Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2020; 8(1): 303-310

Received: 04-11-2019
Accepted: 08-12-2019

Dr. Mousumi Phukon
Assistant Professor, Department of Entomology, Assam Agricultural University, Jorhat, Assam, India

Dr. Ratul Kr Borah
Principal Scientist, Department of Entomology, Assam Agricultural University, Jorhat, Assam, India

Corresponding Author:
Dr. Mousumi Phukon
Assistant Professor, Department of Entomology, Assam Agricultural University, Jorhat, Assam, India

Population dynamics of field rodents in rice-vegetable cropping system at upper Brahmaputra valley zone of Assam

Dr. Mousumi Phukon and Dr. Ratul Kr Borah

Abstract
A study on population density of field rodents in rice-vegetable cropping system at Upper Brahmaputra Valley Zone, Assam during 2015-16 and 2016-17 revealed that population density of field rodents was recorded the highest (64.0 ± 3.0 and 36.0 ± 22.0) in the month of September when the rice crop was at milky stage and lowest (9 ± 2.0 and 4.33 ± 3.05) at an early tillering stage in both the years. The rodent infestation in vegetable crops was initiated at seedling stage and increased gradually with maximum infestation at harvesting stage of the crops. The mean LBC per ha in *rabi* vegetables was recorded the highest (57.67 ± 6.11 and 21.33 ± 9.50) at harvesting stage and the lowest (9.0 ± 2.64 and 2.67 ± 2.51) at seedling stage of vegetable crops during 2015-16 and 2016-17, respectively. The distribution pattern of rodent burrows in the field revealed that the burrow position differs with the crop stage. The burrowing activity in terms of mean LBC/ha was found higher in *kharif* rice than that observed in *rabi* vegetables (harvesting stage) during both the years, 2015-16 and 2016-17, respectively.

Keywords: Population density, live burrow count, damage incidence, trap index

Introduction

Rice is the most important food crop in Southeast Asia where self-sufficiency in rice production is an important influence on social stability. More than 90% of the world's rice is produced and eaten in Asia, with rice producing 35–60% of the total food energy for the three billion people living in the region [9]. Rodents are considered as one of the major limiting factor in rice production. Rodents have long been reported as having a substantial impact on rice crops [17] throughout India. In Asia, annual pre harvest losses in rice production by rodents ranges from 5% in Malaysia to 15% in India [21] and are now considered as the main constraint to rice production, irrespective of production system [14, 18]. It was reported that the overall losses of grain to rodents in India were approximately 25% in the field before harvest and 25-30% at postharvest [7]. It is well known that rice crops are a vital food for India and both chronic and catastrophic losses to rodents have been reported. The chronic losses are economically more important and often these losses go unrecognized [23]. Rodents were reported to consume between 10% and 15% of the national production of all grains in India [3]. Most rodents eat seeds or plants, though some have more varied diets. Some species have historically been pests, eating seeds stored by people and spreading disease. The severity of damage varies from year to year and between localities with estimates of 5-10% in non-outbreak years [10, 20, 22]. The irregular rodent outbreaks are sometimes responsible for extreme crop losses of 30-100%, occasionally leading to localised or widespread famine [6]. There are certain pockets at Jorhat district of Upper Brahmaputra Valley Zone, Assam following the practice of growing *kharif* rice followed by r*abi* vegetables. The present investigation was carried out with a view to understand better on the response of field rodents to food resources including the population density in rice-vegetable cropping system in Upper Brahmaputra Valley Zone, Assam throughout the year.

Materials and Methods

Study area

The experiment was carried out at farmer's field of three locations *viz*., Neul gaon near river bank of the Brahmaputra, Allengmora, a typical rice-vegetable growing area and Bekajan, near Nagaland foot hills of Jorhat district, Assam. The district is located at latitude 20.46^0 N′ and longitude 94.12^{0} E′, at an altitude of 86.5 meters above mean sea level. The experiment was designed and carried out in the rice-vegetable cropping system during 2015-16 and 2016-17.

Population density

The population density in terms of Live Burrow Count (LBC) per ha and damage incidence expressed as per cent (%) was estimated and data was recorded at monthly interval starting from one month after transplanting of rice till harvest of vegetables by following methods,

1. Live burrow count (LBC)
2. Trap Index (TI)

A. Live Burrow count (LBC)

Generally live burrow count gives an idea of living rodents in an area. Live burrow or active burrow generally look fresh, marks of rodents are there, fresh excavated soil and cut parts of various plants etc. may also be there. For the estimation of burrow density, "live burrow count (LBC) method" [11] was followed. In this method, first day all the burrows found in the crop area was counted, marked and closed with soil. On the next day, these burrows were examined and those open one was an indication of the presence of rodents in the burrows called as "alive or active burrows."

B. Trap Index (TI)

The traps were set in two trap lines each of ten traps. Trapping was continued for 72 hours and traps were checked every after 24 hours interval. Trapped rodents were removed and traps were reset by replenishing the bait. Trap index was calculated by using the following formula,

Trap Index = (Rodents trapped/traps set x trap night) x 100

Identification of burrows

The rodent burrows present in the field of rice-vegetable cropping sequence were identified based on certain characteristic features of different rodent species as mentioned below,

The lesser bandicoot (*Bandicota bengalensis*) rat burrows revealed the presence of heaps of soil covering the openings located at different points of burrow. Confirmation regarding the presence of rats inside the burrows was done by closing the burrow at one evening and taking observation in next morning. If the closed burrow is opened in next morning then it was considered as live burrow and if the closed burrows remain closed it was considered as dead burrow.

The burrows of the Indian field mouse (*Mus booduga*) could be distinguished from those of other rodent species by smaller openings of about one centimeter with scooped soil before the burrow opening.

The large bandicoot rat (*Bandicota indica*) burrows were recognized by the fresh, wet globules of soil and soft faecal matter at the burrow opening. Fresh foot prints and tail marks near burrow were also indicators of live burrows.

Results and Discussion

Population density of field rodents in *kharif* rice of rice-vegetable cropping system

Population density of field rodents in rice-vegetable cropping system in terms of live burrow count (LBC) per ha at different crop stages of *kharif* rice during the present investigation revealed that the mean LBC was recorded the highest (64.0 ± 3.0 and 36.0 ± 22.0) in the month of September when the crop was at milky stage followed by the flowering stage (60.33 ± 7.57 and 31.67 ± 20.03) during 2015-16 and 2016-17, respectively (Table 1 & 3). During the course of investigation, per ha LBC was increased programming with the crop growth up to the milky stage with peak and then reduced later. The mean LBC was recorded the lowest (9 ± 2.0 and 4.33 ± 3.05) at an early tillering stage in both the years. It was observed that rodent incidence was nil at the transplanting stage, but the incidence of rodent from the tillering stage onwards indicated the immigration of rodents from nearby non cropped area.

The distribution pattern of rodent burrows in the field revealed that the burrow position differs with the crop stage. The distribution of rodent burrows were concentrated to only bunds and big bunds up to the maximum tillering stage of rice, while the burrow activity within the field have been observed from the flowering stage onwards and continued till harvesting stage (Fig. 1 & 2). Rodents appeared to move between habitats in response to availability of food sources. The growing crop provides food resources for rodents and protects them from predators. No further burrowing activity was observed after harvesting of the crop.

Population density of field rodents in *rabi* vegetables of rice-vegetable cropping system

During the course of investigation, the population density of field rodents in terms of live burrow count per ha in *rabi* vegetables revealed that the association of rodent incidence was correlated with the growth stage of the crop. The rodent infestation in vegetable crops was initiated at seedling stage and increased gradually with maximum infestation at harvesting stage of the crops. The mean LBC per ha in *rabi* vegetables was recorded the highest (57.67 ± 6.11 and 21.33 ± 9.50) at harvesting stage and the lowest (9.0 ± 2.64 and 2.67 ± 2.51) at seedling stage of vegetable crops during 2015-16 and 2016-17, respectively (Table 2 & 4). LBC per ha was reduced just after harvesting of the crops. (Fig.3 & 4). At the initial stage of the crop due to the absence of the food materials at the stage ready to eat so, the incidence of rodents was minimum but with the availability of food materials in the field at harvesting stage increased their incidence. So, rodent's incidence was directly related to the availability of food sources.

When compared the burrowing activity of rodents between *kharif* rice and rabi vegetables, burrowing activity in terms of mean LBC/ha was found higher (64.0 ± 3.0 and 36.0 ± 22.0) in *kharif* rice (milky stage) than that of the highest mean LBC/ha (57.67 ± 6.11 and 21.33 ± 9.50) observed in *rabi* vegetables (harvesting stage) during both the years, 2015-16 and 2016-17, respectively.

Table 1: Population density of field rodents in *kharif* rice of rice-vegetable cropping system during 2015-16

Crop stage	Month	LBC/ ha												
Kharif Rice		Allengmora				Neulgaon				Bekajan				(Mean ± SD)
		field	Bunds	Big bunds	Total	Field	Bunds	Big bunds	Total	Field	Bunds	Big bunds	Total	
Transplanted	July	-	-	-	-	-	-	-	-	-	-	-	-	-
Early tillering	Jul	0 (0)	1 (14.28)	6 (85.71)	7	0 (0)	0 (0)	9 (100)	9	0 (0)	0 (0)	11 (100)	11	9 ± 2.0
Maximum tillering	Aug	0 (0)	3 (17.64)	14 (82.35)	17	0 (0)	4 (19.04)	17 (80.95)	21	0 (0)	9 (36)	16 (64)	25	21.0 ± 4.0
Flowering	Sep	2 (3.63)	31 (56.36)	22 (40.0)	55	0 (0)	27 (47.36)	30 (52.63)	57	0 (0)	31 (44.92)	38 (55.07)	69	60.33 ± 7.57
Milky	Sep	5 (8.19)	33 (54.09)	23 (37.70)	61	2 (2.98)	34 (50.74)	31 (46.26)	67	5 (7.24)	37 (53.62)	22 (31.88)	64	64.0 ± 3.0
Maturity	Oct	11 (26.82)	23 (56.09)	7 (17.07)	41	7 (14.58)	25 (52.08)	18 (33.33)	48	9 (17.64)	28 (54.90)	14 (27.45)	51	46.67 ± 5.13
Harvesting	Nov	13 (46.42)	9 (32.14)	6 (21.42)	28	9 (24.32)	17 (45.94)	11 (29.72)	37	11 (26.19)	18 (42.85)	13 (30.95)	42	35.67 ± 7.09
Post-harvest of rice	Dec	2 (18.18)	6 (54.54)	2 (18.18)	11	1 (7.69)	6 (46.15)	8 (61.53)	13	1 (5.26)	8 (42.1)	10 (52.63)	19	14.33 ± 4.16

Table 2: Population density of field rodents in *rabi* vegetables of rice-vegetable cropping system during 2015-16

Season Crop stage	Month	LBC/ ha												
***Rabi* Vegetables**		Allengmora				Neulgaon				Bekajan				(Mean ± SD)
		Field	Bunds	Big bunds	Total	Field	Bunds	Big bunds	Total	Field	Bunds	Big bunds	Total	
Seedling	Jan	0 (0)	3 (42.85)	4 (57.14)	7	0 (0)	3 (37.5)	5 (62.5)	8	0 (0)	3 (25.0)	9 (75.0)	12	9.0 ± 2.64
Vegetative	Feb	3 (20.0)	4 (26.66)	8 (53.33)	15	2 (11.76)	7 (41.17)	8 (47.05)	17	3 (14.28)	11 (52.38)	7 (33.33)	21	17.67 ± 3.05
Maturity	Mar	7 (16.27)	19 (44.18)	17 (39.53)	43	9 (15.78)	25 (43.85)	23 (40.35)	57	11 (18.64)	27 (45.76)	21 (35.59)	59	53.0 ± 8.71
Harvesting	April	13 (25.49)	21 (41.17)	17 (33.33)	51	17 (28.81)	28 (47.45)	14 (23.72)	59	18 (28.57)	29 (46.03)	16 (25.39)	63	57.67 ± 6.11
Post harvest	May	4 (13.79)	12 (23.52)	13 (44.82)	29	6 (18.75)	11 (34.37)	15 (46.87)	32	9 (23.07)	17 (43.58)	13 (33.33)	39	33.33 ± 5.13
Fallow	June	0 (0)	1 (7.69)	12 (92.30)	13	0 (0)	1 (5.55)	17 (94.44)	18	0 (0)	2 (8.6)	21 (91.3)	23	18.0 ± 5.0

Table 3: Population density of field rodents in *kharif* rice of rice-vegetable cropping system during 2016-17

Season and Crop	Month	LBC/ ha												
***Kharif* Rice**		Allengmora				Neulgaon				Bekajan				(Mean ± SD)
		Field	Bunds	Big bunds	Total	Field	Bunds	Big bunds	Total	Field	Bunds	Big bunds	Total	
Transplanted	Jul	-	-	-	-	-	-	-	-	-	-	-	-	-
Early tillering	Jul	0 (0)	0 (0)	1 (100.0)	1	0 (0)	0 (0)	5 (100.0)	5	0(0)	0(0)	7 (100.0)	7	4.33 ± 3.05
Maximum tillering	Aug	0 (0)	0 (0)	4 (100.0)	4	0 (0)	2 (15.38)	11 (84.61)	13	0(0)	3 (18.75)	13 (81.25)	16	11.0 ± 6.24
Flowering	Sept	0 (0)	2 (18.18)	9 (81.81)	11	1 (3.03)	7 (21.21)	25 (75.75)	33	0 (0)	12 (23.52)	39 (76.47)	51	31.67 ± 20.03
Milkiy	Sept	1 (7.69)	7 (53.84)	5 (38.46)	13	2 (5.26)	14 (36.84)	22 (57.89)	38	0 (0)	23 (40.35)	34 (59.64)	57	36.0 ± 22.0
Maturity	Oct	3 (33.33)	4 (44.44)	2 (22.22)	9	4 (14.81)	12 (44.44)	11 (40.74)	27	7 (18.91)	17 (45.94)	13 (35.13)	37	24.33 ± 14.18
Harvesting	Nov	4 (57.14)	2 (28.57)	1 (14.28)	7	5 (26.31)	8 (42.10)	6 (31.57)	19	9 (29.03)	12 (38.70)	10 (32.25)	31	19.0 ± 12.0
Post-harvest of rice	Dec	0 (0)	2 (100.0)	0 (0)	2	0 (0)	2 (28.57)	5 (71.42)	7	0 (0)	4 (33.33)	8 (66.66)	12	7.0 ± 5.0

Table 4: Population density of field rodents in *rabi* vegetables of rice-vegetable cropping system during 2016-17

Season Crop	Month	LBC/ ha												
Rabi Vegetables		Allengmora				Neulgaon				Bekajan				(Mean ± SD
		Field	Bunds	Big bunds	Total	Field	Bunds	Big bunds	Total	Field	Bunds	Big bunds	Total	
Seedling (vegetables)	Jan	0 (0)	0 (0)	0 (0)	0	0 (0)	1 (33.33)	2 (66.66)	3	0 (0)	1 (20.0)	4 (80.0)	5	2.67 ± 2.51
Vegetative	Feb	0 (0)	0 (0)	1 (100.0)	1	1 (25.0)	2 (50.0)	1 (25.0)	4	2 (8.69)	7 (30.43)	14 (60.86)	23	9.33 ± 11.93
Maturity	Mar	3 (33.33)	2 (22.22)	4 (44.44)	9	5 (26.31)	8 (42.10)	6 (66.66)	19	11 (37.93)	9 (31.03)	9 (31.03)	29	19.0 ± 10.0
Harvesting	April	7 (58.33)	3 (25.0)	2 (16.66)	12	11 (52.38)	9 (42.85)	1(4.76)	21	17 (54.83)	11 (35.48)	3 (9.67)	31	21.33 ± 9.50
Post-harvest	May	3 (50.0)	2 (33.33)	1 (16.66)	6	4 (30.76)	5 (38.46)	4 (30.76)	13	7 (36.84)	9 (47.36)	3 (15.78)	19	12.67 ± 6.50
Fallow	June	0 (0)	1 (33.33)	2 (66.66)	3	0 (0)	2 (22.22)	7 (77.77)	9	0 (0)	2 (18.18)	9(81.81)	11	7.67 ± 4.16

Distribution of burrow density in *kharif* rice during 2015-16 and 2016-17

The data on distribution of burrow density of field rodents in *kharif* rice at three villages during the present study revealed the presence of three types of burrows belonging to three species *viz*., *B. bengalensis*, *B. indica* and *M. booduga* at Bekajan near Nagaland foot hills, burrows of two species *viz*., *B. bengalensis* and *M. booduga* at Neulgaon near river bank and Allengmora, a typical rice-vegetable growing area of Jorhat. At Bekajan, out of 281 burrows recorded throughout the growth period at different stages of the rice crop including post-harvest stage, 81.85 per cent occupied by *B. bengalensis*, 13.16 per cent by *B. indica* and rest 4.27 per cent by *M. booduga* during 2015-16 (Table 5). Similarly, during 2016-17 the study revealed that 89.57 per cent burrows belonging to *B. bengalensis*, 6.16 per cent to *B. indica* and 4.26 per cent to *M. booduga*.

The study at Neulgaon, the river bank of Brahmaputra revealed 91.84 per cent and 90.84 per cent belonging to *B. bengalensis* and 1.98 per cent and 9.15 per cent belonged to *M. booduga* during 2015-16 and 2016-17, respectively (Table 7). Likewise, at Allengmora out of total rodent burrows recorded throughout the different growth stages of rice crop, 89.85-90.05 per cent burrows were of *B. bengalensis* and 9.94-10.14 per cent belonging to *M. booduga* during 2015-16 and 2016-17 (Table 9).

The present study throughout the different growth stages of *kharif* rice in rice-vegetable cropping system revealed that *B. bengalensis* was the predominant species followed by *M. booduga* and *B. indica.*

Table 5: Distribution of burrow density in *kharif* rice of rice-vegetable cropping system at Bekajan during 2015-16 and 2016-17

Month	Crop stage (*Kharif* rice)	LBC/ha							
		B. bengalensis		*M. booduga*		*B. indica*		Total	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
July	Transplanted	-	-	-	-	-	-	-	-
July	Early Tillering	9	6	1	0	1	1	11	7
August	Maximum Tillering	20	14	1	0	2	2	25	16
September	Flowering	62	48	2	1	5	2	69	51
September	Milking	56	50	2	3	6	4	64	57
October	Maturation	40	32	2	3	9	2	51	37
November	Harvesting	28	29	3	1	11	1	42	31
December	Post-harvest	15	10	1	1	3	1	19	12
Percent distribution		81.85	89.57	4.27	4.26	13.16	6.16	100.00	100.00

Table 7: Distribution of burrow density in *kharif* rice of rice-vegetable cropping system at Neulgaon during 2015-16 and 2016-17

Month	Crop stage (*Kharif* rice)	LBC/ha					
		B. bengalensis		*M. booduga*		Total	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
July	Transplanted	-	-	-	-	-	-
July	Early Tillering	9	4	0	1	9	5
August	Maximum Tillering	21	12	0	1	21	13
September	Flowering	57	30	0	3	57	33
September	Milking	67	35	0	3	67	38
October	Maturation	46	25	2	2	48	27
November	Harvesting	36	17	2	2	37	19
December	Post-harvest	12	6	1	1	13	7
Percent distribution		98.41	90.84	1.98	9.15	100.00	100.00

Table 9: Distribution of burrow density in *kharif* rice of rice-vegetable cropping system at Allengmora during 2015-16 and 2016-17

Month	Crop stage (*Kharif* rice)	LBC/ha					
		B. bengalensis		*M. booduga*		Total	
		2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
July	Transplanted	-	-	-	-	-	-
July	Early Tillering	5	1	2	0	7	1
August	Maximum Tillering	15	3	2	1	17	4
September	Flowering	52	9	3	2	55	11
September	Milking	54	11	7	2	61	13
October	Maturation	36	7	5	2	41	9
November	Harvesting	23	6	5	1	28	7
December	Post-harvest	7	2	4	0	11	2
Percent distribution		87.27	82.97	12.72	17.02	100.00	100.00

Distribution of burrow density in *rabi* vegetables during 2015-16 and 2016-17

The data on distribution of burrows throughout the different growth stage of vegetable crops in rice-vegetable cropping system during 2015-16 and 2016-17 revealed that at Bekajan, out of total burrows 90.32 to 94.91 per cent occupied by *B. bengalensis*, 4.60 to 5.08 per cent by *B. indica* and 0 to 5.06 per cent burrows due to *M. booduga* (Table 6).

Similarly, 89.85 to 90.05 per cent burrows of *B. bengalensis*, 9.94 to 10.14 per cent of *M. booduga* were recorded at Neulgaon during 2015-16 and 2016-17 (Table 8). On the other hand, at Allengmora, 80.64 to 84.81 per cent burrows of *B. bengalensis* and 15.18 to 19.35 per cent burrows of *M. booduga* was recorded throughout the different stages of crop growth of *rabi* vegetables in rice-vegetable cropping system during 2015-16 and 2016-17 (Table 10).

The association between rodent infestation in terms of LBC/ha in different stages of rice crop from tillering to harvesting stage with peak at flowering stage was also reported by earlier workers [12] which was similar to the present findings.

It was reported that rodents attack almost all vegetable crops mostly at seedling and maturity stages [14]. It was reported that vegetables were severely affected by rodents due to their high water content in the arid region of Rajasthan [1]. It also reported that *B. bengalensis* extended their burrows just beneath the watermelons and make holes in these to get their seeds and pulp [5]. Similar observations were recorded in the present investigation showing the highest burrowing activity within the field at maturity stage of vegetables infesting brinjal, pumpkin and potato. During peak season of food crops the burrowing activity also increased.

In the present investigation, the burrowing activity of rodents were in accordance with the findings of earlier workers [22, 24] who reported that *B. bengalensis* has shown peak activities in *winter* and low density in *summer* in West Bengal and Karnataka, respectively.

Table 6: Distribution of burrow density in *rabi* vegetables of rice-vegetable cropping system at Bekajan during 2015-16 and 2016-17

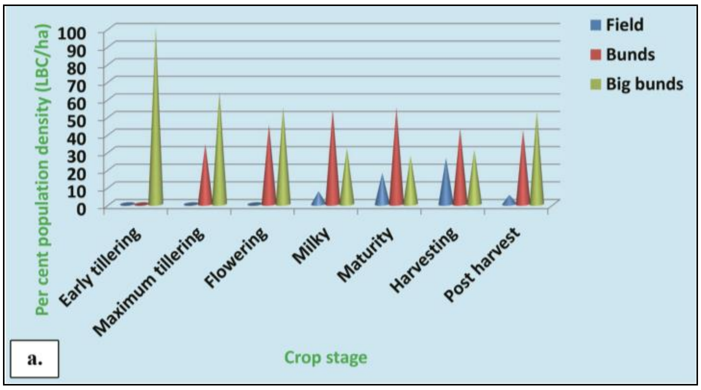
Month	Crop stage (Rabi vegetables)	LBC/ha							
		B. bengalensis		***M. booduga***		***B. indica***		**Total**	
		2015-16	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
January	Seedling	12	4	0	0	0	1	12	5
February	Vegetative	19	22	2	0	0	1	21	23
March	Maturity	52	27	4	0	3	2	59	29
April	Harvesting	55	29	3	0	5	2	63	31
May	Post-harvest	36	19	2	0	1	0	39	19
June	Fallow	22	11	0	0	1	0	23	11
Percent distribution		90.32	94.91	5.06	0	4.60	5.08	100.00	100.00

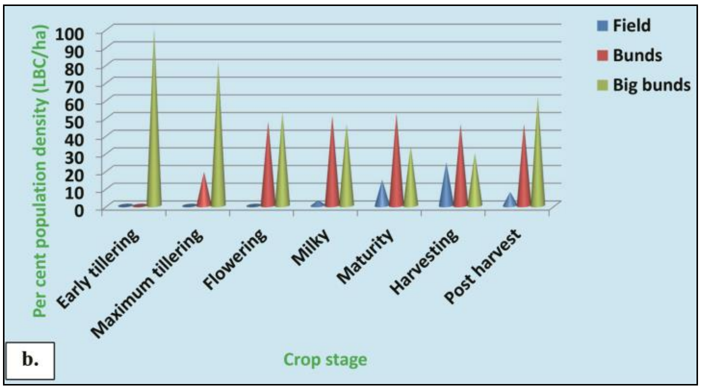
Table 8: Distribution of burrow density in *rabi* vegetables of rice-vegetable cropping system at Neulgaon during 2015-16 and 2016-17

Month	Crop stage (Rabi vegetables)	LBC/ha					
		B. bengalensis		***M. booduga***		**Total**	
		2015-16	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
January	Seedling	6	3	2	0	8	3
February	Vegetative	15	3	2	1	17	4
March	Maturity	54	17	3	2	57	19
April	Harvesting	54	18	5	3	59	21
May	Post-harvest	27	13	5	0	32	13
June	Fallow	16	8	2	1	18	9
Percent distribution		90.05	89.85	9.94	10.14	100.00	100.00

Table 10: Distribution of burrow density in *rabi* vegetables of rice-vegetable cropping system at Allengmora during 2015-16 and 2016-17

Month	Crop stage (Rabi vegetables)	LBC/ha					
		B. bengalensis		***M. booduga***		**Total**	
		2015-16	**2016-17**	**2015-16**	**2016-17**	**2015-16**	**2016-17**
January	Seedling	5	0	2	0	7	0
February	Vegetative	14	0	1	1	15	1
March	Maturity	36	7	7	2	43	9
April	Harvesting	42	10	9	2	51	12
May	Post-harvest	26	5	3	1	29	6
June	Fallow	11	3	2	0	13	3
Percent distribution		84.81	80.64	15.18	19.35	100.00	100.00
June	Fallow	18.0 ± 5.0				1.84	-





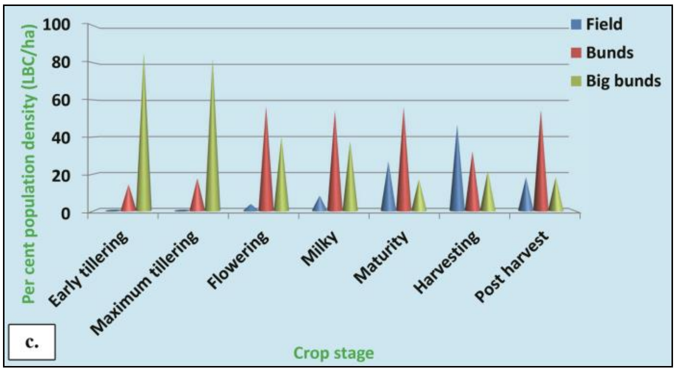


Fig 1: (a-c): Population density of field rodents in *kharif* rice of rice-vegetable cropping system during 2015-16. (a): Bekajan (b): Neulgaon (c): Allengmora

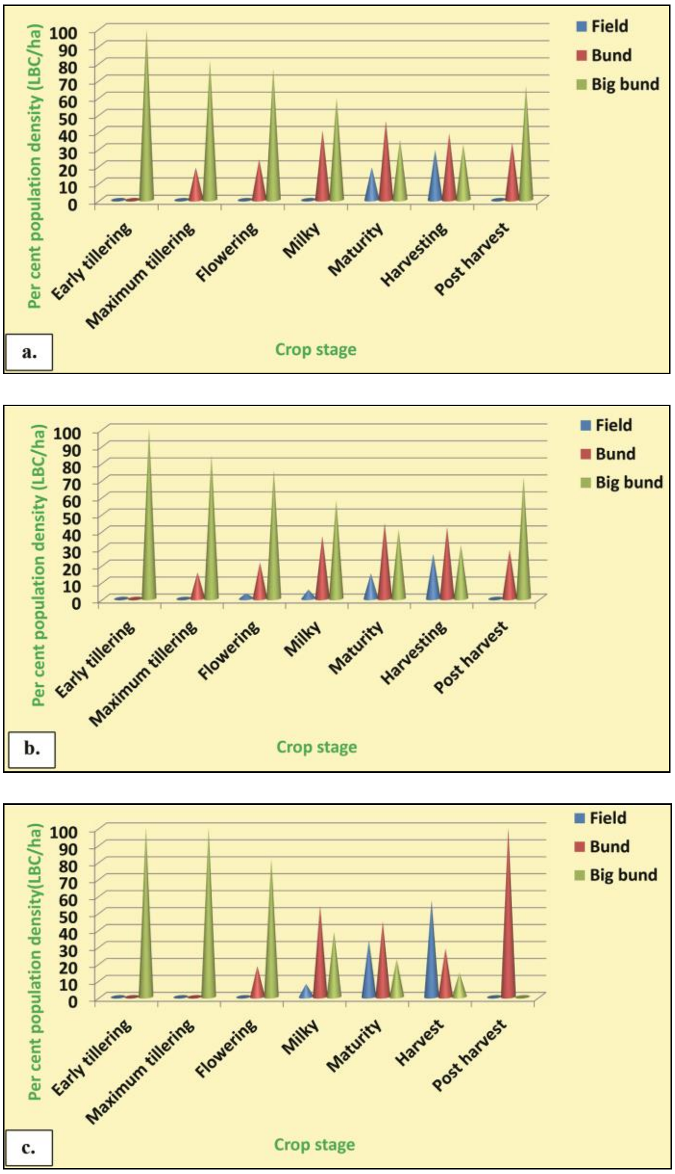


Fig 2: (a-c): Population density of field rodents in *kharif* rice of rice-vegetable cropping system during 2016-17 (a): Bekajan (b): Neulgaon (c): Allengmora

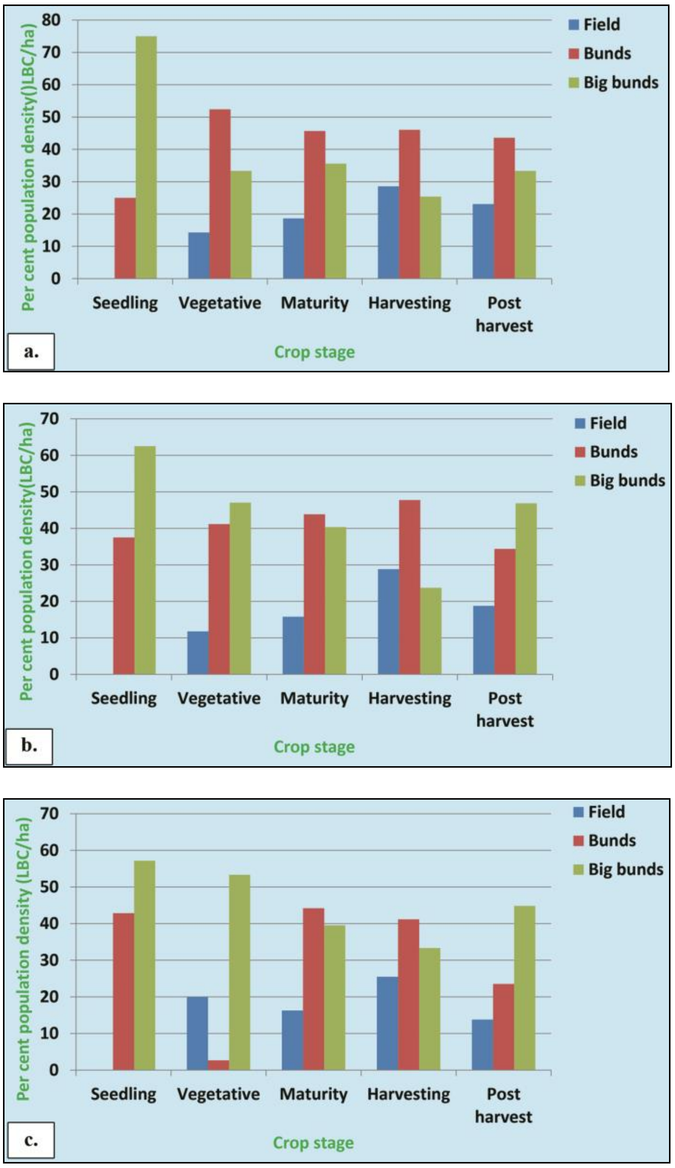


Fig 3: (a-c): Population density of field rodents in *rabi* vegetables of rice-vegetable cropping system during 2015-16 (a): Bekajan (b): Neulgaon (c): Allengmora

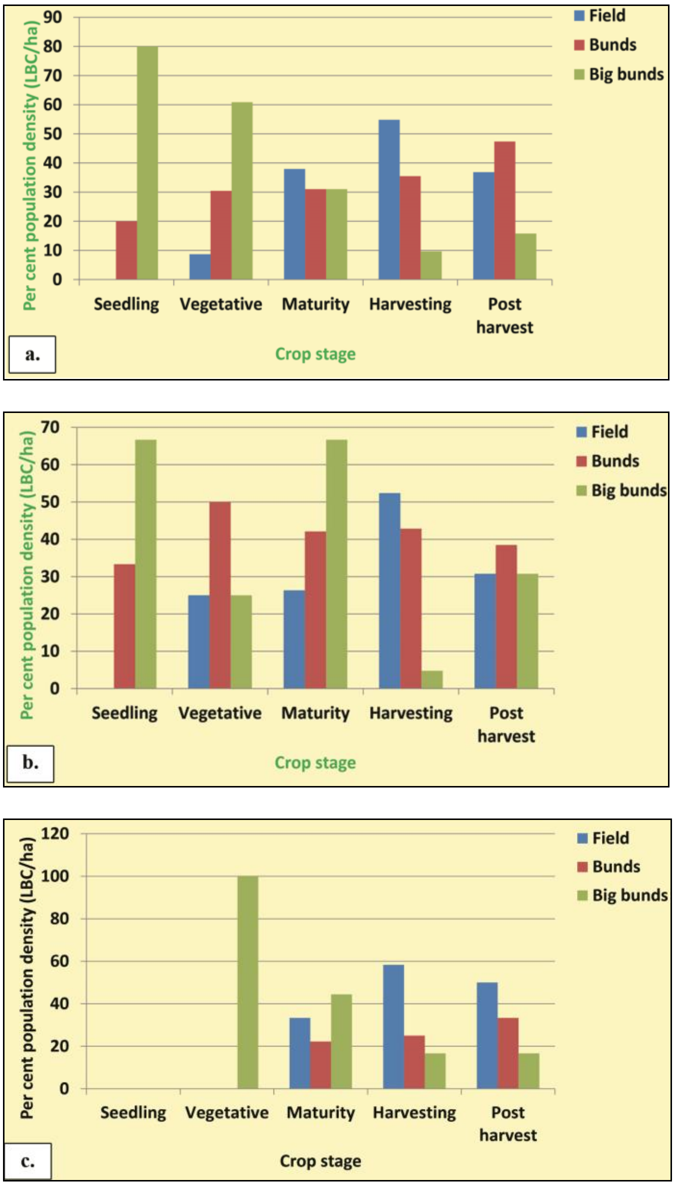


Fig 4: (a-c): Population density of field rodents in *rabi* vegetables of rice-vegetable cropping system during 2016-17 (a): Bekajan (b): Neulgaon (c): Allengmora

Conclusion

The present investigation revealed a clear understanding of response of the field rodents with the predominant species, association between population density with the crop stage, peak period of their occurrence in rice-vegetable cropping system which is an important outcome for scheduling the management strategy at the proper time with the best suited component in a particular region. In recent decades, major changes in agricultural systems and continuous availability of food sources in the fields have increased the sustainability of rodent population in an upright direction. A better understanding of the population ecology of the pest species including the breeding ecology and population dynamics associated with the cropping systems plays a key role in formulating a better management practice.

References

1. Advani R, Prakash I, Mathur RP. Assessment of rodent damage and field losses in standing wheat crop in a desert village complex. Z. Angew. Zool. 1982; 99:257-66.
2. Anonymous. Annual Report. AINP on Rodent Control, Jorhat, 2015.
3. Barnett SA, Prakash I. Rodents of economic importance in India. Arnold-Heinemann, New Delhi, 1975.
4. Brown PR, Hung NQNM, van Wensveen M. Population ecology and management of rodent pests in the Mekong River delta, Vietnam. In: Singleton, G.R., Hinds. L.A., eirs, H. and Zhang, Z., (ed). Ecologically based management of rodent pests. *ACIAR Monograph* No. 59, Canberra, 1999, 319-337
5. Chopra G, Parshad VR. Rodent damage to watermelon. Indian Farm. 1986; 30:40-43.
6. Douangbouphal B, Aplin KP, Singleton GR. Rodent outbreaks in the uplands of Laos: analysis of historical patterns and the identity of nuu khii. Australian centre for International Agricultural Research (ACIAR), Canberra, 2003, 103-111.
7. Hart K. Postharvest losses. In: Pimentel D, ed. Encyclopedia of pest management. New York: Marcel Dekker, 2001. Electronic web access at http://dekker.com/servlet/product/DOI/10.1081-E-EPM-100200058/ main/
8. Jain AP, Tripathi RS, Rana BD. *Rodent Management: The State of Art*, Technical Bulletin No. 1, Indian Council of Agricultural Research, New Delhi, 1993a, 38.
9. Khush GS. More food and a safe environment. Food comes first for Asia. Parkville (Australia): Crawford fund for International Agricultural Research, 1993, 31-33
10. Khamphoukeo KB, Douangboupha KP, Aplinand GR Singleton. Pest and non-pestrodents in the upland agricultural landscapeof Laos: a progress report. In Rats, mice andpeople: rodent biology and management. ACIAR Monograph. 2003; 96:284-289
11. Kumar D, Pathak KA. Rodent pests and their management in North East Hill Region. Glimpses of Rodent Research in India, 2002, 36-39.
12. Kumar N, Kumar V, Singh C, Shukla V. Studies on association between rodents infestation in different stage of rice cultivation. International Journal of Agricultural Science and Research. 2013; 3(3):117-126.
13. Mathur RP, Prakash I. Comparative efficacy of some anticoagulant rodenticides against Indian rodents. In: Proc. The organization and practice of vertebrate pest control (ed. A.C. Dubock) ICI Plant Protection Division, Surrey, U.K, 1984, 381-393.
14. Parshad VR. Rodent control in India. Integrated Pest Management Reviews. 1999; 4:97-126.
15. Parshad VR, Malhi CS. Rodents. In: G.S. Gill and I.S. Mangat (eds) Handbook of Field Problems of Vegetable Crops of Punjab, 1994, 217-24, Punjab Agricultural University, Ludhiana, India.
16. Parshad VR, Singla N, Kocher DK, Kaur R. The lesser bandicoot rat, Bandicota bengalensis Gray and Hardwicke. Technical Bulletin No. 14, ICAR, New Delhi, 2007.
17. Rao AMKM, Joshi NC. Crop losses due to rodents: an overview. Indian J. Entomol. 1986; 48:366-371.
18. Rao AMKM. Rodent problems in India and strategies for their management. In: Singleton GR, Hinds LA, Krebs CJ, Spratt DM, eds. Rats, mice and people: rodent biology and management. Canberra (Australia): Australian Centre for International Agricultural Research, 2003; 203-212.
19. Rao AMK. Rodent Related Problems and their Management–A Training Manual. NIPHM, Hyderabad,

2010.
20. Schiller JM, Douangboupha B, Bounnaphol O. Rodents in agriculture in Lao PDR—a problem with anunknown future. In: Singleton, G.R., Hinds, L.A., Leirs, H. and Zhang, Z., ed., Ecologically-based management ofrodent pests. ACIAR Monograph No. 59. Canberra, Austra-lian Centre for International Agricultural Research, 1999, 372-387.
21. Singleton GR. Impacts of rodents on rice production in Asia. IRRI Discussion Paper, Series No. 43. International Rice Research Institute, Los Ban˜ os, Philippines, 2003.
22. Spillet JJ. Growth of three species of Calcutta rats, *Bandicota bengalensis* Gray, *Bandicota indica* Bechstein and *Rattus rattus* L. *In*: *Proc*. Indian Rodent Symposium. Calcutta. 1966, 176-181.
23. Sridhara S. Rice. In: I. Prakash and P.K. Ghosh (eds) Rodents in Indian Agriculture, Jodhpur: Scientific Publishers, 1992, pp.211-30.
24. Srihari K, Govinda Raj G. Effective period for the control of *Bandicota bengalensis* in paddy fields. Tropical Pest Management, 1988; 34:141-146.
25. Tripathi RS. Recent trends in Coordinated Research on Rodent Control. Rodent Newslett. 2007; 31:1-4.