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Rodent Population Dynamics and Crop Loss Assessment due to Rodent Pests in Finger Millet [*Eleusine coracana* (L.) Gaertn]

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Abstract: Finger millet (*Eleusine coracana* (L.) Gaertn) commonly referred as ragi is an important millet widely grown in Asia and is the major staple food in southern Karnataka. Rodents are critical vertebrate pests and are regarded as a major constraint to agricultural production. In the present studies the rodent population and resulting crop losses in finger millet crop during the year 2022 were analyzed. The studies revealed that rodent activity (mean trap index of 10.51) in the finger millet crop was observed throughout the year with peak rodent activity recorded in *Kharif* and *Rabi* crop seasons and was least in the dry (summer) seasons. The population comprised a male female ratio of 1:0.92 and adult infant ratio of 1:0.56. The Shannon index (H^{l}) in finger millet crop found to be 1.08 and the peak index was recorded in the month of August with a highest relative rodent species abundance of *Bandicota bengalensis*, *Tatera indica and Mus platythrix*. The yield loss estimation studies indicated a grain loss of 298 kg ha^{-1} in finger millet crop with a monetary loss of Rs. 10,662 (US $129.48) ha^{-1}.

Key words: *Eleusine coracana*, rodents, Shanon index, species composition, crop loss

Rodents are known for their regular periodic fluctuations and sometimes extreme eruptive populations (Andreassen *et al.*, 2021). These tiny vertebrates are mostly fossorial, nocturnal, neophobic in nature and are omnivorous in their diet (Aulicky, 2022). Rodents are critical vertebrate pests and are regarded as major biotic problem to economy as they cause damage to food items in farm lands, orchards, range lands, godowns, store houses, poultry units, and urban dwellings (Sridhara 2006; Witmer and Singleton, 2010). Rodents infest almost every crop in the field and have affected food security on a global scale (Brown *et al.*, 2006). Crops like cereals, pulses, vegetables, oilseeds are damaged at crucial stages of the crop and are responsible for 5-10% losses annually during production, processing, storage and transport. It is estimated that the losses to food grains due to rodents' ranges to the tune of 10-17 metric tonnes annually (Hazra *et al.*, 2017). Due to such ahuge crop losses, rodents play a significant role in influencing food

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security and poverty alleviation programs for the rural Asia (Buckle and Smith, 2015).

Finger millet [*Eleusine coracana* (L.) Gaertn.] also known as ragi is an important millet widely grown in Asia and Africa. In India, Karnataka is the biggest producer of ragi and has the largest area under cultivation. Ragi is the major staple food in southern Karnataka (Suresh and Chandrakanth, 2015). It is cultivated both in rainfed as well as irrigated conditions as a pure crop and also as intercrop mostly by small and marginal farmers (Ravi *et al.,* 2015). In recent days the productivity of ragi is showing an increasing trend due to the use of high-yielding varieties and technological interventions (Bellundagi *et al.,* 2017). The ragi production is hampered by various diseases and pests. Among the vertebrate pests, rodents cause considerable losses by damaging the growing tillers and also by consuming and hoarding the ear heads (Naik *et al.,* 2015). For the effective management of rodents, detailed data on population dynamics is essential (Lawton *et al.,* 2022). Hence, in this study, the emphasis was given to study the population dynamics, diversity index, sex ratio, age structure and yield losses due to field rodents in finger millet based crop lands.

Material and Methods

The population dynamics of the field rodents inhabiting the ragi crop lands was studied at selected farmers' fields in village Thippagaondanahalli (Yellappanahalli) (12°56′54.0″N 77°20′10.2″E) of Tavrekerehobali, Bangalore south taluk, Bangalore district, and Marimakalahalli of (13°25′19.7″N 77°34′30.2″E), Doddaballapura taluk, Bangalore rural District, Karnataka, India.

Rodent trapping was undertaken at 15 days interval over a twelve-month period beginning of January to December of 2022 to assess the field rodent population. The traps were laid in two parallel lines at equal distances in an area of 5 ha comprising of six replicates measuring 2 acres. The live box traps (10 cm x 10 cm x 10 cm) @ 50 traps ha^{-1} were used to sample and estimate the live population. The fresh coconut bait was used as attractant. One-inch piece of these coconut preparations was attached to a metal pin provided inside the trap and the small pieces of the same (Coconut bait) were sprinkled around the entrance of each trap. The traps were placed with baits for two continuous days without setting for acclimatization and it was followed by baiting on the third day late in the evening and rodents were collected on the following morning at about sun rise and continued for three days. During monsoon the traps were placed in the bait stations.

The data on population dynamics were recorded at fortnightly interval. Each captured rat was identified up to the species level, relative abundance of the species and Shannon index were calculated. The data on sex and age structure were also computed. The trapped rats were classified based on their size and weight into adults and infants. The rodents trapped per day per trap were estimated by applying trap index method as suggested by Jain *et al.* (1993). Trap index (I) was calculated and expressed in percentage, using the formula:-

Trap index (I) = (M/Nt) X 100

where N=No. of traps used in trap line; t=No. of nights' traps were set; M=Total number of rodents trapped.

Relative abundance = (Total number of individual species/Total number of species population) X 100.

Shannon index (H^{l}) = $-\sum[(pi)*\log(pi)]$, (pi=n/N); n = individuals of a given type/ species; and N=total number of individuals in a community.

Yield loss assessment

The trials for loss assessment due to rodents in finger millet was carried out at Marimakalahalli of (13°25′19.7″N 77°34′30.2″E), Doddaballapura taluk, Bangalore rural district during 2022. Recommended management measures were taken in fields which was treated as protected plot while the plot in which no any control measure was applied was treated as unprotected plot (Prajapati *et al.,* 2013). In the present study: (i) Treatment 1: 2% zinc phosphide baiting at ear head formation stage with pre baiting was considered as protected area and (ii) Treatment 2: no control measures were taken up, as unprotected area. The, trap index and yield data was recorded to calculate the yield loss.

Statistical analysis: One-way Analysis of Variance (ANOVA) followed by multiple comparison tests were conducted to find out

Table 1. Population dynamics of rodent pests in finger millet crop lands during 2022

Month	Trap index	M:F ratio	A:I ratio	Species composition [Relative abundance (%)]						H^{l} index
				B.b	M.me	T.i	M.b	M.p	R.r	
January	13.97 (21.86)^{b}	1:0.76	1:0.28	52.38	-	28.57	19.05	-	-	1.01
February	11.97 (20.12)^{bc}	1:0.69	1:0.27	22.22	33.33	-	-	44.44	-	1.06
March	5.25 (12.71)^{f}	1:0.76	1:0.31	-	-	16.67	25.00	58.33	-	0.96
April	3.43 (9.95)^{g}	1:0.82	1:0.26	-	-	50.00	30.00	10.00	10.00	0.95
May	4.75 (11.92)^{g}	1:0.65	1:0.38	28.57	-	42.86	-	14.29	14.29	1.28
June	7.60 (15.79)^{e}	1:0.83	1:0.54	26.92	23.08	34.62	-	15.38	-	1.35
July	9.42 (17.69)^{de}	1:1.21	1:0.47	51.52	21.21	-	-	24.24	3.03	1.12
August	13.05 (21.07)^{bc}	1:1.32	1:1.06	28.95	-	34.21	18.42	13.16	5.26	1.46
September	17.45 (24.63)^{a}	1:1.16	1:1.02	27.03	40.54	21.62	2.70	2.70	5.41	1.40
October	19.05 (25.87)^{a}	1:0.96	1:1.12	40.63	18.75	34.38	6.25	-	-	1.22
November	10.75 (19.00)^{cd}	1:0.82	1:0.51	41.67	-	25.00	33.33	-	-	1.08
December	9.45 (17.72)^{de}	1:1.01	1:0.53	18.08	-	50.10	-	27.27	4.55	1.15
Mean	10.51	1:0.92	1:0.56	28.17	11.41	28.16	11.23	17.49	3.54	1.08
F test	**	B.b>Ti>M.p>M.me>M.b>R.r								
CD (0.05)	1.93									
SEm±	0.66									
CV%	6.29									

** Significant at P<0.01 and 0.05; the same alphabets in superscript did not differ significantly, but alphabets with different superscripts differed significantly. Figure in parenthesis are Arcsin^{0} transferred * M= Male; F= Female; A= Adult; I=Infant; B.b=Bandicota bengalensis; Ti= Tatera indica; M.p=Mus platythrix; M.me=Millardia meltada; M.b=Mus booduga; R.r=Rattus rattus

the difference in the population of rodent pests at the monthly interval at *P*<0.05. The trap index was ArcSin^{o} transformed.

Results and Discussion

Rodent population

Regular trapping of rodents in finger millet crop revealed round the year activity of rodent pests, however, there were statistically significant (p<0.05) difference in rodent population in the different months of trapping. The trap index ranged from 3.43 to 19.05 with a mean trap index of 10.51 was recorded in finger millet crop lands. The highest number of rodents were trapped in October with a peak trap index of 19.05; it was followed by September (17.45), January (13.97), August (13.05), February (11.97), November (10.75), December (9.45), July (9.42), June (7.60), March (5.25), May (4.75) and April (3.43) (Table 1). Understanding the pest population dynamics plays a major role in planning and implementation of effective integrated rodent pest management strategies (Lawton *et al.,* 2022). The higher rodent activity (trap index) was recorded in the months of October, November, September, August, July, June, January and December which coincides with the *Kharif* and *Rabi* crop seasons and from tillering to harvesting stages of the crop. The rodent activity recorded in the dry (summer) seasons was, however on lower side. The present studies were in accordance with the studies conducted by Nayak (2012), Naik *et al.* (2015)

and Anonymous (2016) who reported that in ragi-soybean cropping system and ragi-pulses cropping system *Bandicota bengalensis*, *Mus booduga*, and *Tetra indica* were the predominant rodent pests and the peak rodent activities were recorded in wet seasons and lower activities in the summer seasons.

Sex ratio

The population was in general, male biased in finger millet crop with a male female ratio of 1:0.92. During August, July and September the population was female biased with a male female ratio of 1:1.32, 1:1.21 and 1:1.16, respectively, whereas, during October (1:0.96), June (1:0.83), March (1:0.76), November (1:0.82), January (1:0.76), February (1:0.69), May (1:0.65), April (1:0.82) the population was male dominant (Table 1). The present studies were in accordance with the findings of Naik *et al.* (2015) who reported the male dominance in the rodent population of the ragi-soybean cropping system. Betancourt *et al.* (2003) reported that the female dominance in rodent population is due to the high foraging behavior of the female rats during the period of pregnancy and lactation to meet the nutritional needs.

Age structure

The rodent population in finger millet crop was mainly adult dominant, with an adult infant ratio of 1:0.56. The trapping data revealed that in October, August and September with an adult and infant ratio of 1:1.12, 1:1.06, 1:1.02, the population was infant dominant, respectively. However, the ratios in November (1:0.82), June (1:0.54), December (1:0.53), July (1:0.47), May (1:0.38), March (1:0.31), January (1:0.28), February (1:0.27) and April (1:0.26) revealed that the rodent population was adult dominant (Table 1). The present findings are in accordance with the studies conducted by Naik *et al.* (2015) who reported the adult dominance in the rodent population of the ragi-soybean eco system. Panti-May *et al.* (2012) reported that differences in capture rates among age groups could be due to heterogeneous response to trapping because of their aggressive behavior and active search for resources and mates. In the present studies the population was adult dominant except during the months of August, September and October may be due to the high trapping rates of the adults during the period of active foraging in search for food resources.

Species composition and dominance

In the finger millet crop, the rodent species composition comprised of *Bandicota bengalensis* and *Tatera indica* as the dominant species with a relative abundance of 28.17 and 28.16%, respectively. It was followed by *Mus platythrix* (17.49), *Millardia meltada* (11.41), *Mus booduga* (11.23) and *Rattus rattus* (3.54). The population of *B. bengalensis* (40%) peaked in January, July, October and November with a relative abundance of 52.38, 51.52, 41.67 and 41.67%, respectively. *M. meltada,* recorded highest relative abundance of 40.54 and 33.33% in September and February, respectively. The population of *T. indica* peaked in December and April with a relative abundance of 50.10 and 50.00%. *M. booduga* population was dominant in November and April with a relative abundance of 33.33 and 30.33%, respectively. *M. platythrix* population was found to be dominant in the month of March and February with a peak relative abundance of 58.33 and 44.44%, respectively. However, occurrence of *R. rattus* was very low (3.54%). The mean Shannon index (H^{l}) was found to be 1.08, however, the peak Shannon index was recorded during August (1.46), and it was followed by September (1.40), June (1.35), May (1.28), October (1.22), December (1.15), July (1.12), November (1.08), February (1.06), January (1.01), March (0.96) and April (0.95) (Table 1). Srihari *et al.* (1984) reported that the *B. bengalensis* showed the peak rodent activity during September to November. Govindaraj and Srihari (1989) reported the peak breeding of *M. meltada* in the months of September to November. Govindaraj and Srihari (1992) and Neetu *et al.* (2020) reported the peak reproductive activity of *T. indica* during the months of October to November. Govindaraj (1994) reported that the peak breeding period in *M. platythrix* lasted from the month of September to November. The present studies were in accordance with the above studies.

Yield loss assessment

The loss in finger millet yield due to rodents was assessed during the year 2022 at Marimakalahalli of Doddaballapura taluk, Bangalore rural District. The results revealed that mean grain yield of finger millet in protected plot was 2221 kg ha^{-1} whereas, in unprotected plot, the yield was 1923 kg ha^{-1} thus, the loss of grain yield occurred due to

Table 2. Yield losses and economic loss due to rodent pests in finger millet

S. No.	Treatment	Trap index	Reduction in population (%)	Yield (kg ha^{-1})	Yield loss over control (%)	Loss per hectare
1	2% zinc phosphide baiting at ear head formation stage with pre baiting. (Protected)	4.59	75.42	2221	13.41	-
2	Un protected plot (Control)	18.68	-	1923	-	Rs. 10,662 /- US $ 129.48 /- (MSP. Rs. 3,578 per 100 kg)

the rodent infestation was 13.41% (298 kg ha^{-1}). In protected fields the trap index was found to be 4.59 whereas, in unprotected fields the trap index was very high (18.68) which indicated that the rodent infestation was significantly controlled by 78.23% in protected plots. The economic loss with a grain loss of 298 kg ha^{-1} was found to be Rs. 10,662 (US $129.48) ha^{-1} (Table 2). The present results were on par with the studies conducted by Wondifraw *et al*. (2021) and Munawar *et al.* (2022). Wondifraw *et al.,* (2021) reported that the barley yield loss due to rodent pests was 21.7 kg ha^{-1} with monetary value of 121.9 US$ ha^{-1}.

Conclusion

In the present study the rodent activity in the finger millet crop was observed throughout the year recorded apeak activity in *Kharif* and *Rabi* crop seasons and was less in the dry (summer) seasons. The population was male and adult dominant however in the wet seasons the population was female and infant dominant. Mean Shannon index (H^{l}) in finger millet crop was 1.08, however the peak Shannon index was recorded in the month of August with a highest relative abundance of species like, *B. bengalensis*, *T. indica* and *M. platythrix*. The yield loss estimation revealed a grain loss of 298 kg ha^{-1} in finger millet with a monetary value of Rs. 10,662 (US $129.48) ha^{-1}.

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