Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(1): 961-969

Received: 06-11-2018
Accepted: 10-12-2018

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

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

Species composition of field rodents in rice-vegetable cropping system at upper Brahmaputra valley zone, Assam

Mousumi Phukon and Dr. Ratul Kr. Borah

Abstract
A study on species composition of field rodents in rice-vegetable cropping system was carried out at three locations of UBVZ, Assam during 2015-17, revealed five field rodent species *viz*., *Bandicota bengalensis*, *B. bengalensis indica*, *Mus booduga*, *Rattus sikkimensis* and *Dremomys lokriah macmillani*. Out of these five species, the *B. bengalensis bengalensis* was recorded the most predominant species with highest mean number (9.21 ± 5.50 and 6.71 ± 4.6) during 2015-16 and 2016-17 respectively followed by *M. booduga*, *D. lokriah macmillani* and *R. sikkimensis*. The data on relative abundance in *rabi* vegetables also revealed *B. bengalensis* as the most predominant species (85.83% and 81%) followed by *M. booduga* (9.16% and 11%) during 2015-16 and 2016-17 respectively. In the study *kharif* rice showed higher (0.7901 and 0.838) species richness with species diversity (- 0.873 and -0.967) than those of *rabi* vegetables. Trap index data indicated that sex ratio was in favour of males.

Keywords: Relative abundance, species richness, trap index, upper Brahmaputra valley zone (UPVZ)

Introduction
Rodentia is the largest order of mammals in the world comprising 2277 species in 481 genera under 33 families [21]. In India, present checklist Report valid rodent taxa up to subspecies level includes 103 species 89 subspecies under 46 genera, which belongs to 7 families. Out of 33 families of rodents found in the world, seven families *viz*, Sciuridae, Diplodidae, Platacanthomyidae, Spalacidae, Cricetidae, Muridae and Hystricidae occur in India. Family Muridae is the largest family, represented in India by 21 genera and 56 species followed by family Sciuridae having 13 genera and 27 species [15]. The North East hill region was reported to be quite rich in rodent fauna. As many as 7-8 species were of major economic importance and were found to inhabit in this region [9]. The survey at Shillong, Charapunji, Nongpoh and Tura in Meghalaya revealed occurrence *of Rattus rattus*, *R. Norvegicus*, *Bandicota bengalensis* and *Mus musculus*. In Kolasib region of Mizoram, the rodent species were R. *Norvegicus*, *R. Nitidus* and *M. musculus*. Some of the squirrel species occurring in north eastern states of India including Assam are *Belomys pearsonii*, *Petaurista petaurisa*, *P. Philippensis*, *P. Caniceps*, *Hylopetes alboniger*, *Ratufa bicolour*, *Dremomys lokriah*, *D. Pernyi*, *D. Rufigenis*, *Callosciurus pygerythrus*, *C. erythraeus* and *Tamiops macclellandi* [5]. Total eight rodent species were recorded in Jorhat district of Assam during 2002-04. The species in Muridae were *Bandicota bengalensis bengalensis* (Gray), *B. indica indica* (Bechstein), *M. musculus castaneus* Waterhouse, *M. booduga* (Gray), *Rattus rattus* (Linnaeus), *R. sikkimensis* (Hinton) and *R. norvegicus* (Berkenhout) and the only squirrel species under Sciuridae was *D. lokriah macmillani* (Thomas) as result of survey in different habitats [7]. Knowledge of the population biology, social behavior, taxonomy and community ecology of rodent pest is an important foundation for developing effective management strategies. Knowledge of the characteristics, extent of damage and the situations vulnerable to attack by rodents in different crops and regions is important in planning management strategies. Keeping in view, the present investigation was carried out to study the species composition of field rodents in rice-vegetable cropping system of Upper Brahmaputra Valley Zone, Assam.

2. Materials and Methods
2.1. 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.

2.2. Sample collection

Field rodents were sampled at fortnightly interval to record their occurrence and abundance throughout the year by using bandicoot and Sherman traps starting from June, 2015 (*kharif* rice) to May, 2016 (*rabi* vegetables) and June, 2016 to May, 2017. All the morphometric measurements of rodents were carried out at the animal house cum Rodent laboratory of All India Network Project on Vertebrate Pest Management, Department of Entomology, Assam Agricultural University, Jorhat. Rodent species were identified with the help of keys given earlier [2, 8] and confirmed with the earlier findings [7].

2.3. Trap Index

Trap index was calculated by using the following formula [11],

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

2.4. Species composition

Species composition of a particular rodent species in a habitat was expressed as % (per cent) using the following formula given [3],

Species composition = n/N x 100

n= No. of rodents of a species collected

N = Total number of rodents of different species collected

2.5. Species diversity and richness

The diversity was calculated by using "Shannon Wiener Index (1949)", which is defined as

$H' (S) = -\Sigma\ pi\ ln\ pi$

Where, Pi = ni/N

ni = Number of individual of a species at a time i

N = Size of whole community

Σ = Number of species/ Number of seasons

S = Total number of species

The Richness indices was calculated by using "Margalef index (1958)", which is defined as-

$D = (S-1)/ln\ (N)$

Where, S = Number of species

N = Total number of individual of all the species

For calculating the evenness of species, "Pielou's Evenness Index (1966)" was used, which is defined as -

$e = H / In\ S$

Where, H = Shannon – Wiener diversity index

S = Total number of species in the sample

For the estimation of rodent population in terms of burrow density, "live burrow count (LBC) method" [12] was followed.

3. Results and Discussion

Species composition

Study on species composition of field rodents in rice-vegetable cropping system at Bekajan revealed the presence of 4 (four) species *viz*., *Bandicota bengalensis bengalensis* (Gray), *B. indica indica* (Bechstein), *Mus booduga* (Gray), *Rattus sikkimensis* Hinton out of which the *B. bengalensis* was found to be the most predominant species followed by *B. indica, M. booduga* and *R. sikkimensis*. Species composition of field rodents in rice-vegetable cropping system at Neulgaon revealed the abundance of *B. bengalensis* and *M. booduga* while four rodent species *viz., B. bengalensis bengalensis, M. booduga, R. sikkimensis* and *Dremomys lokriah macmillani* Thomas were recorded from the rice-vegetable cropping system of Allengmora.

Out of these five field rodents recorded *viz., B. bengalensis, B. indica, M. booduga, R. sikkimensis* and *D. lokriah macmillani* [Plate1(a-e)] in rice-vegetable cropping system of Jorhat district of Assam, *B. bengalensis* was recorded with the highest mean number (9.21 ± 5.50 and 6.71 ± 4.6) and persistent species in rice-vegetable cropping system at all the three villages of Jorhat district followed by *M. booduga* (1.21 ± 1.21 and 1.21 ± 1.21), *B. indica* (0.62 ± 0.92 and 0.63 ± 0.97), *D. lokriah macmillani* (0.33 ± 0.65 and 0.29 ± 0.55) and *R. sikkimensis* (0.21 ± 0.41and 0.25 ± 0.44) during 2015-16 and 2016-17, respectively (Table 1 & 2).

While reviewing the literature on abundance of rodent fauna of Assam, seven species [7] under Muridae *viz.*; *B. bengalensis* (Gray), *B. indica indica* (Bechstein), *Mus musculus castaneus* Waterhouse, *M. booduga* (Gray), *R. sikkimensis Hinton, R. rattus* (Linnaeus), *R. norvegicus* (Berkenhout) and Sciuridae the only species, *D. lokriah macmillani* Thomas were reported. Moreover, *D. lokriah macmillani* the only rodent species under family sciruidae was prevalent at Allengmora, the typical rice-vegetable growing area surrounded by human habitation including kitchen gardens and horticultural orchards. However, the change in the species composition in the present study may be due to change in location, weather parameter, soil type and cropping pattern of the area.

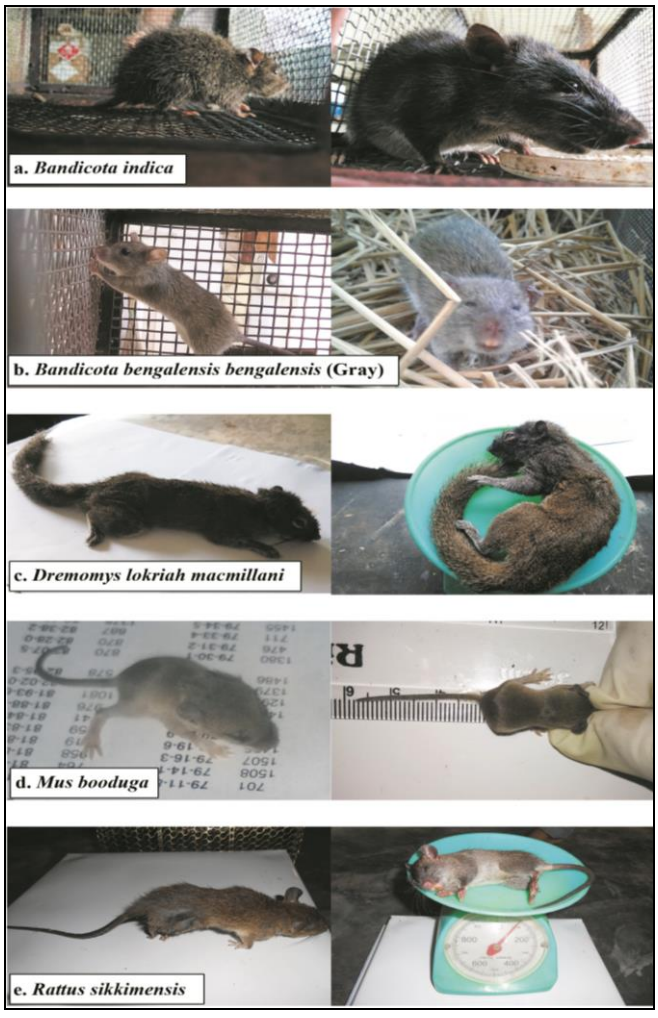

Plate 1 (a-e): Field rodent species in rice-vegetable cropping system

Table 1: Species composition of field rodents in rice-vegetable cropping system (3 ha) of Jorhat during 2015-16

Month	Crop stage	Fortnight	*B. bengalensis*	*Mus booduga*	*B. indica*	*Rattus sikkimensis*	*Demormys lokriah*
June	Fallow land	I	5	1	0	0	0
		II	4	0	0	0	0
July	Seedling	I	6	1	0	0	0
		II	5	0	0	0	0
August	Tillering (Rice)	I	5	2	0	1	0
		II	8	0	1	0	1
September	Reproductive (Rice)	I	15	2	0	1	0
		II	17	0	2	0	0
October	Reproductive(Rice)	I	12	1	1	0	1
		II	18	1	1	1	0
November	Harvesting (Rice)	I	6	1	2	0	0
		II	4	2	3	1	1
December	Post harvest (Rice)	I	7	4	2	1	1
		II	6	3	1	0	0
January	Seedling (veg.)	I	5	2	2	0	0
		II	4	0	0	0	2
February	Vegetative (veg.)	I	4	1	0	0	0
		II	6	0	0	0	0
March	Maturity (veg.)	I	17	2	0	0	1
		II	16	0	0	0	1
April	Harvesting (veg.)	I	18	3	0	0	0
		II	19	0	0	0	0
May	Post harvest (veg.)	I	6	3	0	0	0
		II	8	0	0	0	0
Grand Total			221	29	16	5	8
Mean ± SD			9.21 ± 5.50	1.21 ± 1.21	0.62 ± 0.92	0.21 ± 0.41	0.33 ± 0.65

Table 2: Species composition of field rodents in rice- vegetable cropping system (3 ha) of Jorhat during 2016-17

Month	Crop stage	Fortnight	*B. bengalensis*	*Mus booduga*	*B. indica*	*Rattus sikkimensis*	*Demormys lokriah*
June	Fallow land	I	3	1	0	0	0
		II	2	0	0	0	0
July	Seedling	I	4	1	0	0	0
		II	2	0	0	0	0
August	Tillering (Rice)	I	2	2	1	1	0
		II	4	0	1	1	0
September	Reproductive (Rice)	I	11	2	0	0	0
		II	13	0	3	0	0
October	Reproductive (Rice)	I	9	1	0	0	0
		II	13	1	0	1	0
November	Harvesting (Rice)	I	5	1	3	1	0
		II	3	2	2	1	1
December	Post harvest (Rice)	I	5	4	2	1	1
		II	4	3	0	0	0
January	Seedling (veg.)	I	3	2	1	0	0
		II	3	0	0	0	2
February	Vegetative (veg.)	I	4	1	0	0	0
		II	4	0	0	0	0
March	Maturity (veg.)	I	13	2	0	0	1
		II	14	0	0	0	1
April	Harvesting (veg.)	I	16	3	1	0	0
		II	13	0	1	0	1
May	Post harvest (veg.)	I	5	3	0	0	0
		II	6	0	0	0	0
Grand Total			161	29	15	6	7
Mean ± SD			6.71 ± 4.6	1.21 ± 1.21	0.63 ± 0.97	0.25 ± 0.44	0.29 ± 0.55

Species composition in *kharif* rice of rice-vegetable cropping system

Species composition of field rodents in *kharif* rice at Bekajan, near Nagaland foot hills revealed the per cent abundance of *B. bengalensis* (67.69% and 64.91%), *B. indica* (21.53% and 22.80%) and *M. booduga* (7.69% and 8.77%) as the predominant species followed by *R. sikkimensis* (3.07% and 3.50%) during 2015-16 and 2016-17, respectively. While at Neulgaon, near the river bank of the Brahmaputra, *B. bengalensis* was the predominant with (95% and 93.10%) abundance followed by *M. booduga* (5% and 6.89%) in both the years. On the other hand, *B. bengalensis* (65.45% and 48.48%), *M. booduga* (20% and 33.33%), *D. lokriah macmillani* (9.09% and12.12%) and *R. sikkimensis* (5.45% and 6.06%) [Fig. 1(a-f)] were recorded from the rice field of Allengmora during 2015-16 and 2016-17, respectively.

During the course of investigation on species composition of rodent pests in *kharif* rice of rice-vegetable cropping system,

B. bengalensis was found to be the most predominant species with (74.68% and 67.79%) abundance followed by *M. booduga* (11.39% and 15.25%), *B. indica* (8.22% and 10.16%), *R. sikkimensis* (3.16% and 5.08%) and *D. lokriah macmillani* (2.53% and 1.69%) during 2015-16 and 2016-17, respectively [Fig. 2(a-b)].

It was also reported that *B. bengalensis bengalensis* was the most abundant species (43.75%) in paddy field as compared to other habitat [7]. *B. bengalensis* was recorded as the major pest of paddy, ragi, soybean etc [20]. In present investigation, among the observed species *B. bengalensis bengalensis* and *M. booduga* were found predominant in *kharif* rice throughout the crop stages in both the years. *B. bengalensis bengalensis* and *M. booduga* was also reported as predominant species of rice field of Karnataka (hill region) [4] and Andhra Pradesh (Godavari delta) [16] respectively.

Species composition in *rabi vegetables* of rice-vegetable cropping system

During *rabi* 2015-16 and 2016-17, the study on abundance of rodent pests in *rabi* vegetables at three villages of Jorhat district revealed the prevalence of *B. bengalensis* with (88.88% and 90.0%) followed by *M. booduga* (5.55% and 5.0%) and *B. indica* (5.55% and 5.0%) at Bekajan, near Nagaland foot hills while *B. bengalensis* (90% and 92.85%) followed by *M. booduga* (10% and 7.11%) at Neulgaon, near river bank and *B. bengalensis* (81.39% and 65.51%), *M. booduga* (11.62% and 17.24%) and *D. lokriah macmillani* (6.97% and 17.24%) at Allengmora, a typical rice-vegetable growing area near human habitation [Fig. 3(a-f)].

The data on relative abundance of field rodents in *rabi* vegetables of rice-vegetable cropping system revealed that *B. bengalensis* was the most predominant species (85.83% and 81%) followed by *M. booduga* (9.16% and 11%) during 2015-16 and 2016-17 respectively. Apart from these two species *B. indica* (1.66% and 3%) and *D. lokriah macmillani* (3.33% and 5%) were also prevalent in both the years during the course of investigation [Fig. 4(a-b)].

B. bengalensis was also reported as predominant species in summer vegetables causing damage to developing and ripe fruits of muskmelon in Punjab [14]. *M. booduga* was reported as common pest of agriculture throughout the India [17].

[1] Two subspecies were recognized from India, *viz*., *B. bengalensis bengalensis* and *B. bengalensis wardi*. The subspecies *B. bengalensis bengalensis* identified from rice-vegetable cropping system of Jorhat was brown to dark brown without glossy structure in contrast to grayish brown in case of the other subspecies *B. bengalensis wardi* [9]. Similar findings, [7] were also earlier reported from Jorhat.

Diversity indices of field rodents in rice-vegetable cropping system

Diversity indices of field rodents in rice-vegetable cropping system were calculated by using the formulas given by Margalef index and Shannon-Weiner index. During the present investigation, the data on diversity indices of field rodents between *kharif* rice and *rabi* vegetables of rice-vegetable cropping system when compared, revealed that *kharif* rice showed higher (0.7901 and 0.838) species richness with species diversity (- 0.873 and -0.967) than those of *rabi* vegetables with species richness indices (0.626 and 0.651) and species diversity (-0.612 and -0.712) during 2015-16 and 2016-17, respectively (Table 3).

While comparing the data on diversity indices of field rodents in rice-vegetable cropping system during 2015-16 and 2016-17 among different situations of the district, revealed the highest (0.748 and 0.857) species richness indices in *kharif* rice at Allengmora followed by species richness in *kharif* rice (0.718 and o.742) at Bekajan as compared to the least (0.271 and 0.296) species richness indices at Neulgaon during *kharif* crop. Similarly, data on species richness indices during *rabi* vegetables recorded the highest (0.593) at Allengmora during 2016-17 followed by Bekajan (0.558 and 0.542) the least (0.271 and 0.300) at Neulgaon near the river bank of Brahmaputra during 2015-16 and 2016-17, respectively (Table 4, 5 & 6).

The current study revealed that *B. bengalensis* was found to be the most predominant species in terms of live burrow count per ha followed by *M. booduga* in rice-vegetable cropping system of Jorhat. It was also reported that *B. bengalensis* was the most predominant species in various habitat in Jorhat district of Assam [7].

Table 3: Diversity indices of field rodents in rice-vegetable cropping system of Jorhat during 2015-16 and 2016-17

Crop and season	Species richness		Species diversity		Evenness	
Year	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Kharif rice	0.7901	0.838	- 0.873	-0.967	-0.542	-0.601
Rabi vegetables	0.626	0.651	-0.612	-0.712	-0.542	-0.514

Table 4: Diversity indices of field rodents in rice-vegetable cropping system at Bekajan (near foot hills) during 2015-16 and 2016-17

Crop and season	Species richness		Species diversity		Evenness	
Year	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Kharif rice	0.718	0.742	-0.735	-0.710	-0.530	-0.512
Rabi vegetables	0.558	0.542	-0.434	-0.447	-0.395	-0.407

Table 5: Diversity indices of field rodents in rice-vegetable cropping system at Neulgaon (near river bank) during 2015-16 and 2016-17

Crop and season	Species richness		Species diversity		Evenness	
Year	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Kharif rice	0.271	0.296	-0.398	-0.357	-0.574	-0.515
Rabi vegetables	0.271	0.300	-0.430	-0.352	-0.620	-0.508

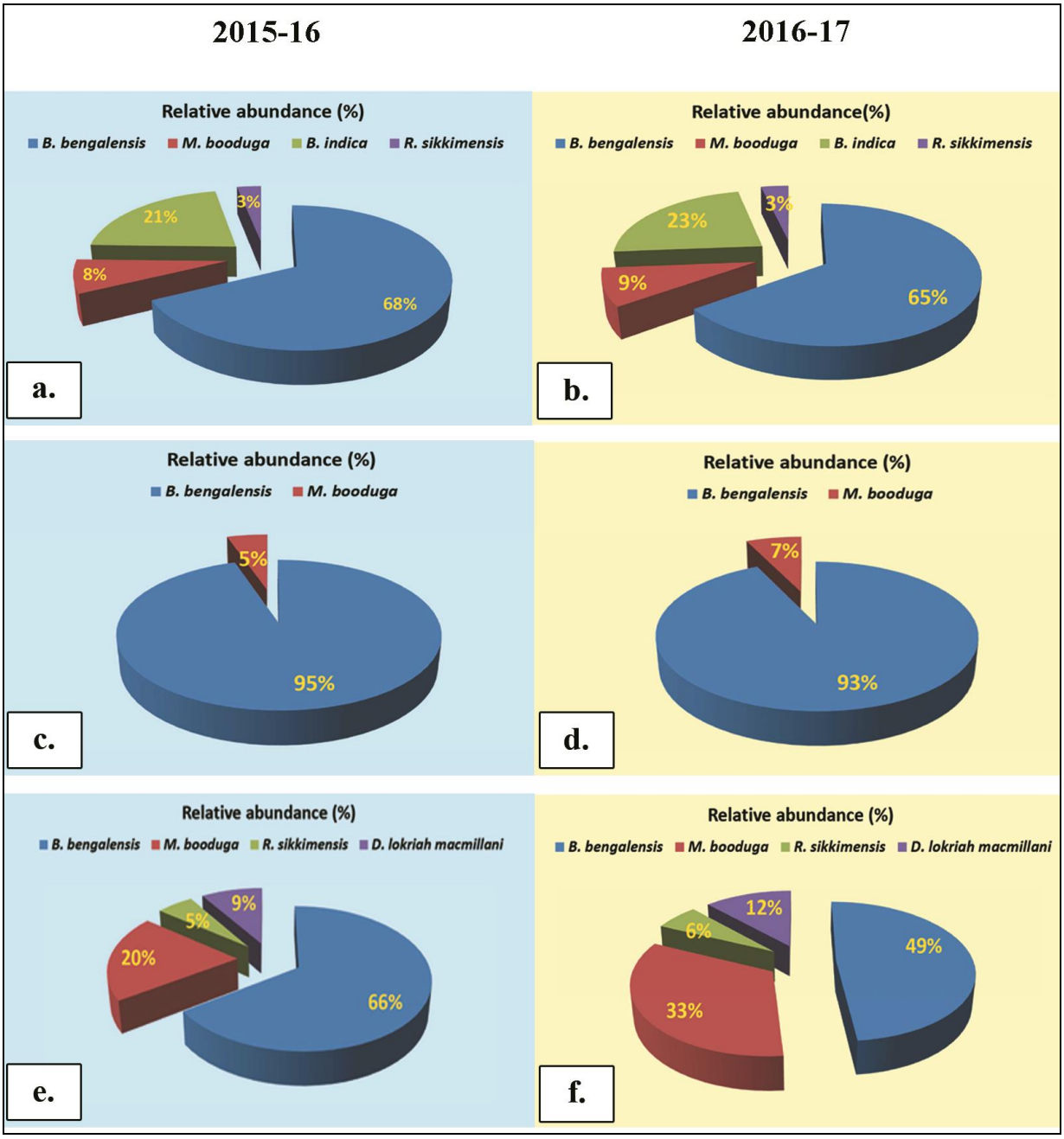

Fig 1 (a-f): Relative abundance of (location wise per ha) of different field rodents in kharif rice during 2015-16 and 2016-17 (a-b): Bekajan, (c-d): Neulgaon, (e-f): Allengmora

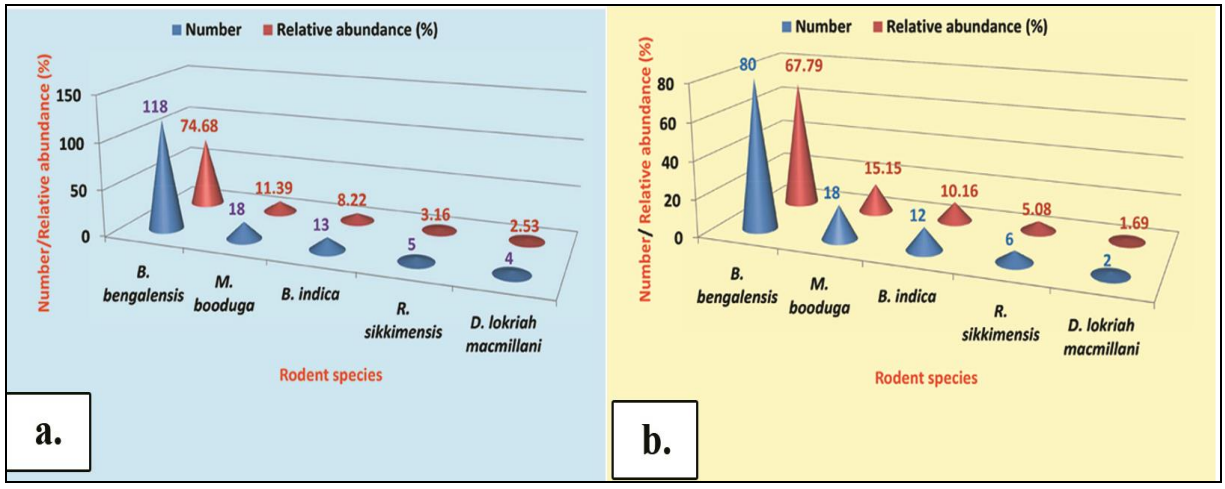

Fig 2 (a-b): Relative abundance of Jorhat (3 ha) of different field rodents in kharif rice during 2015-16 and 2016-17

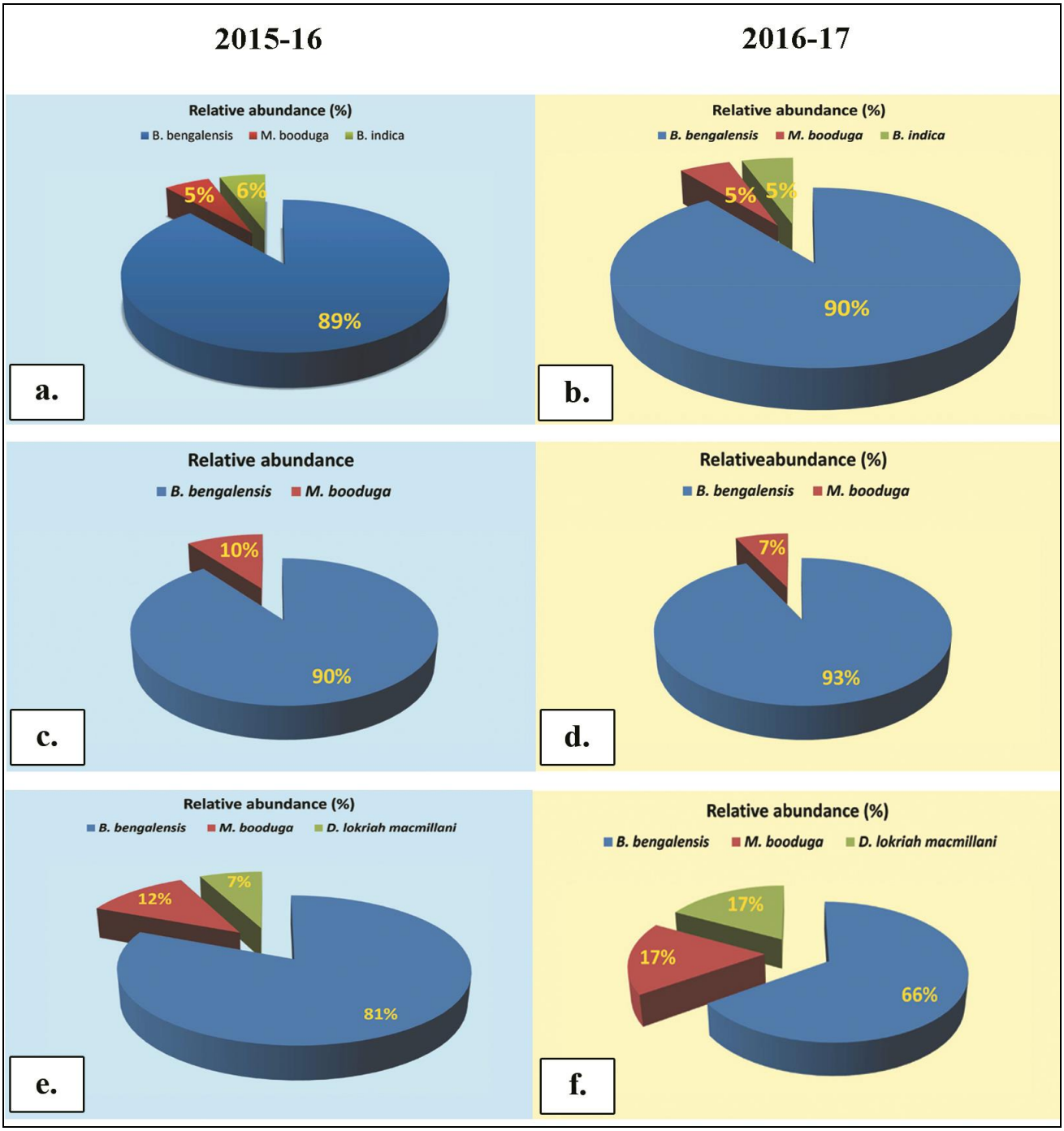

Fig 3(a-f): Relative abundance of (location wise per ha) of different field rodents in *rabi* vegetables during 2015-16 and 2016-17 (a-b): Bekajan, (c-d): Neulgaon, (e-f): Allengmora

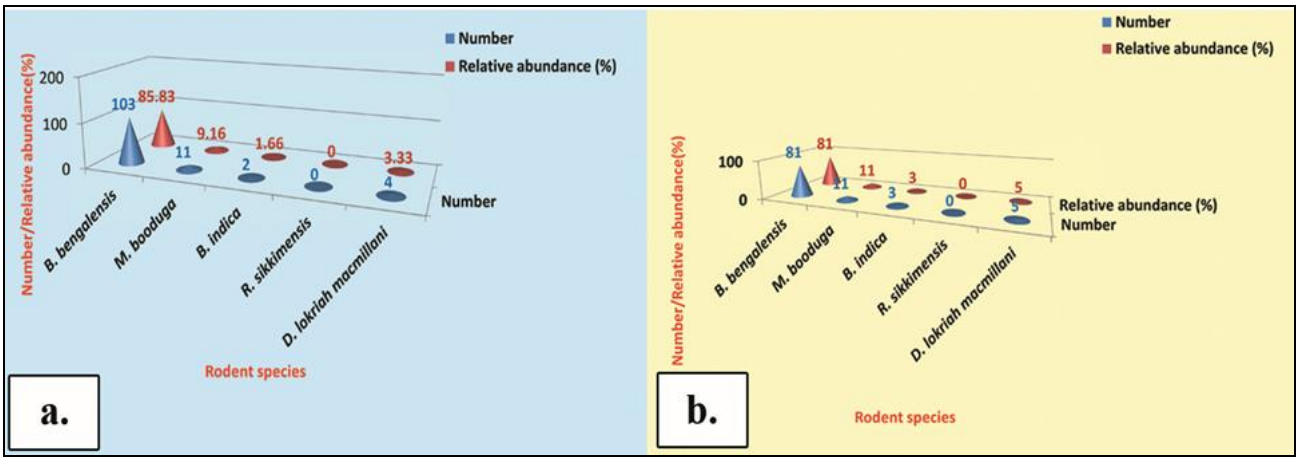

Fig 4 (a-b): Relative abundance of Jorhat (3 ha) of different field rodents in *rabi* vegetables during 2015-16 and 2016-17

Table 6: Diversity indices of field rodents in rice-vegetable cropping system at Allengmora during 2015-16and 2016-17

Crop and season	Species richness		Species diversity		Evenness	
Year	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Kharif rice	0.748	0.857	-0.707	-0.565	-0.510	-0.408
Rabi vegetables	0.531	0.593	-0.518	-0.473	-0.471	-0.430

Sex ratio

During the course of investigation, male: female ratio was recorded at fortnightly interval throughout the year from the trapped rodents in rice-vegetable ecosystem at three villages of the district. The total number of male and female *B. bengalensis* trapped was 44 and 27, 41 and 33, 46 and 30 at Allengmora, Neulgaon and Bekajan respectively during 2015-16 with a corresponding sex ratio of 1.66: 1, 1.24: 1 and 1.53:1 showing higher male ratio over most of the study period. In the present investigation, the male: female ratio during 2016-17 was recorded as 3.3:1, 1.65:1 and 1.28:1 at Allengmora, Neulgaon and Bekajan respectively (Fig. 5 & 6).

In case of *B. indica* the total number of male and female rodents trapped was 9 and 6 with corresponding sex ratio of 1.5: 1 recorded at Bekajan in both the years, 2015-16 and 2016-17 (Fig. 7). The total number of male and female rodents of *M. booduga* was 11 and 5, 4 and 2, 4 and 3 at Allengmora, Neulgaon and Bekajan respectively with corresponding sex ratio of 2.2:1, 1.5:1 and 1.33:1, respectively during 2015-16 and 2.25:1, 2:1 and 1.5:1 during 2016-17 (Fig. 8 & 9). However, in case of *R. sikkimensis* the total number of rodent trapped during the entire study period was only 2 and 1 at Allengmora with corresponding sex ratio of 2:1 and 1:1 at Bekajan during 2015-16. Similarly, during 2016-17 the recorded sex ratio of trapped rodents was 2:1 and 1:0 at Allengmora and Bekajan respectively (Fig. 10 & 11). Moreover, the total number of male and female rodent trapped in *D. lokriah macmillani* was 5 and 3 with a sex ratio of 1.66:1 during 2015-16 and 2.5:1 during 2016-17 respectively (Fig. 12).

In the present investigation, there was a significant preponderance in males in overall rodent trappings. Although the number of male and female rodents in all the species except *B. bengalensis* and *M. booduga* was very less, but the sex ratio was observed in favour of males. However, the sex ratio had no relevance due to their small numbers.

B. bengalensis and *M. booduga* showed higher trapping frequency for males as compared to females. Researchers [10] reported that *Mus formosanus, Apodemus agrarius* and *Rattus losea* showed a higher capture frequency for males. Rice rat males were more abundant than females in population samples [22]. Earlier workers [17] reported the sex ratio of *M. meltada* was dominated by males, in both rice and wheat fields, there was a significant preponderance of males in the overall sample. It might be that males are more active than females or more willing to approach and eat novel bait; yet it might have been that the absolute numbers of males in these species were higher than that of females as indicated by [9]. An excess of males which might have been due to the larger home ranges of males, giving them increased trappability [11]. On the other hand, the female rodents were trap shy or lived more concealed or were retracted during spring prior to breeding in summer and autumn.

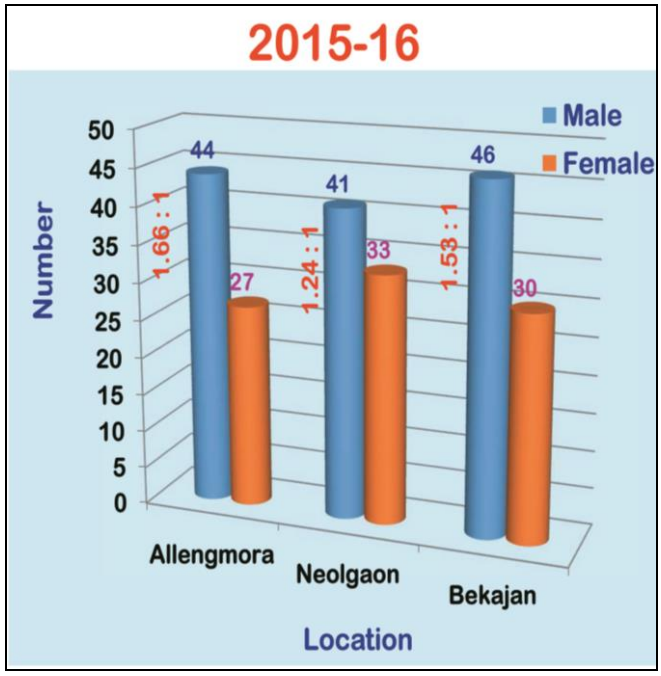

Fig 5: Sex ratio (Male: Female) of *Bandicota bengalensis* in rice-vegetable cropping system during 2015-16

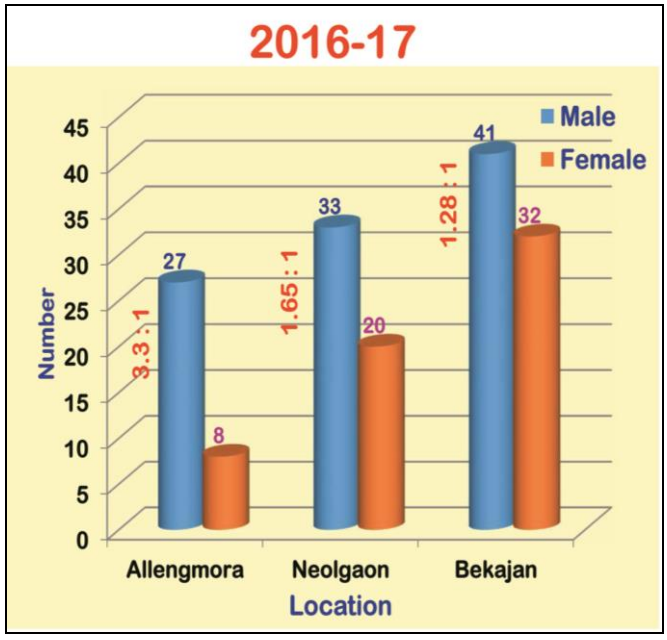

Fig 6: Sex ratio (Male: Female) of *Bandicota bengalensis* in rice-vegetable cropping system during 2016-17

Fig 7: Sex ratio (Male: Female) of *B. indica* in rice-vegetable cropping system during 2015-16 & 2016-17

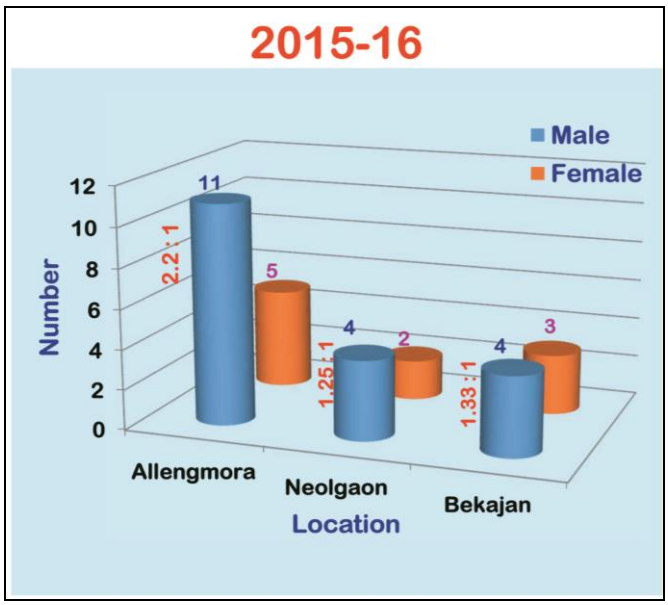

Fig 8: Sex ratio (Male: Female) of *Mus booduga* in rice-vegetable cropping system during 2015-16

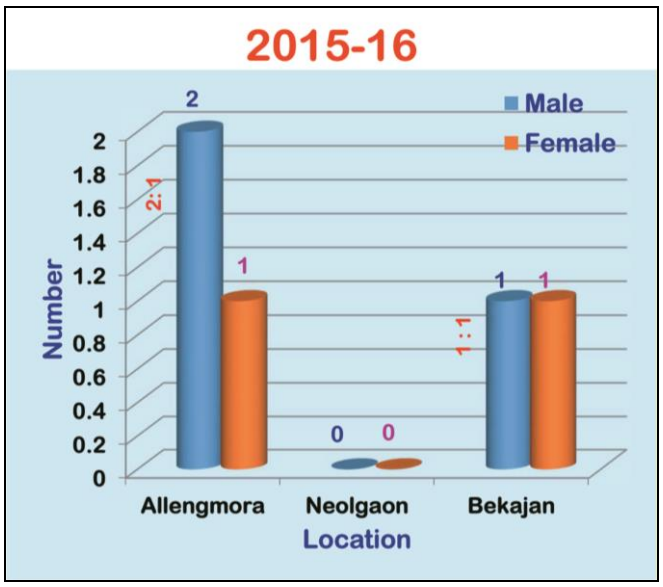

Fig 10: Sex ratio (Male: Female) of *Rattus sikkimensis* in rice-vegetable cropping system during 2015-16

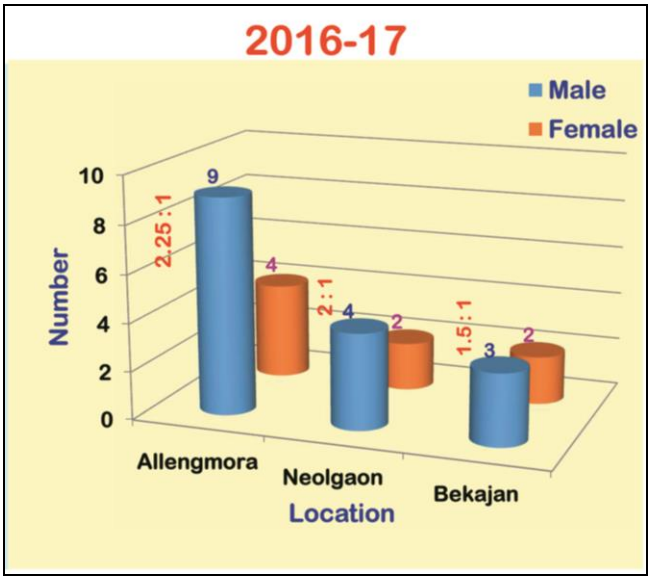

Fig 9: Sex ratio (Male: Female) of *Mus booduga* in rice-vegetable cropping system during 2016-17

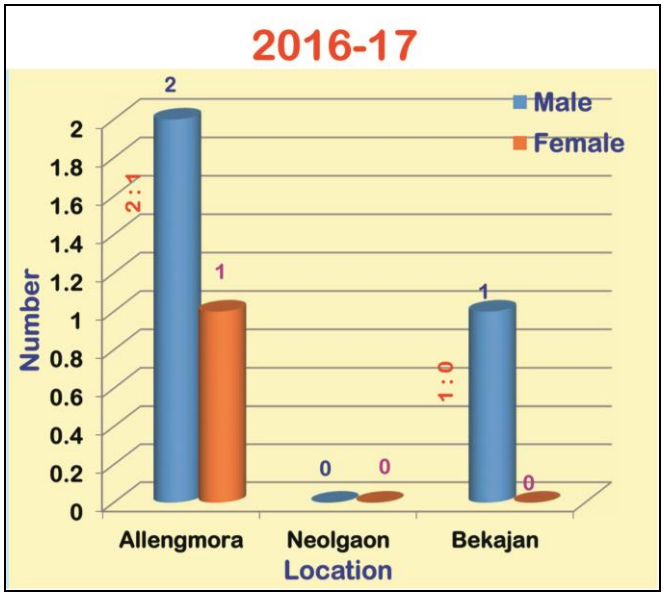

Fig 11: Sex ratio (Male: Female) of *Rattus sikkimensis* in rice-vegetable cropping system during 2016-17

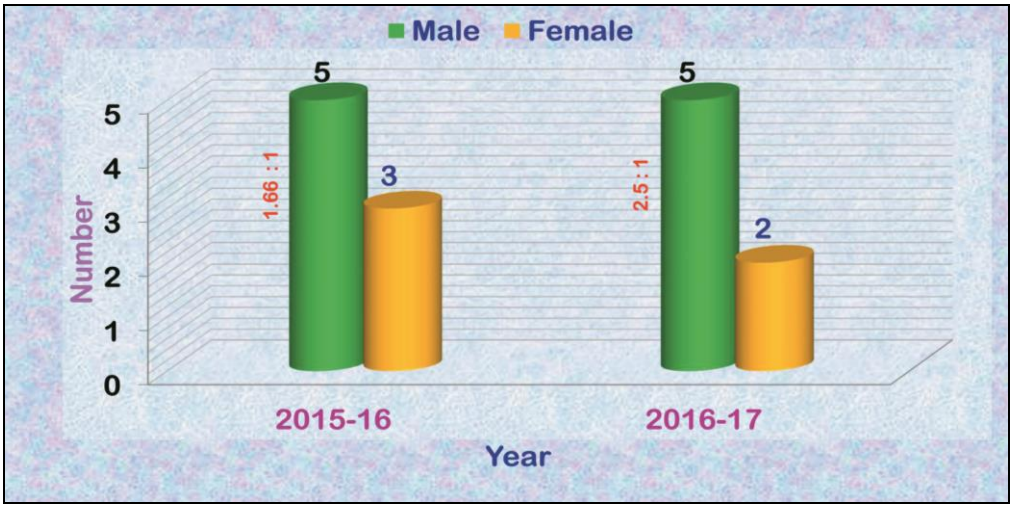

Fig 12: Sex ratio (Male: Female) of *Dremomys lokriah macmillani* in rice-vegetable cropping system during 2015-16 & 2016-17

4. Conclusion

The present investigation revealed a clear understanding on the abundance of the field rodents with the predominant species in rice-vegetable cropping system at Upper Brahmaputra Valley Zone, Assam. Species composition of field rodents in rice-vegetable cropping system revealed the presence of 5 (five) species *viz*., *Bandicota bengalensis bengalensis* (Gray), *Bandicota indica indica* (Bechstein), *Mus booduga* (Gray), *Rattus sikkimensis* Hinton belonging to Muridae family and *Dremomys lokriah macmillanil* Thomas the only species belonging to family Sciuridae, out of which *B. bengalensis* was found to be the most predominant species in both *kharif* rice and *rabi* vegetables this particular cropping sequence.

5. References

1. Agrawal VC, Chakraborty S. Revision of the subspecies of the Lesser Bandicoot rat, *Bandicota bengalensis* (Gray) (Rodentia: Muridae). Rec. Zool. Surv. India. 1976; 69:267-274
2. Agrawal VC. Taxonomic studies on Indian Muridae and Hystericidae (Mammalia: Rodentia) Rec. Zool. Surv. India, Occasional. 2000; 180:1-180
3. Agrawal VC, Prakash I. Ecoogical distribution of Indian rodents. In: Rodents in Indian Agriculture. 1992, I.
4. Chakravarthy AK, Shadakshri YG, Gangappa E. Rodent damage to rice germplasm in Mudigere, Karnataka. Rodent Newl. 1992; 16:6.
5. Choudhury A. Checklist of the Mammals of Assam, Gibbon books with Assam Science Technology & Environment Council, 1997, 103.
6. Corbet GB, Hill JE. The Mammals of Indomalayan Region: A systematic Review. Oxford University Press, Oxford United Kingdom, 1992, Viii(488).
7. Dutta BC, Sarma K. Species composition of rodents in Jorhat, Assam. The Bioscan. 2007; 2(2):135-138.
8. Ellerman JR. A key to the Rodentia inhabiting India, Ceylon and Burma based on the collections in the British Museum. J Mammal. 1947; 28:249-278.
9. Ellerman JR. The fauna of India including Pakistan, Burma and Ceylon, Mammalia (Rodentia) Part 1 and 2. Govt. Of India, Delhi. 1961; 3:849.
10. Hseun YK, Hague CW, Ku TY. Observation on population of five field rodent in cultivated land in central Taiwan. Plant Prot. Bull. 1978; 20:302-312.
11. Jain AP, Tripathi RS, Rana BD. Rodent management, the state of art, technical bulletin-1, AICRP on rodent control, CAZRI Jodhpur, 1993, 1-38.
12. Khan AA, Beg MA. Reproduction and structure of *Bandicota bengalensis* population in an agroecosystem. J Agri. Sci. 1984; 21:49-60.
13. Kumar D, Pathak KA. Rodent pests and their management in North East Hill Region. Glimpses of Rodent Research in India. 2002, 36-39
14. Malhi CS, Parshad VR. Rodent damage and control in vegetable crops. Kissan World. 1992a; 19:29.
15. Pradhan MS, Talmale SS. A Checklist of valid Indian rodent taxa (Mammalia: Rodentia) (updated till May, 2011-online version), 2011, 1-13. Retrieved from http://www.zsi.gov.in/checklist/Valid_Indian_ Rodents.pdf.
16. Rangareddy A. Rodent management in cereal crops with reference to rice. Paper presented to the Apex Level Rodent Control Training, ICAR, NEH Complex, Barapani, Shillong, 1994, 86-92.
17. Rao AMKM, Baasubramanyam M. The mice, Mus spp. In: Rodents in Indian Agriculture Eds.: Ishwar Prakash and P.K. Ghosh. 1992; 1:146-164
18. Shaher BL, Abdu RK, Syed MA. Population Dynamics of Soft-furred field rat, *Millardia meltada* in rice and wheat fields in Central Panjab, Pakistan. Turk. J Zool. 2003; 27:155-161.
19. Singh YP, Kumar D, Gangwar SK. Status paper on rodents in North-Eastern hill region and their management. Rodent Newl. 1994; 18:3-11.
20. Sridhara S. Rodents and theor management in Karnataka. Glimpses of Rodent Research in India. 2002, 24-27
21. Wilson, Don E, Reeder DM. Mammal species of the world. A Taxonomic and Geographic Reference (3rd ed), Johns Hopkins University Press, 2005, 2142.
22. Wolfe JL. Population ecology of the Rice rat (*Oryzomys palustris*) in a coastal marsh. J Zool. 1985; 205(2):235-244.