundant in maize than wheat followed by *A. niloticus* and then L. *striatus* being more in wheat than maize this probably could be because *Lemniscomys striatus* is typically a grass mouse would prefer short wheat grass habitat than maize. There was variation in species distribution during the period of study with rodent species showing negative correlations in terms of species and habitat with no statistically significant difference in year two ($t= -.677$, $P > .05$) and positive correlation in year one ($t=3.859$, $P < .05$) and year three ($t=1.529$, $P > .05$) of study. The pooled three-year observation of the difference in distribution between maize and wheat for the three species overall findings showed that there was a significant difference ($t= 3.523$, $P= .001$) in distribution of myomorph rodents pest species in the two crops. The rodent species populations differed significantly between year one, year two and year three with *M. natalensis* and *A. niloticus* showing preference for maize field than wheat and *L. striatus* being least captured. In their studies Barnnet *et al.* (2000) reported single specimen of *L. striatus* that preferred grassland with dense undergrowth in a fallow rice field. Abundance and distribution of small mammals depends on nature and density of vegetation which in turn influences food and shelter. Low captures and species diversity could be attributed to low density of vegetation cover (weeds) therefore limited shelter cover and rodents could have become exposed to natural enemies. This implied that rodent pests were not only limited in distribution but the density of the identified species were limited, indicating that interpretation of observations should be based on longer duration of research and not only on one year cropping season. The variation in rodent population observed in the three years could be attributed to annual variation in available resources like food, shelter for nesting ground, mate, and environmental changes due to regular ploughing and probably rodent poor adaptability to changes in the environment. According to Leirs (1992), who reported that rodent populations are highly dynamic and are influenced by a number of environmental factors, particularly rainfall, which has an impact on vegetation and human activities, the observed year-to-year variations in small rodent abundance reported here are consistent with his findings. Although Tripathi and Choudhary, (2017) reported population increase occurs when adequate rainfall is experienced, human activities on the maize and wheat farm could have interfered with rodent reproductive behavior that could have contributed to low populations observed in this study. Low incidences of these species in farms may reflect a frequent clearance of weeds and general vegetation ground cover through weeding and regular use of herbicides that lead to lack of weeds and reduced shelter and could increase competition due to reduced breeding sites and nesting sites, discourage entry of rodents through immigration into farms, exposure of residents to predation due to lack of hiding places and encourage emigrations to other areas leading to lowered populations and distributions of myomorph rodents in maize and wheat farms. This agrees with Tripathi and Choudhary, (2017) who reported that regular weed control in and around the crops can reduce the entry of rodents into an area and cause stress to regular inhabitant rodents resulting in the rodent migration to other weedy and bushy areas maintaining low populations. The three rodent species *M. natalensis, A. niloticus* and *L. striatus* captured are also known to be responsible for most post-harvest crop damage in East Africa (Makundi *et al.,* 1999). Although not investigated in this study it could also be due to habitat destruction through harvesting such that even rodents that got into these fields could not stay long enough to establish themselves as resident populations since tunnels and burrows that act as nesting sites had been interfered with.

It was observed from the results from this study that *M. natalensis* was the most dominant species followed by *A. niloticus* and *L. striatus* throughout the study period. These findings agree with studies by Meheretu *et al*., (2013) where *Arvicanthis* and *Mastomys* genera were most abundant and caused heavy damage on wheat and barley when the crop was at milky and fruiting stage and just before harvest. This is in agreement with Makundi *et al*. (2005) observations despite the fluctuation in *M. natalensis* abundance seen in the current investigation of maize and wheat fields. *Arvicanthis niloticus* and *M. natalensis* have been reported as being common rodent species in farmlands of wheat, lentils, and beans by Shenkut and Balakrishnan (2006), where the population distribution and abundance showed significant temporal variation with *M. natalensis* dominating cultivated fields while *A. niloticus* dominated outside the cultivated fields. All the three species of rodents captured during this study have a wide distribution and are not unique to this study area. It has been reported that they are major agricultural rodent pests in maize fields by Bekele and Leirs, (1997). The current study also established that *M. natalensis* and *A. niloticus* exhibited inter annual differences in distribution in maize and wheat farms. Comparing *Mastomys* (*60.61%)* and *Arvicanthis* species (38.42%) distribution during the study period, *M. natalensis* was the most common rodent pest during the study period. In this study *Arvicanthis* was captured in both maize and wheat farms throughout the three-year study period but in low numbers this could probably be as reported by Bekele *et al*. (2003) that it prefers natural habitat for shelter but only visits farmland for food.

According to Krebs (1999), food is unquestionably one of the key ecological elements that control and restrict population size; therefore, rodent density would typically rely on the amount of food that is present in the fields. Maize habitat recorded higher population than wheat habitat throughout the study period. This is consistent with research by Leirs (1995), who estimated the population sizes of several rodents in Africa and discovered that there were often substantially bigger variations during epidemic years and several hundred during typical seasonal peaks. Further, Singla and Babbar (2010) demonstrated that study locations depending on food abundance may be responsible for population shifts and the discontinuity between various habitats.

According to Taylor and Green (1976), removing vegetation from a habitat decreased rodent species populations, and the locations where the species were most common also provided enough cover for hiding and a sufficient supply of food. This implies that organisms can be plentiful if their chosen resources are abundant but uncommon if their preferred microhabitat is constrained. In the present study, maize was a more open habitat compared to wheat but had huge bushy fences that could act as hiding places for rodents. Rodent communities and densities are influenced by habitat uniformity in composition, whereas the population of small mammals is impacted by habitat heterogeneity, according to Bekele and Leirs' (1997) observations of rodents in natural habitats but in large numbers in maize fields during the dry season in central Ethiopia. As Massawe *et al*. (2007) reports, *Arvicanthis* species to be herbivorous grass loving species and they have opportunistic and generalized diets that make them common in agricultural fields and staple crop pests where they cause pre-harvest damage.

These studies showed significant ($t\ (469) = 3.523$, $P = .001$) relationship between habitat and abundance of each species captured with *M. natalensis* and *A. niloticus* showing year after year changes during the three years of study and annual variations in distribution in maize and wheat fields. This indicates that species abundance varies with different types of environments. The findings in this study are consistent with the findings in a study by Odhiambo *et al*. (2008). According to Odhiambo *et al*. (2008), *M. natalensis* and *A. niloticus* are opportunistic feeders who consume diverse forms of food at various frequencies depending on the availability of those foods in their environment. *Mastomys natalensis* consumes a variety of foods, including seeds, insects, and grasses during the rainy season and various plant materials during the dry season. Although feeding habits was not tested in this study, growth of seasonal weeds could have affected them due to cleaning of fields which could have led to low captures during this study. Rodents are also known to vary in distribution in various habitats due to ground cover and food quality as reported by (Jędrzejewski and Jędrzejewska 1996). However, *M. natalensis* has a widespread range and may be found in varying amounts in many types of settings. According to prior research (Taylor & Green, 1976), M. *natalensis* was less sensitive to the loss of vegetation than other mouse species. This may be a result of its inherent flexibility. This probably could have been the reason it was most abundant in the present study. This *M. natalensis* is also known to vary with habitat and season (Mulungu *et al*., 2015). The findings in this study in this showed variation in numbers of each of the species from year to year throughout the study period. This is in agreement with Monadjem and Perrin, (2003), findings where M. natalensis remained the dominant species but numbers fluctuated without seasonal basis. In this study the fluctuation did not follow any particular pattern on annual basis. The findings of Monadjem and Perrin, (2003) on *Lemniscomys* species could not be effectively compared for their indication was that there was fluctuation but numbers were highest during dry winter months. In this study though the fluctuation was clearly noted, the observations was based on year to year observation. The *Arvicanthis niloticus* species could not be compared with species reported by because they were identified in this study but was not one of the seven species identified in their study.

These studies found out that the distribution of gender (male and female) myomorph rodents during the study period showed variations in year one, year two and year three of study. There were more males of *M. natalensis* (58.44%) followed by *A. niloticus* (40%) and then *L. striatus* (0.56%) than females *M. natalensis* (62.24%), *A. niloticus* (36.20%) and *L. striatus* (1.56%). The distribution of rodent's gender was statistically significantly different in habitats of maize and wheat in the second year of study (P = .009) showing variation in distribution in maize and wheat fields. Generally, no significant difference in gender distribution during study period (P = .600). Reports on rodent gender distribution have not been comprehensively documented and where they have been reported there is no particular pattern in the distribution hence no reliable prediction on how gender distribution can affect population for example studies by Delany and Monro, (2009) showed variation in distribution of male and females of *A. niloticus*. As Delany and Monro, (2009) observed in their studies, males generally traversed a wider range than females. Their findings do not however explain how this influenced gender distribution and therefore may not be able to explain how it would affect rodent pest population in general.

In conclusion, there existed variation in infestation of rodent pest population in maize and wheat farms in different cropping years at university of Eldoret with higher incidences of pests in maize than wheat fields. Despite the varying numbers of either species in both maize and wheat, the types of species did not vary in both fields. There was no significant difference between gender (male and female) of rodent species in maize and wheat farms.

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